VIRTUAL PRODUCTION & BEYOND

SLAYING THE MYTH TO UNCOVER THE TRUTH

CASE STUDY: SHORT FILM

KAPRI LADD · TREMARRI LIMBRICK · CATHERINE KILBOURNE · MICHAEL SAUNDERS with NOTLIM TAYLOR and TIKA SUMPTER as "MOTHER"

Executive Producer
ERIK WEAVER

Lead Author & VP Producer
TOM THUDIYANPLACKAL

Consulting Editor
ROBERT SCOTT

Presented by the ENTERTAINMENT TECHNOLOGY CENTER at THE UNIVERSITY OF SOUTHERN CALIFORNIA

etc ENTERTAINMENT TECHNOLOGY CENTER

TABLE OF CONTENTS

This section has already been released and published.
It is available to read online at http://www.tinyurl.com/fathead-wp-cloud.

01 CLOUD COMPUTING: GROWTH WITHOUT BOUNDS

TABLE OF CONTENTS

This section has already been released and published.
It is available to read online at http://www.tinyurl.com/fathead-wp-sound.

02 SOUND MITIGATION: PERFORMANCE MATTERS

TABLE OF CONTENTS

This section has already been released and published.
It is available to read online at http://www.tinyurl.com/fathead-wp-soti.

03 THE STATE OF THE INDUSTRY: BEYOND TRENDS

TABLE OF CONTENTS

04.1 KEY CONTRIBUTORS: PROCESS PIPELINES

Fathead's pioneering virtual production journey showcases a harmonious blend of traditional storytelling and groundbreaking technology facilitated by a diverse team of innovators. This collaborative venture, involving talents from various sectors — filmmakers, virtual production specialists, and educators to technical directors—navigated the complexities of integrating Unreal Engine's capabilities, MetaHumans, and photogrammetry within a cohesive narrative framework. Each contributor, whether in visualization, asset creation, or educational support, embraced the dynamic challenges of virtual filmmaking, contributing to an academic and exploratory process. Their collective experiences underscore the evolving landscape of film production, where technological advancement and creative vision converge, heralding a new era of storytelling that transcends traditional boundaries and paves the way for future innovations in the industry.

[**Keywords:** Virtual Production, Unreal Engine, MetaHumans, Photogrammetry, Real-Time Rendering, Previsualization (Previs), Storyboarding, Digital Humans, Cinematics, Virtual Art Department (VAD), Erik Weaver, Ben Baker, Scott Squires, Asset Optimization, Educational Collaboration, Technology Integration, Narrative Storytelling, Virtual Environments, LED Walls, Cross-Disciplinary Education, Innovation in Filmmaking, Collaboration Tools (Perforce, Slack), Motion Capture, 3D Modeling, Creative Direction].

TABLE OF CONTENTS

04.1 KEY CONTRIBUTORS: PROCESS PIPELINES

TABLE OF CONTENTS

04.1 KEY CONTRIBUTORS: PROCESS PIPELINES

TABLE OF CONTENTS

04.2 PROJECT PARTNERS & INDUSTRY RESOURCES

The virtual production of *Fathead* highlighted a confluence of technology and creative vision, showcasing contributions across various disciplines and technologies. Innovations by ARRI, Silverdraft, Move.ai, and Wacom, alongside insights from experts like Tomas Misura from RealityCapture, have underscored the transformative power of virtual production. From ARRI's ALEXA Mini LF camera enhancing cinematic quality to Silverdraft's computing solutions boosting creative processes and Move AI's advancements in real-time motion capture, each has expanded the filmmaking landscape. Wacom's integration facilitated a seamless digital creative workflow, while Misura's work with RealityCapture bridged historical preservation with modern storytelling. This collaboration across companies and technologies reflects a shift towards a more dynamic, efficient, and creative filmmaking process, pushing the boundaries of traditional and digital realms.

[**Keywords:** Virtual Production, ARRI, Silverdraft, Move.ai, Wacom, Tomas Misura, RealityCapture, ALEXA Mini LF, Computing Solutions, Real-Time Motion Capture, Digital Creative Workflow, Filmmaking, Historical Preservation, Storytelling, ARRI's UMC-4, Lens Metadata, Codex Compact Drive, Amy Gile, Niall Hendry, Photogrammetry, Digital Transformation, 3D Printing, MetaHumans, Unreal Engine, Creative Vision, Innovative Technologies, Film Industry Transformation].

TABLE OF CONTENTS

04.2 PROJECT PARTNERS & INDUSTRY RESOURCES

TABLE OF CONTENTS

04.2 PROJECT PARTNERS & INDUSTRY RESOURCES

CREDITS

Executive Producer: Erik Weaver

Chief Administrative Officer: Edie Meadows

Interviewers: Tom Thudiyanplackal, Rebecca Perry, Peter Amodeo Gould (BTS Crew)

Lead Author: Tom Thudiyanplackal

Editor: Robert Scott

Designer: Yeji Seo

CHAPTER 4.

INTRODUCTION TO VIRTUAL PRODUCTION & BEST PRACTICES

In filmmaking, there are definite steps to achieve a final goal that most effectively conveys the creator's original intention and amplifies it with the power of collaboration.

Directors commonly face challenges regarding the time or budget to investigate the methods required to convey the unique style and techniques needed to deliver their vision. Assembling the right team, asking relevant questions, testing novel approaches, and taking other vital steps result in numerous individuals with different skills and experiences joining a production team to realize the director's vision.

How does one convey that vision without becoming a bizarre game of telephone?

Questions are our greatest ally in discovering how to bring a script to life effectively and efficiently. Every tool and process must be chosen to address the following queries adequately:

- What are the writer's intentions as codified in the script?
- How does the director interpret the text?
- What is the visual language that most effectively conveys the story with all its nuanced expression of tone, pacing, and scale?
- Who is best equipped to lead a particular department, and how do we pick the most suited candidate?
- If money were no object, how would you make this film? Who would you hire, and who would be your dream cast?

The next step is to identify the necessary tools and resources. The following steps are critical:

- Hire the heads of departments who are naturally aligned with the director's desired working style and vision for the project (production designer, cinematographer, costume designer, editor, sound department, music composer, etc.)
- Mood boards and mix tapes are an excellent way to identify how each of these candidates has responded to the material and the director's notes
- Other important members to bring in early are the storyboard artist, concept artist, and previs artist
- When the show is decidedly reliant on virtual production, engaging a virtual production supervisor with a visual effects background is invaluable
- Know your strengths and play to them
- Know your deficits and make up for them elsewhere rather than spending too much time or effort trying to play catch-up or patching things up

PREPARATION IMPROVES FORESIGHT & GUARANTEES SUCCESS

Identifying your stage partners early in the game can also be a great advantage. However, most producers dislike locking this in until the last minute. Many shortfalls may result from this prevailing practice. Every stage is built differently, and the tech stack significantly impacts what will become possible on the shoot day. Knowing the strengths of the stage team and the technology available will help engineer solutions and integrations to maximize the output.

Designing the virtual environments must be more targeted to economize the investment of time and labor. Most productions have been overbuilding virtual environments and underutilizing them on the shoot day. Many shows have spent several months with the virtual art department (VAD) and realized this practice's disadvantages too late. They walk away with a sour aftertaste and blame the entire process.

The fault lies elsewhere: not forecasting perceptively by engaging the LED stage team early in the planning and decision-making phase.

Once you get into building the environments in Unreal Engine (UE), either doing everything within the Engine or roundtripping from other Digital Content Creation (DCC) applications like Autodesk Maya, Blender, or Houdini; the director and department heads should not be going back to the drawing board and making massive changes. The VAD work within the Engine should remain focused on getting things ready for production, and all input from the creative team must be streamlined toward art direction and improving the shot mechanics that are likely to yield the best results at the selected volume stage.

TOOLS USED ON *FATHEAD*

Below is the flowchart showing the progress made through the months that involved some going back and forth with several rewrites leading to 26-27 drafts before the team arrived at the one locking the production script.

The flowchart captures the process of going through some of the recommended steps from the script to the finished production captured at a virtual production volume.

The director assesses the screenplay and discusses it with his department heads, including the cinematographer, production designer, costume designer, and virtual production supervisor, to identify the best approach to interpret it on screen.

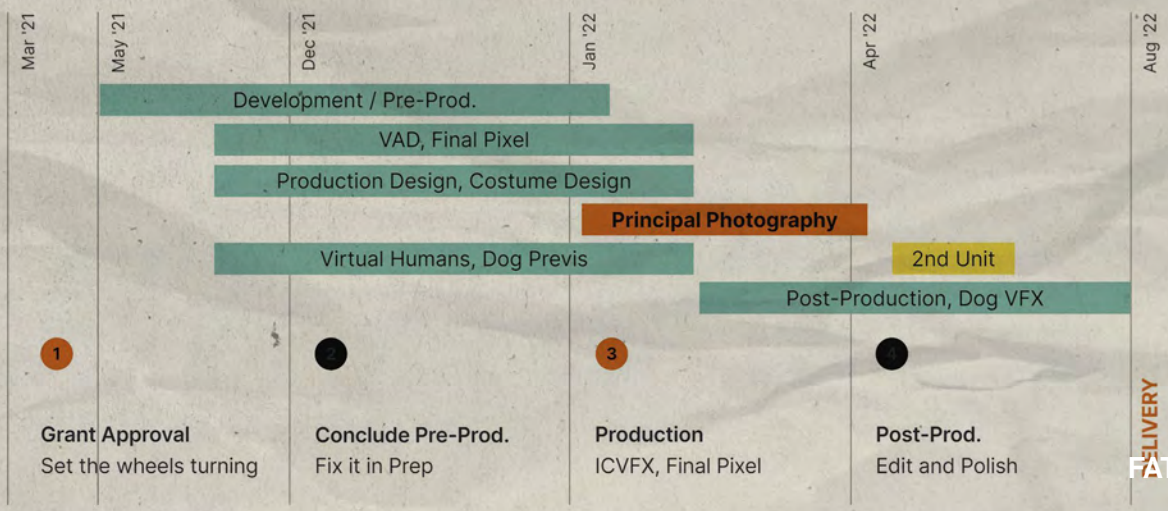
These discussions are codified in a visual format through several tools, starting with storyboards to capture the successive frames that help tell the story through composition, shot progression, and tempo, which are stitched together in an animatic where the storyboards are edited together to identify tempo and timing, in addition to learning more about the interplay of these sequences.

Complex sequences may be further investigated through previs and VCam sessions. The environments used for previs can start with simple gray box layouts that are comprised of primitive geometry without any textures or shaders. The gray box aims to establish the scale of the environment and overall layout that informs the flow of events in the scene. These gray box environments can be used in previs with the Unreal Engine mannequins or low-polygon 3D humanoid models as stand-ins for blocking and staging.

The environments can also be investigated further for accuracy to what may work best at the virtual production volume by placing a 3D mesh of the stage and flying through this space with VR goggles in a virtual scouting session. This session can be used to place props and dress these sets to further inform the action in each scene.

During the VCam sessions, the cameraperson can use a shoulder rig or a gimbal to navigate the camera in the virtual environment to achieve the most effective framing. Motion capture can be utilized in these VCam sessions to drive the digital actors to investigate blocking and staging further, especially for action sequences and complex choreography.

TIMELINE



These processes should be used extensively to address as many queries as possible and solidify the plan so the information transferred to the VAD team is exact. These investigations will ensure that they need little or no adjustments to get them to work at the volume stage on the shoot day(s).

To further confirm its accuracy and adherence to the production needs, the team can use techvis as a way to bring in digital twins of film gear such as a jib arm, a techno crane, Steadicam, dolly, etc., to lay down tracks, estimate the distance and coverage that can be achieved, the time it may take between one set up and the next, etc., and provide these details to the producers and first assistant director to plan the shoot days with trustworthy foresight.

When the gray box environments travel through previs, virtual scouting, and VCam sessions, gathering deep insights from all key stakeholders, and through each iteration, that build can get closer and closer to what could work flawlessly at the LED stage. Those early assets can inform or, even better, get utilized in creating the final pixel delivery, traveling from start to finish, by hugely mitigating redundancies and wastage.

Once the VAD teams start work on the environment builds, the director and department heads are encouraged to dive into the Unreal Project with VR headsets for more virtual scouting sessions during the review process to offer valuable feedback and to improve the look with art direction and prop placements. Using the virtual cameras, the cinematographer and director can perform more VCam investigations to test how well the shots they designed in the earlier sessions with gray box and previs environments still feel like the right approach, and they can make adjustments as needed. Things are still pliable at this stage.

In these VCam and virtual scouting sessions with the VAD teams, it is crucial to involve the virtual production supervisor and the stage team to identify what parameters must be exposed so they can be accessed and altered with the desired degrees of freedom on the shoot day. Anticipating these adjustments and variations that will be required during production is significant.

You cannot expect something to happen on the day that wasn't planned and incorporated into the Unreal Engine project beforehand. Changing the time of day, weather conditions, adding wind, changing materials or color grading sections of the environment, etc., are all functions that may depend on several other factors that, if done haphazardly without planning, will break the project when you least expect it.

Once the VAD builds are almost complete, it's best to start testing them at the stage as early as possible because when you add the tech stack and what the stage is primarily built to serve, certain things may work differently than expected. Identifying these early and applying fixes or workarounds is critical to ensuring an uninterrupted shoot day.

Beyond these test dates at the stage, you should also schedule a tech day and pre-light day. Depending on the complexity of the shoot, maybe just one day, a half day, or a couple of days to rehearse these needs with the technicians at the stage to develop a shorthand between the crew and the LED stage team that helps move the shoot days along at a great clip. ■

PUSHING BOUNDARIES: INNOVATING VIRTUAL PRODUCTION ON FATHEAD

After finishing the prestigious Unreal Fellowship in March 2021, Ben Baker signed on as executive producer of virtual production for the Entertainment Technology Center's ambitious short film, *Fathead*. Working closely with ETC's director for adaptive and virtual production, Erik Weaver, Baker helped guide innovative techniques like integrating digital humans and experimenting with LED walls to mitigate sound issues.

ASSEMBLING SPECIALIZED TALENT FROM THE UNREAL FELLOWSHIP

To achieve *Fathead*'s ambitious goals, Baker knew assembling the right team would be crucial. He drew heavily from the Unreal Fellowship network to build a capable talent pipeline. Baker was confident about the caliber of talent he'd find at the Fellowship, noting, "You're looking at the top visual effects talent in the world funneling through there."

Baker and Weaver presented the project at a Fellowship event that reached around 600 alums plus vendors and companies working with Epic Games. There, the project attracted Tom Thudiyanplackal, who took on the role of virtual production producer. The team handling the ambitious MetaHuman work was assembled through the same network. Baker described how vendors were "amazed that it's not a company. It's a collection of individuals that came together to do this."

IMPLEMENTING NEW TECH LIKE METAHUMANS

Fathead aimed to integrate MetaHumans, Epic Games' tool for creating highly realistic digital humans. As Baker stated, "We aimed to utilize a technology still six months from release."

Since Epic had only provided beta previews of MetaHumans to select users then, leveraging this untested system presented challenges. Baker recalled initial skepticism: "Incorporating MetaHumans before being widely available was likely the biggest technical risk."

Baker anticipated its future influence if executed successfully. He remembered, "We received support even from visual effects powerhouses and Epic Games themselves, who understood the potential impact."

The team handled all aspects of the ambitious MetaHuman work, from body/facial rigging to motion

capture and digital wardrobing. Despite doubts from major vendors, they accomplished the milestone by rendering over 30 MetaHumans simultaneously with fully simulated interactions.

DEVELOPING ENVIRONMENTS & BUILDING COLLABORATION

Baker started in April 2021 by breaking down the script to consolidate locations into distinct environments for building virtual set extensions in Unreal Engine.

He recalled, "In my initial analysis, I outlined 16 different environments featured in the script. In my first pass, I quickly consolidated this down to seven key environments, which proved crucial for building cohesive digital worlds within budget."

Baker brought experience in visual effects and post-production to *Fathead*, having worked on major films like the *Chronicles of Narnia* franchise. He also worked as a post-producer on smaller shows without dedicated visual effects units, where he'd manage 60+ green screen replacements and extensions as needed by getting those lists out and preparing the specs sheet.

This background of managing vendors and coordinating complex VFX productions, coupled with his recent completion of the Unreal Fellowship, where he acquired critical knowledge of virtual production tools and techniques, made him well-suited to spearhead *Fathead*.

To effectively manage this groundbreaking production, Baker established a comprehensive Airtable database covering every facet of the process. With his production experience, he understood the value of organized tracking.

Baker explained, "My background is in post-supervision and post-producing. That is compiling lists. What's the list for today? What's next week's?"

The Airtable system soon evolved into 35 interconnected tables used by the entire crew. "This allowed each department, such as cameras and production design, to contribute their detailed work in an integrated manner," Baker noted. "It served as a model for the communication required in virtual production."

Given the scale and complexity involved, he emphasized that coordinating each contribution was essential: "Virtual production requires immense cross-departmental collaboration."

CROSS-DEPARTMENTAL COLLABORATION

Baker noticed how initial communication gaps attributed to uneven virtual production fluency across the crew. "The director approached it from a traditional camera coverage perspective," he observed, "while our approach focused more on shot planning within the virtual environment."

Partners like The Third Floor helped unify perspectives by emphasizing a camera-centric mindset. Baker summarized, "They stressed the importance of always viewing the scene through the camera lens rather than as independent elements."

He learned that every department's contribution must be coordinated for each shot. He said, "This perspective revealed how production design and other departments needed to coordinate for each shot." Baker prioritized implementing tools and practices that enable clear cross-departmental communication and coordination.

ASSET MANAGEMENT & WORKFLOW

The team utilized Perforce for asset management and version control. Baker stated, "Ihar Heneralau's team at ICVR set up and managed Perforce." He polled Narwhal Studios, The Third Floor, and ICVR about recommendations for where assets should be organized in the project, where they should sit, and how to share and collaborate because it gets rather complex.

Baker explained that mismanaging

assets significantly slows work: "It can gum up your pipeline. Anytime anyone touched the project, if they had to download all assets again, that'd take a couple of hours. When people are ready to work and have to spin their wheels for two hours waiting for all those assets already on their system to download again, that's a nightmare."

Given the complexity of virtual production, organizing assets and workflow was crucial. Baker's priority was implementing tools that enable the team to work efficiently.

VENDOR PARTNERSHIPS

Baker worked extensively with vendor partners who contributed specialized expertise. For example, "partners like The Third Floor helped unify perspectives by emphasizing a camera-centric mindset."

Vendors like Narwhal Studios and AWS provided vital technologies and services. Baker stated, "Organizing assets and workflow was crucial given the complexity of virtual production. Baker's priority was implementing tools enabling the team to work efficiently."

Given the pioneering nature of the production, relying on dedicated partners to provide specialized components was essential. Baker focused on coordinating vendors to ensure the latest virtual production capabilities were available.

Here's a partial list of vendors Baker managed for the production:

- The Third Floor: Look development and previs
- Narwhal Studios: Final pixel environment
- ICVR: Perforce setup and management
- AWS: Cloud-centered technologies and services
- Rochester Institute of Technology: Unreal Engine layout for Ragamuffin Camp
- UME Studios: Unreal Engine layout for Mother's Grassland
- Epic Games: Unreal Engine, MetaHuman Creator tool, and overall guidance

VISUAL DEVELOPMENT & PREVIS/ITERATION

Baker described the visual development process as a collaborative "art of constant iteration" across concept art, previs, tech scouting, etc.

The team received perspective from partners like The Third Floor on lighting virtual environments. "They stressed the importance of always viewing the scene through the camera lens rather than as independent elements," Baker explained. "This perspective revealed how production design and other departments needed to coordinate for each shot."

Partners emphasized keeping the camera fixed and building shots by moving assets. "You don't move the camera at all," noted Baker. "You're just bringing in different pieces of production design and maybe rotating the wall a bit to give you a different background."

This iterative approach enabled prudent planning, so *Fathead* could ultimately be staged completely virtually without conventional effects shots.

VIRTUAL PRODUCTION PIPELINE & LESSONS LEARNED

Baker gained several key insights from managing *Fathead*'s pioneering virtual production pipeline:

- Make decisions early – Constant iteration makes it costly to change course, so lock in environments, assets, and techniques upfront whenever possible.
- Collaboration is crucial – New communication rhythms across departments are needed to align on virtual designs and shots.
- Think in shots – Plan by shots instead of just coverage to meet visual effects complexity.
- Look through the lens – Keep the camera fixed and move modular set pieces to build scenes efficiently.
- Stage strategically – Balance virtual and traditional techniques based on creative needs and budget factors.
- Asset access woes – A connected marketplace for efficiently evaluating assets is needed.
- Expand scale slowly – A limited talent pool versed in virtual production makes scaling difficult.

While complex, Baker proved that ambitious, fully-virtual production is possible. He stated: "Through prudent planning, *Fathead* was staged completely virtually with no conventional effects shots." The project broke new ground in multiple areas and progressed virtual techniques.

INNOVATIONS & INFLUENCE

Baker reflected on *Fathead*'s pioneering innovations that would influence the future of virtual production:

- "It will be truly exciting to see where this technology progresses. I've already seen discussions of holographic displays that could bring visual effects inside virtual volumes."
- "We ultimately manifested 30 MetaHumans on screen, running fully simulated. It was a major milestone, defying skepticism."
- "*Fathead* moved virtual production forward significantly, presaging its expanding role in Hollywood."

Key innovations like digital human workflows and collaborative pipelines proved the extensive possibilities. Baker felt proud of the team's accomplishments: "While challenging, the collaborators believed in the vision, culminating in a successful pioneering production. The project showcased techniques that would shape many future virtual productions."

Fathead produced groundbreaking results and advanced virtual techniques for the industry. Baker is looking forward to seeing how the tools and workflows continue to evolve. ■

introduction:

Erik Weaver & ETC's Role in Filmmaking Innovation

Erik Weaver, the executive producer at ETC, is pivotal in driving innovation in filmmaking through his role at the organization. He said, "[*Fathead*] is our fifth film. I help bring all the resources together and empower these amazing folks." His vision extends to utilizing R&D innovation grants to explore new technologies, ensuring that high-stake, high-budget projects don't bear the risk of untested methods.

R&D INNOVATION GRANT: FOSTERING DIVERSITY & EXCELLENCE

Weaver has been instrumental in founding the R&D Innovation Grant at ETC, focusing on diversifying the film industry. "The grant goes to an individual of diversity who has graduated with a master's from USC film school," he explained. The process involves an award committee and a detailed evaluation of the project and the individual, emphasizing the importance of understanding both aspects equally.

DRIVING FORWARD WITH TECHNOLOGY & BEST PRACTICES

Under Weaver's guidance, ETC has explored new frontiers in virtual production, sound, metadata workflow, and more. Stressing the practical application of these technologies, he said, "Doing an end-to-end virtual production allowed us to see how this rolled out. Were they useful? Did they work on set? What fails? What works?"

ETC's contributions include significant industry standards like Digital Cinema (DCI), Interoperable Master Format (IMF), and the 'C4' SMPTE ST 2114:2017.

VISION FOR THE FUTURE & GENERATIONAL CHANGE IN FILMMAKING

Weaver envisions a transformative era in filmmaking driven by emerging technologies and collaborative processes. He believes we are at a pivotal moment where new cinematic languages will emerge, greatly influenced by virtual production and in-camera visual effects. "We're at that precipice right now... It's absolutely about to explode," he asserted.

COLLABORATION & PLANNING IN EVOLVING PRODUCTION PROCESSES

Highlighting the shift in filmmaking paradigms, Weaver emphasized the increased need for planning and collaboration in virtual production. He contrasts this new approach with traditional methods, highlighting the critical need for discipline and meticulous planning in modern filmmaking.

THE FUTURE PATH OF ETC & ITS IMPACT

Weaver indicated that ETC will continue pushing boundaries, particularly in virtual production and cloud-based workflows. The focus will be on harnessing the potential of emerging technologies and megatrends to revolutionize the industry. Projects like *Fathead* exemplify ETC's commitment to integrating storytelling with cutting-edge technology, laying the foundation for the industry's future. ▪

c. CRAIG PATTERSON

c. Craig Patterson is the writer-director of the innovative short film Fathead, created through the University of Southern California's Innovation in Technology grant program with the Entertainment Technology Center. Patterson is a New Orleans native who studied filmmaking at NYU, Columbia, and USC's prestigious School of Cinematic Arts.

Fathead centers on a young girl's journey through a fantastical junkyard to rescue her kidnapped brother. Patterson describes the story as "a love letter" to his mother, inspired by tales she told of her childhood. He calls the grant funding to make *Fathead* using virtual production "a great out-of-nowhere experience" that allowed him to realize this imaginative world with resources well beyond his indie filmmaking roots.

Patterson expresses immense gratitude for the faith and efforts contributed by the cast, crew, USC classmates, and industry volunteers who made *Fathead* possible. He describes the team as a "scrappy bunch" willing to problem-solve and figure out solutions to manifest his vision.

While Patterson came into *Fathead* with no prior experience in virtual production, he recognized the tremendous learning opportunity the project provided. He eagerly absorbed the expertise of the visual effects veterans, previs artists, game engine wizards, and virtual production trailblazers who surrounded him.

VIRTUAL PRODUCTION VS. TRADITIONAL FILMMAKING

Patterson contrasts his traditional filmmaking methods with the new virtual production workflow he encountered on *Fathead*. Typically, Patterson would have about a month of preparation and rely on shot lists and storyboards to develop a shooting strategy. The filming would then happen in a more freewheeling way on set.

On most of his other work at USC and his professional gigs, he has had a month of prep at most. "You go at 100 miles an hour. You always wish you could have more, but you have to shoot at some point," he commented.

On *Fathead*, that changed. Patterson was introduced to previs and the virtual art department (VAD), where planning became even more critical for every single component of production. The pre-production phase was much more extensive at over seven months. This required knowing intricate details in advance, like the exact size and scale of set pieces.

Patterson describes this as an immersive experience where he couldn't just ask for a pile of tires without precise specifications. He said, "Had it not been for the seven months of pre-production, this production approach would have been re-

strictive and confining." It was an all-around immersive experience in every way for him. He added, "Because I couldn't just say, 'I want a big pile of tires over there.' No, it's like, 'How big is that pile? How far does it go?'"

Patterson compared the shift to virtual filmmaking tools like game engines as monumental as the industry's transition from film to digital cameras. He believes all directors should rapidly gain fluency in virtual production techniques, as they will soon become ubiquitous. Though the learning curve was steep, Patterson remained open and flexible to new workflows needed to bring *Fathead's* imaginative world to life.

LEARNING PROCESS

On *Fathead*, Patterson described himself as "the generalist in the room, who also happened to be leading the charge." He was surrounded by top experts. "I came to this project with no experience in [virtual production] whatsoever," he noted. "I always thought I would be an indie director. Now, I can tell you, it doesn't hurt to have resources." Patterson recognized that he benefited tremendously from being surrounded by experts, which was entirely new for him as an indie filmmaker. He described having to run into many walls and bump a lot of heads along the way.

"I certainly enjoy the indie stuff, but virtual production is really cool too," admitted Patterson. "An open mind and a certain degree of flexibility in the workflow is probably a good thing. If the pipeline is completely rigid, it's going to impede the creative. There has to be a certain ratio."

"Before this, I think the largest team I had was 20 people. We're 209 right now," said Patterson. He described the adjustment as going from working with small teams of fellow scrappers who could come together to make decisions and adjustments on the fly to coordinating and aligning hundreds of people across multiple departments and locations.

However, he felt things just flowed because everybody enjoyed what they were doing, which made it easier over time. Patterson got to share details about the Ragamuffin world and how the Dums use color in certain ways to express something. "It gave mythos to everything," he said.

Once the various departments imbibed these visions, they started imagining and building the world. Patterson described it as "imagination on top of imagination." He appreciated giving people the creative

latitude to play in imagining a world of kids. Patterson suggested they had to think about how children would build their society and what their worlds would be.

"I think it turned out cool," remarked Patterson. "I certainly understand how, if that's not your particular upbringing, it could be a big 'Oh, no!' In the future, to do this again, one of the bigger things will be getting access to either the VCam or the stage a lot sooner," Patterson suggested.

TEAM & COLLABORATION

Patterson surrounded himself with many of his colleagues from USC, who faced obstacles head-on. "We're there to make a movie," he explained, "and we're going to figure out what we need to do to make the movie."

However, Patterson recognized that constantly having team members exit and join due to the prolonged timeline posed challenges. He said this was the first time; he's never finished a project with the same people he started with.

"Generally, as a team sticks through the entire length of a show, communication tends to get smoother and operations less cumbersome. But constant exits due to a prolonged timeline hinder the necessary autonomy in departments for leadership to focus on crucial next steps," he explained.

However, Patterson recognized he benefited tremendously from being surrounded by specialists. "I've never created anything in my life alone. I hope to never create anything in my life alone," Patterson asserted.

Patterson at the volume with the cast of *Fathead*.

STORY & VISION

Patterson explained that he wrote over 26 drafts of the *Fathead* screenplay throughout development and pre-production while remaining committed to maintaining the core story arc and keeping character motivations intact through each revision.

However, Patterson detailed that he did have to relinquish certain visuals and scenes from early drafts that he would have loved to shoot. While the treatment of particular moments changed, he ensured the narrative beats and emotional impact remained consistent. "The new scenes may have a different visual treatment, but the moments are the same," described Patterson.

"I recognize that if we do our job right, this will not be the last time we ever see it," suggested Patterson. He has ambitions to further explore the *Fathead* characters and the world he built around them through future projects. He envisions the story having life beyond just this short film.

Patterson remained open and flexible to making story changes as needed to fit the capabilities of the virtual production tools and pipeline. He recognized that not all ideas conceived on the page may translate seamlessly to the technology in its current iteration. "Virtual production means you better learn to be nimble and do so quickly," advised Patterson. "Things cannot be precious. They have to be useful." He believes this discipline makes one a stronger filmmaker.

Patterson described his collaborative exchanges with different department heads in conveying the vision and emotions of each scene through 25+ drafts. With the production designer, he shared inspirations around happiness and rigidity. For costumes, he explored emotional significances. And with the composer, he focused directly on the core feelings to underscore.

"It was about the raw emotion of the moment — this is how people should feel when this happens," Patterson described conveying to the composer. He clarified that the through-line for the team remained centered on the kids' story and journey. He used this focus as his guidepost in navigating creative choices.

BUDGET & RESOURCES

Patterson described his background as an indie filmmaker accustomed to limited budgets and "scrappy" filmmaking on passion projects with friends. "I always thought I would be an indie director," recalled Patterson. The grant funding and industry donations afforded by the Entertainment Technology Center to support *Fathead* provided Patterson with far greater resources than typically available for his low-budget productions.

He remarked that the level of production design, visual effects artistry, and worldbuilding expertise contributed was well beyond his usual "pay grade" as an indie director. The virtual production technologies enabled a scale of creativity not feasible for Patterson's past DIY films. "It gave me a chance to make Junkyard Paradise 'crazy expansive,'" said Patterson.

"There are no wrong answers here, other than this is the 'world of the story.' Let's keep it inside that world," he described, regarding the expansive creative freedom. The project's experimental nature and prolonged timeline introduced unforeseen constraints.

However, he emphasized that the *Fathead* team worked within considerable budget and time limitations despite the expanded resources available. "They made the absolute best of it. They didn't have a large budget at all," Patterson said, praising his production designer for stretching finances.

While grateful for the opportunity the grant funding afforded, Patterson acknowledged virtual production on the scale of *Fathead* remains far beyond the means of most independent filmmakers. He expressed hope that the technology would become more accessible to lower-budget films over time. "Right now, it can very much help a $100 million film, which probably has the budget to do it elsewhere, but this offers benefits," he added. It's a better palette to use. But budgetarily, not many people can swing it."

Patterson concluded, "It's a bold new world. When you're in a new space, the allies are important."

TECHNOLOGY & TOOLS

The virtual production techniques and tools used to create *Fathead* blew open Patterson's vision for what was possible. The LED volume stage enabled immersive environments far larger and more fantastical than feasible on indie budgets. Patterson described the first time the MetaHuman digital doubles and digitalized scanned actors were projected onto the massive LED screens as a "cool moment in film history" that left the crew in awe. He recognized how special it was to be among the first productions pioneering techniques like virtual humans.

"Those kids — that blew all our minds. That will go down as one of the coolest days in my filmmaking life, period, not just for *Fathead*," said Patterson. Seeing those scanned actors and MetaHumans come alive on the volume walls was a surreal and evocative experience, even though Patterson knew they were digital.

"It was a tiny moment in film history. They know this is not only possible but also more possible than they had hoped to achieve," remarked Patterson on the breakthrough. While his original aspirations for the interactivity and complexity of the MetaHumans had to be scaled back, he remained inspired by the glimpse of the future their use represented.

Patterson found previs to be a vital tool for complex scenes involving multiple departments, helping to literally get everyone on the same page visually. "Right now, we're in the Pong era of previs, or maybe even Super Nintendo," Patterson explained, hoping future tools will be as accessible as dragging and dropping real-world film equipment.

"I remember one of the things we were racking our brains about was getting our teammates, who come from animation, to understand our need for coverage in scenes. Coverage is far less of a consideration when using an animation pipeline — only the specific shot for the specific moment is the goal." He explained, "For instance, let's say our protagonist is in a scene with our villain. Traditionally, we would shoot coverage for that interaction: wide/medium/close shots." On *Fathead*, Patterson said, "We had to make it through around 200 shots in 10 shooting days, using all new technology. Understandably, we didn't have the time to do coverage for every setup."

The approach Patterson and his technicians took is far more intentional — with a higher degree of precision, which "is a great lesson to learn as a filmmaker — distill things down and get to the heart of the matter in as few shots as possible." He noted, "That's a part of virtual production that may be challenging to filmmakers who haven't yet experienced the pressure cooker of shooting on the volume."

Game engines like Unreal enabled Patterson to scout and explore the virtual environments in a way that deeply informed his directorial choices. He hopes all filmmakers gain fluency in navigating these expansive digital worlds. The creative possibilities opened up by real-time rendering of digital scenes directly in-camera represented a dream come true for Patterson. He remarked that tools like the virtual flashlight used on *Fathead* would have been pure science fiction just years ago. He was thrilled to be working at the bleeding edge of what was possible in virtual production. "We used a flashlight, but it wasn't real," said Patterson. "It was a digital flashlight that shined on our digital beast."

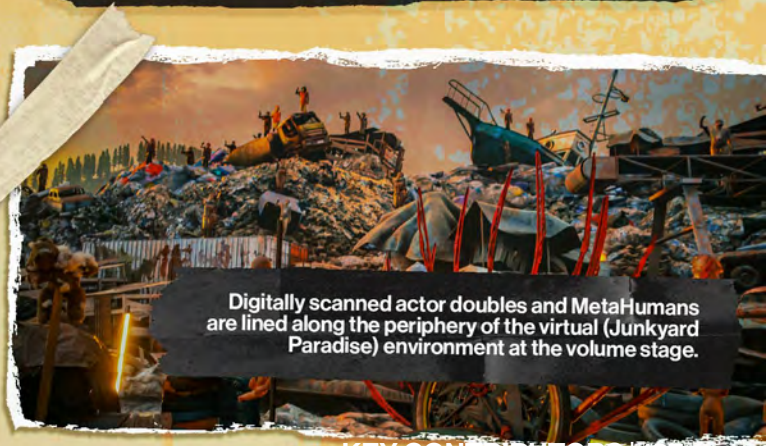
"If you go into your pitch and have a scene or part of the scene done in Unreal Engine, just to show 'this is what I'm thinking visually,' it's nothing but an advantage to you," he added. "I would tell every filmmaker to take benefit of it as quickly as possible because at least you'll be somewhat prepared for what it's like to do this."

CLOSER TO THE REAL THING

Patterson believes the way the volume was utilized to shoot *Fathead* will become the norm. He said, "As it keeps going, they're going to lean away from the way they're currently doing it and more to where we were trying to go with it."

The method presented to him was to pre-conceive his shots and only have sections of the environment designed that cater to those specific shots and angles. Another limitation that was brought to him early on was that he had to shoot in a manner that would avoid the ground plane entirely by sticking to shot choices that were waist-up.

On *Fathead*, Patterson challenged his colleagues to go beyond the prescribed methods and entertain his directorial approach of being able to investigate the environments in every direction to identify where and how some parts of it deliver the extra dimension demanded by the story.



Digitally scanned actor doubles and MetaHumans are lined along the periphery of the virtual (Junkyard Paradise) environment at the volume stage.

PREVIS

Patterson believes previs should be a tool available to all filmmakers when needed, though not every production will require the same level of planning and visualization. "To previs everything would be the wrong approach," he cautioned. "It would mean that we'll have to make it within this scope. And if you give me 10 to 15 percent on either side, that's a world of change you can make within a shot at the moment."

While the *Fathead* team lacked the time and personnel for traditional previs, building the full virtual environments rather than just shots gave Patterson useful flexibility. He embraced the problem-solving creativity required within limitations. Patterson explained the lack of personnel meant the team could not provide the 3D assets needed for the vendor to complete previs. This caused them to be far behind schedule, but Patterson embraced the creativity forced by limitations. "We had a deficit there because it wasn't a thing we knew we had to have," he explained.

However, for scenes involving heavy VFX or complex blocking, he found previs invaluable in getting departments to align around the visual language. It also enabled spontaneity within a defined creative sandbox during shooting.

"In traditional filmmaking, the computer part is at the end, and it wasn't something a director necessarily had to deal with throughout the process," said Patterson. "The fix-it-in-post attitude is now turned to fix-it-in-pre, and I think we're better for it."

POST-PRODUCTION

The real-time rendering capabilities of virtual production signaled a major shift in Patterson's approach, to one focused on precision during pre-production. Patterson described likely needing to rely on some traditional post-production techniques like ADR and digital compositing to supplement the virtual production work. However, he was proud of how much they were able to accomplish in-camera.

While unexpected problems mid-shoot would have been an expected improvisational opportunity shooting traditionally, Patterson noted that virtual production requires rethinking scenes within the established digital parameters.

"You'd better be prepared to pivot. And not pivot and trip, but pivot and continue the race," Patterson suggested regarding the need for adaptable problem-solving.

"We were lucky to get those rusty, broken-up cars — a big shout-out to Cinema Vehicles," said Patterson.

HITTING THE GOALS

Fathead was expected to be a research initiative and a regular film production.

"Hopefully, we achieved both," said Patterson. "The audience will relate to it and have real fun with it, and filmmakers will look at it and say this is a really cool medium to build in. And I think that those things are the grander scale of what the goals were. And on an individual scale, there were very specific things we were testing."

His assessment of several aspects of the different pipelines integrated into the workflow was as follows:

- MetaHumans — "The audience will accept them as kids, so to me, that's a win."
- Virtual environments — "feel real and a part of the story. I think we passed at that, and the environment is going to be eye-catching to people."
- Sound — "I have full faith, after seeing Eric Rigney and Brandyn Johnson and all the work they put in to make that space sound as best it could, I assume that will turn out well, too."

Patterson concluded, "Point by point if we checked every box, we definitely got close. We got data."

IMPORTANT MILESTONES

Patterson listed the milestones along the way that helped the most in moving forward.

- When Virtual Production Producer Tom Thudiyanplackal and the Virtual Humans workgroup led by Pavan Balagam showed him the MetaHumans in action for the first time, Patterson said, "I had never seen anything like that aside from stuff you might see on YouTube."

- Patterson recognized the Scan Truck Day as "a major milestone for us as a team because that was the first time it started to feel very real. That was the first day we ever saw the Ragamuffins."
- When the scanned actors were turned into digital doubles and animated, Patterson said, "Those kids — that blew all our minds. That will go down as one of the coolest days in my filmmaking life, period, not just for *Fathead*."
- Doing the mocap, at the Yahoo Ryot capture volume, was another cool experience for Patterson.
- Patterson and his department heads — including the cinematographer, production designer, producers, executive producers, virtual production supervisor, and virtual production producer — were all welcomed at the ARRI Burbank LED stage to get their feet wet with the technology. He said, "I have such reverence for ARRI as a company, so to be there working on something was fantastic."
- "Stepping on our stage for the first time — I couldn't have dreamt that," said Patterson. "It's a beautiful moment when reality surpasses dreams, and you know your dreams will be better because you are now aware this other thing exists." Comparing it to the behind-the-scenes picture from *The Mandalorian*, Patterson noted, it felt like "being *in* something instead of just looking."
- "The first time, we started doing stunts, and seeing the stunts happen," he noted.
- "The first time they put the environments on the wall, that was insane," said Patterson. "I got a chance to see a team of hundreds of awesome people's work on the wall. It took so long to get to that moment, and right after that, it was like, go to work!"

"Those were some of the many, many highlights." He concluded, "Anytime Erik Weaver had great news for us was a highlight. Anytime executive producer Ben Baker was really happy about something we did, that was a highlight." (*Chuckles*.)

Patterson conferring with his DP Kathryn Boyd-Batstone between takes, and both are double-masked on stage as the production took place as Omicron was on the rise in Los Angeles.

KUDOS TO...

Who are the contributors or touchpoints that you benefited the most from in your filmmaking process on *Fathead*?

"First things first — every single one person and department — everybody had a huge impact on it," said Patterson. "As far as things that stand out, it was awesome to get a chance to build with Mark Reisch (project manager, Rochester Institute of Technology) — that was really fantastic."

Speaking with the Virtual Production Producer Tom Thudiyanplackal, Patterson said, "Obviously working with you is a whole new experience. You're so measured in the way that you take things. It was a pleasure to build with you, and I hope I have the chance to do it many times."

"The entire team at Happy Mushroom was unbelievable," added Patterson. "We haven't spoken in a while, but someone whose approach I'll never forget, no, his advice, is Rainer Gombos [credited as a photogrammetry technician under the Photogrammetry and Lidar department]. What a fantastic filmmaker. He and I definitely had different points of view, but I had so much respect for his candor and ability to say what's what. And he was right 100 percent of the time! A wonderful filmmaker."

"Dan Smiczek [credited as virtual production supervisor, Amazon Studios Virtual Production]. He was such a valuable member of our team," said Patterson.

"Working with DP Kathryn 'Kat' Boyd-Batstone and storyboard and previs artist Nhan Le, we've seen four complete versions of this movie, shot-by-shot," shared Patterson. "They've seen it, cheered for it, wept for it at times. Their relationship to this story is something I'm very grateful for."

Patterson added, "Kat, because she had to approach every version with the same amount of enthusiasm. The whole team did, but it's different when you literally have to help come up with the shots for each day. That's a whole different relationship. Production Designer Miranda Friel and Art Director Samuel Keamy-Minor were beyond beyond," said Patterson. "What they were able to put together so many times. What was asked of them was, from the digital ground up, build a world."

"But everybody I had a chance to work with on this project taught me a lot about filmmaking, and I'm grateful to everyone who took the time to teach me," concluded Patterson. "So, my answer is everyone."

"It may have been nothing for me to change course, but it meant that department by department by department had to change course, and it happened more than I'm guessing most productions have to do," he shared. "It shows the tremendous strength of all of those artisans. Those filmmakers are in my heart forever because what was required of them was nothing short of colossal, and they did it. They really built something that, at least from my perspective, is special." ▪

Producers' Roundtable

Letia Solomon, Mitchell Graham Colley, and Anthony Gaitros were the producers who came on board *Fathead* midway through production to take over after the original producing team had to leave for other work. Solomon had initially pitched the project along with writer-director c. Craig Patterson and was brought on as a co-producer in May 2021. She had been involved since the early stages of securing the ETC grant.

Colley and Gaitros joined the project around September 2021 when reinforcements were needed to get the production back on track. They took on the challenge of dividing up responsibilities and identifying problems to carry *Fathead* through to completion. The project experienced numerous hurdles during production related to relying heavily on volunteer labor, donation of services, limitations of the grant structure, and complex new workflows. The producers played a pivotal role in assessing issues and guiding the production through uncertainty.

TAKING OVER PRODUCTION

Solomon explained that when she first came on board in May 2021, the *Fathead* project already had a website in place and some early previs done by Nhan Le. At that time, the production was still operating on a large scale, with plans for dozens of child actors and ambitious action sequences. As Gaitros described, the original producers Alexa Villarreal and Brandyn Johnson had to depart midway through production when they booked other projects. This left a gap that Solomon helped bridge as part of the "changing of the guard." When Gaitros and Colley joined in September 2021, the situation was precarious. According to Gaitros, the team was "trying to keep ourselves on schedule for something that we didn't quite know what the schedule was." Locations, vendors, and the LED stage had not yet been secured.

Gaitros remembered, "We were in a situation where we were trying to secure VAD vendors and a stage and trying to prop up some previs." The increased demand for virtual production solutions made it challenging to lock down essential elements. Faced with uncertainty about whether to scale down or stay the course, the new producers divided their responsibilities. As Gaitros described, Solomon handled bridging the transition while he and Colley focused on wrangling locations and vendors.

After about a month, the team determined that pushing the schedule to December/January was necessary. According to Gaitros, this "was a huge shift," but it was a pivotal decision to get the derailed production back on track under the new leadership.

NAVIGATING CONSTRAINTS

The *Fathead* production faced unique constraints due to its experimental nature and grant structure. As Gaitros explained, most of the labor came from student volunteers or the producers' professional networks. Services and products were often donated, creating "implied, ambiguous exchanges of value" to navigate.

With no formal budget or monetary commitments, the producers had to creatively "assess and track those different realities," as Gaitros described. The

available volunteer labor also meant relying on "more labor rather than a lot of one person's time," according to Gaitros.

Solomon pointed out the tricky balance of classifying the production – as a USC student film but also a professional one. Adapting to the grant's parameters was challenging. As she said, the team had to "navigate our way through this."

Still, the producers had to focus on delivering a viable final product. As Gaitros put it, their responsibility was providing "a viable working narrative that engages an audience in whatever capacity it is supposed to engage them." This purpose oriented the producers amidst nebulous constraints.

TECHNOLOGY INTEGRATION

The producers had to quickly get up to speed on the complex new tools and workflows required for virtual production. Each vendor had strong convictions about the "right" process, making it hard to navigate competing perspectives, Gaitros explained.

There were cultural discrepancies to bridge between the different partners coming from various industries. Colley noted that the economics and business goals behind the tech, VFX, and film sectors were sometimes at odds. Finding common ground was challenging.

The learning curve was steep, as the producers had to tackle unfamiliar concepts like game engines, virtual scouting, ShotGrid, and more. "Not knowing all those things is very intimidating," Gaitros suggested. An educational primer would have eased this transition.

Solomon agreed that a primer on timelines, workflows, and reasonable expectations would be extremely helpful for future teams. It would allow the focus to stay on innovating and storytelling rather than "exhaustion and uncertainty," as she experienced.

The producers had to quickly assimilate new paradigms. Gaitros said he had to "develop my philosophy around it" on the fly. More defined standards and best practices would help smooth technology integration for future productions.

PREVIS & PRE-PRODUCTION

According to Gaitros, the previs process for *Fathead* involved constant readjustments as new information emerged that altered the scope of the production. He remarked, "If you're learning too much through previs, then it defeats the purpose of doing previs itself." Factors that impact the project should be decided beforehand to maximize previs value.

Colley explained that comprehensive previs and techvis likely would have benefited *Fathead*'s complex scenes. However, he said, "Not having those usual vendors available greatly affected us" by preventing extensive visualization upfront.

Solomon agreed that locking the LED stage and VAD partners sooner would have reduced stress for the team. It also would have better enabled creative optimization of the volume stage through more planning and exploration.

While excessive rigidity in shot planning can limit creative freedom, Colley pointed out that "having some flexibility to adjust and improvise shots during the shoot proved beneficial for *Fathead*'s production needs." Still, he noted that for complex VFX-heavy shots, comprehensive previs remains essential "to have a solid plan in place before shooting."

Overall, Gaitros believed that clearly defining previs parameters and securing essential labor and vendors early is vital for optimizing pre-production on virtual productions. Though it was challenging due to *Fathead*'s reliance on volunteer labor, this would streamline processes for future projects.

PRODUCTION CHALLENGES

The producers had to quickly get up to speed on the complex new tools and workflows required for virtual production. Each vendor had strong convictions about the "right" process, making it hard to navigate competing perspectives, Gaitros explained.

Adapting the directing approach also proved challenging. According to Gaitros, Patterson had to adjust his intimate style with actors to the virtual production environment. More preparation and technical aptitude

would ease this transition for future filmmakers.

Capturing production sound on the reflective LED volume stage surface was another hurdle. Colley acknowledged they addressed sound issues "probably too late at times." Strategic use of sound blankets and flags helped mitigate audio problems.

Despite limitations, Gaitros was impressed that the production sound mixer and cinematographer creatively developed a dual-purpose approach for the sound blankets to also function as flags. Innovative thinking like this helped the team overcome production challenges.

LESSONS LEARNED

The producers gained valuable insights from navigating *Fathead*'s unconventional production. Critical lessons included defining project scope and parameters upfront.

Solomon explained that setting expectations for timeline, budget, locations, and vendors early on would enable better focus on innovation and creativity. "That way, everybody could innovate and make films and do what we love without as much exhaustion," she remarked.

Gaitros stressed the need to shape the story and script to fit defined constraints. Trying to force solutions to fit an unrestricted vision led to wasted efforts. Being realistic about scope early allows smoother sailing.

Due to the reliance on volunteer labor, meticulous planning and communication were essential. As Gaitros put it, with an unstable workforce, "you have to be perceptive" about people's motivations and abilities in order to coordinate effectively.

In retrospect, clearly setting rules and securing key elements early would have smoothed the process. But as Colley noted, some discomfort comes with significant change and growth. The challenges were part of the invaluable learning experience.

CONCLUSION

Despite numerous hurdles, the producers expressed appreciation for the invaluable learning the *Fathead* project provided. As Solomon said, the challenges stretched the team in "wonderful ways."

Key recommendations for smoother future virtual productions included clearly defining scope, securing vendors early, and setting expectations upfront. This would allow more focus on innovation and creativity.

The producers praised the grant for benefiting volunteers and partners with learning opportunities. Solomon suggested that with more structure in place for future projects, participants could leave with better energy and accomplish even more.

Though exhausting at times, the experience provided rare insight into new tools and workflows. As Gaitros said, the demanding trial by fire helped rapidly build critical skills that will be applicable to future work.

In closing, Solomon reiterated that there are "so many things that we've learned from the ups and downs." Despite limitations, the team was proud to have overcome numerous obstacles to complete an ambitious project and push creative boundaries. ▪

EMBRACING THE VIRTUAL WORLD

Miranda Friel's journey as the production designer for *Fathead* marked a significant shift from traditional film production to the avant-garde realm of virtual production. Coming from a background rich in 3D modeling, Friel was at the forefront of this transition. "This is certainly my first virtual production film experience. So, you know, there was a lot of learning curve," Friel explained.

THE CREATIVE PROCESS: BLENDING REAL & VIRTUAL

In *Fathead*, the conventional boundaries of production design were expanded, merging real-world scouting with virtual world-building. Friel's role involved not just designing sets but also conceptualizing entire environments. "We were building a location, and we were building a time of day, and then we were shooting," she said. This approach required her to navigate uncharted territories, translating the director's vision into a seamless physical and virtual reality.

COLLABORATIVE DYNAMICS: ART IN TEAMWORK

One of the most striking aspects of Friel's experience on *Fathead* was the required depth of collaboration. The project called for a synergy of various artistic inputs, challenging her to step back and embrace the ideas of others. "It becomes a little bit of a necessity to relinquish a lot of control," Friel remarked. This new dynamic pushed her to appreciate the value of collective creativity and underscored the importance of flexibility in the creative process.

DESIGNING THROUGH A CHILD'S EYES

Designing from a child's perspective brought unique challenges and opportunities. Friel's task was to see the world from the viewpoint of the young characters, influencing both the physical and virtual aspects of the set. "You're small, you're a child, you're looking up at the world," she recalled, emphasizing how this perspective reshaped the design approach. This strategy enriched the visual storytelling and aligned the set design with the narrative's core.

CHALLENGES IN SOUND INTEGRATION

Integrating sound into the virtual environment proved to be a significant hurdle. The dominance of visual elements often overshadowed the sound quality, creating a challenging puzzle for the sound department. "We certainly gave [the sound department] a bit of a challenging puzzle," Friel acknowledged. This aspect of production highlighted the complex interplay between different departments and the need for balanced solutions.

THE WORLD OF JUNKYARDS: FROM REALITY TO VIRTUALITY

Friel's foray into junkyards for photogrammetry was pivotal in creating the film's virtual backgrounds. Her keen observation of the surroundings played a crucial role in this process. "I was looking at the soil, and I was looking at the texture of objects," she shared. This meticulous attention to detail was essential in translating real-world elements into convincing virtual assets, adding depth and authenticity to the film's environments.

UNIQUE SET PIECES: CREATIVITY IN DETAIL

The design of individual set pieces in *Fathead* was a testament to Friel's creativity and attention to detail. Each set piece was crafted to reflect specific thematic and visual objectives. "We wanted it to feel like it came from that world," Friel stated, discussing one of the sets. These carefully thought-out designs contributed significantly to the film's visual narrative, showcasing Friel's ability to bring abstract concepts to life.

BALANCING VISUALS & PRACTICALITY

The production design process often involved a tug-of-war between achieving visual splendor and accommodating practical constraints. Sound quality frequently had to be weighed against the visual impact. "It ends up being a sort of fight between sound quality and the visual world," Friel said. This ongoing battle highlighted the nuanced decisions that production designers must make, balancing aesthetic vision with functional reality.

CONCLUDING THOUGHTS: LEARNING & GRATITUDE

Reflecting on her experience, Friel expressed deep gratitude for the learning opportunities presented by the project. "It's been an amazing learning experience," she said. Her journey through *Fathead* was a professional milestone and a personal growth experience filled with challenges, collaborations, and innovations. This project, as Friel's experience suggests, was a testament to the evolving landscape of film production, where traditional methods and modern technology converge to create something truly remarkable. ▪

"YOU'RE SMALL, YOU'RE A CHILD, YOU'RE LOOKING UP AT THE WORLD."

MADDI MAYS

Madeleine "Maddi" Mays, a versatile costume designer, has enriched various platforms with her eclectic style. Her career spans television, film, theater, and music videos, contributing to works like Hulu's Dollface and NBC's Bust Down. Beyond costume design, Mays' talents extend to graphic design, as seen in Bust Down's logo, and styling for music videos like "Perfect Peach" and "I'm Hot." Her dual BFAs from the California Institute of the Arts and Santa Fe University of Art and Design underpin her expertise in experience design, production, and costume design. Mays' artistry is deeply rooted in exploring character, identity, and femininity, "creating striking and thought-provoking work."

STEPPING INTO VIRTUAL WORLDS

Mays' venture into *Fathead* marked her first foray into virtual production. She hadn't grasped "the full spectrum of what this was, at first." Her journey into this uncharted territory involved learning new terminology and techniques. Mays said, "While it was challenging at points, I loved the challenge of being able to learn and get through those hoops." Her adaptability shone as she experimented with new materials and programs, navigating the blend of animation and live-action in *Fathead*.

COLLABORATIVE DESIGN PROCESS

In *Fathead*, Mays' collaboration with various departments was key. She worked closely with the production designer and the virtual humans team, holding weekly meetings to synchronize their creative visions. As she ventured into digital costume design, this collaboration was a learning curve for her. "I've never dipped my fingers into that world before," Mays recalled, appreciating the new level of collaboration. Her involvement included creating a swatch of colors and texturing guides for the digital clothing department, ensuring the virtual costumes reflected her artistic vision.

SYMBOLISM & DETAIL IN COSTUMES

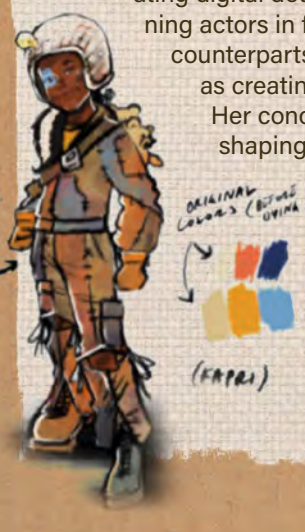
Mays' costume designs in *Fathead* were rich with symbolism and detail. She particularly cherished using the teddy bears as a motif, representing the loss of innocence and the journey of the characters. "This little detail represents these kids and the loss of innocence," Mays explained. The teddy bear theme varied across characters, from Fathead's satchel to the Ruler's coat adorned with the same number of bears as the Ragamuffins, and the Mother's fragmented teddy bear shawl. Each costume element was thoughtfully crafted to add depth to the characters' narratives.

CHALLENGES & INNOVATIONS

One of the significant challenges Mays faced was balancing aesthetics with practical considerations, especially regarding sound. Collaborating with sound expert Eric Rigney, she had to modify her designs to suit the reflective environment of the LED volume stage. For instance, in her original designs, Mays wanted "trash-can lids and pots and pans as helmets" but realized it would be problematic for sound. This led to a more toned-down approach while maintaining individuality and vibrancy in the costumes.

CREATING DIGITAL DOUBLES

A notable aspect of Mays' work on *Fathead* was creating digital doubles. This process involved scanning actors in full costume to generate virtual counterparts. Mays described this experience as creating "weird, uncanny valley things." Her concept art played a crucial role in shaping these virtual characters, combining traditional costume design with digital technology to create a unique, immersive world in *Fathead*. ▪



Kathryn Boyd-Batstone was the director of photography on Fathead. She has worked as a photojournalist and a director, and her diverse work showcases a wide gamut of sensibilities. She won a 2020 DGA Student Film Award in the Best Women Student Filmmakers category. She has an MFA in cinematography and direction from USC's School of Cinematic Arts.

"From the start, I've always loved using visuals, specifically a camera, to tell a story," she explained. "Being behind a camera is a way for me to understand and process the world. I get to challenge myself to see the world from the director's point of view and bring their perspective to life — a welcome challenge to try to grow visually in that sense."

"To me, filmmaking stands on the foundation of trust and collaboration," Boyd-Batstone added, noting that the relationship with the director "is a two-way street — one, them trusting me with their vision, which I don't take lightly because I understand how close a director is to their vision, and two, me trusting in their vision."

HITTING THE GOALS

Boyd-Batstone transitioned out of photojournalism to reach a wider audience as a cinematographer, but she retains those sensibilities in her style and aesthetic. "At its core, what I love about journalism is the genuine and authentic stories it allows the world to experience," she said. "Photojournalism allowed me to connect with so many people in a way where they felt comfortable being vulnerable." She gets to know the actors in order to help them feel that same comfort and perform authentically in front of her camera. She wants the emotions from the scene expressed by the actors to travel through the camera to the audience.

"The goal of photojournalism is to tell a story in a single photo, so as a cinematographer, I try to bring that understanding of light, color, and composition to narrative filmmaking," said Boyd-Batstone. "Even if you weren't listening to the dialogue, you'd know how the character was feeling because of visual cues."

On *Fathead*, Boyd-Batstone chose to open the film with fiery red and orange lighting to visually express the panic and fear of the film's central characters, Fathead and her younger brother Tudaloo, who are being hunted down by a band of Ragamuffins. She ended the film with a beautiful golden hour sunset to express their victorious reunion. In moments of contemplation or decision, she placed the camera close to the actors, so the audience feels the character's inward reflection.

DISCOVERING FATHEAD

Boyd-Batstone started on *Fathead* in May 2021. She felt excited about getting on board early enough to collaborate with writer-director Patterson and storyboard artist Nhan Le, "which was a great experience because I got to truly understand c. Craig's style and intentions." She worked with Patterson and the rest of the team to plan the different environments. What she found to be a bit different "was working in the virtual world when they are creating these environments that would be displayed on the walls."

"We went from having a car chase scene, to a flying stunt, to a blended virtual and practical film," she said. "We found that being adaptable was going to serve us best and helped us identify which filmmaking elements we had control over and which we didn't." She described the film as "a show about a little girl who is not so little at heart. She goes to all lengths to save her brother from the Ragamuffins."

"We weren't sure how much floor of the virtual production we'd be able to see, so we came up with creative ideas for hiding the ground, like having Fathead see Tudaloo being taken from inside a tarp with a hole in it. Narratively, this worked as well because, at that moment, Fathead was feeling trapped and confined in her ability to save her brother," said Boyd-Batstone.

NEW TO SOMETHING

Being her first time on a virtual production project, Boyd-Batstone felt "it was definitely intimidating, but I also felt incredibly supported." She received helpful insights from Dan Smiczek (VP supervisor at the Amazon Studios Virtual Production volume stage) about working with the wall and matching the prac-

POWER WINDOWS OF VARYING STRENGTHS ARE PLACED ON THE CEILING TO CONTROL THE SKY BRIGHTNESS.

J.L. FISHER MODEL 11 DOLLY BEING SET UP ON THE DOLLY TRACK.

tical set to the virtual environment. She reminded herself that "at its core, light is light, and this LED volume was a huge light source." She is confident about her ability to shape light. "After that, the wall became an incredible resource to manipulate light and color to ensure every frame matched exactly how we wanted it," she added.

For example, the sky was overexposed for some of the wide shots, so she used a power window to select only the sky and adjust the color correction of that single area. With help from Smiczek and the volume control team, Boyd-Batstone brought down the highlights and exposure to match the sky color and the production lights, creating an image that blended both the practical and virtual worlds. She said, "Just like that, we had an evenly exposed image."

HOW TO LIGHT INSIDE AN LED VOLUME

Boyd-Batstone recalled, "One of the things that made this production different than anything else I've ever worked on was the amount of pre-lighting and thought that went into pre-production before I even got behind the camera or started setting up any lights. We spent a lot of time crafting the environments."

"We start in this vivid red, fiery environment. There's danger in this 'high stakes' environment," she elaborated. "Then it gets gloomy and cloudy as we enter Mother's environment and the Ragamuffin camp. In the end, they exit a cave. But at its core, it is the same for me — using light to tell how the characters are feeling emotionally." She collaborated with the gaffer, Dawit Adera, to identify what was happening in the environment and how that would affect the actors on stage.

The Ragamuffin camp has a lot of cars placed in a valley with overcast skies. "We tried to amplify what was already going on in the virtual world," said Boyd-Batstone. "What was exciting for me is that I could just say, 'Hey Dan, can you bring down the sky a few stops because it is a little too bright, and I want to add a little bit more contrast?'"

Smiczek carried an iPad that was installed with custom-built dynamic controls using the Web Remote Control feature within Unreal Engine. He was positioned inside the volume, within earshot of Boyd-Batstone and the other key contributors present, to take vital notes, several of which were easily handled using the iPad controls. The rest he would convey via two-way radios to various specialists at the volume control stations situated right outside the mouth of the gigantic volume, and they would quickly engineer solutions.

If some object in the virtual background was unfavorable and was seen to be distracting for the scene, it could be deleted or hidden with a click. "That was exciting to me," said Boyd-Batstone. She is convinced of the benefits of virtual production and the use of LED walls, having considered the implications of bringing a whole production of 100-plus people on set to a cave and working with kids in that setting, which was a scene they captured with relative ease inside

the volume. "We had a scene at sunset, and we could have a full day and a half to shoot at sunset," she said. "I was pleased."

TAMING THE VOLUME

Creating a balance while blending the virtual world with the practical one is where Boyd-Batstone found the answers to what may serve this process best. She said, "Because we are shooting a screen, being able to work with the production designers to add enough depth to the practical environment helps a lot." She felt there's a huge learning curve to figure out what the screen does well. What she learned from the *Fathead* experience is that "it is forgiving, when there's depth in the environment," like vistas that can go on and on, which can be a thing of luxury when you consider the cost involved in creating digital or physical environments at that scale. In the absence of those luxuries, she found "it got a little bit harder to create frames that had that depth when they are just objects right there on the screen."

Another benefit of the screen that Boyd-Batstone noted "was that we could add circles of light." Sometimes that would spread around too much. "But we could add black cards to create a little bit more negative fill. We could do targeted areas where we added a bit more light to create just a tiny bit of backlight or negative fill. That was handy and so quick." Smiczek worked closely with Boyd-Batstone to color correct and get the two worlds to match each other. The color outputted by the production lights and the screen has to be matched accordingly. "Dan was so fast and amazing at doing that. It was great working with him. I felt supported on this project."

Fathead was shot using an ARRI ALEXA Mini LF and the ZEISS Compact Prime CP.3 XD Lenses. Boyd-Batstone also used quarter-density Tiffen Black Pro-Mist and density one Glimmerglass filters to help soften the transition from practical to virtual.

"We had a few scenes with flashlights. It was so beautiful to see them flaring the lenses," Boyd-Batstone said. "Especially in that final scene, when Fathead comes out of the cave and is reunited with her brother Tudaloo — there's a sweet moment where the two of them are just looking at each other. The lenses worked beautifully for that."

UNIQUE USE CASES FROM THE FATHEAD EXPERIENCE

On the set, Boyd-Batstone worked closely with the digital imaging technician (DIT) team as the crew jumped around a lot on scenes, "and they were incredible at pulling things up and making sure everything was matching." The DIT helped with matching the colors for the virtual worlds coming for a screen, which was a new experience for everyone.

The film features a virtual dog. Boyd-Batstone had never worked with live compositing before. They could "frame up and see what the intention behind the VFX was." As a DP, that helped her "frame exactly for what the motion would be."

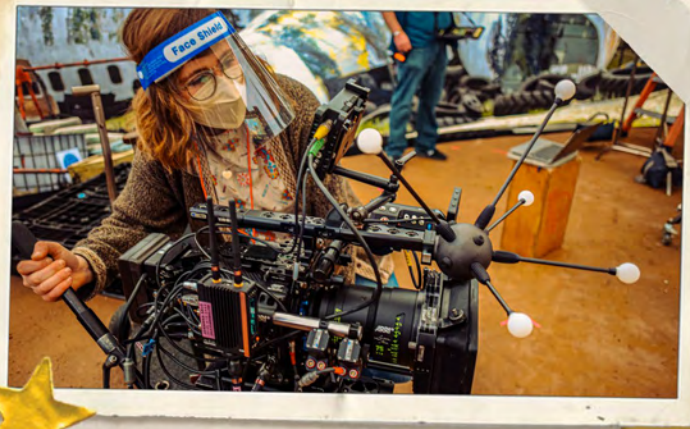
In a scene where the Ruler and Fathead are in a cave, a beast comes out and is about to pounce on them. They shine the flashlight at the beast. Boyd-Batstone said, "You don't want the flashlight to illuminate the LED wall because it just washes it out completely." A motion-tracking puck was placed on the prop that communicated its position in 3D space in conjunction with its coordinates in the Unreal Engine virtual environment displayed on the wall. When it was pointed at the wall, it would light up the environment on the wall, and "we matched its color temperature to the flashlight we were using."

J.L. Fisher, Inc. donated a Model 11 Dolly for *Fathead* that allowed Boyd-Batstone to capture shots with "all these beautiful movements that I matched with the character to help tell the story of how they're feeling down and victorious." The camera movement mimicked those emotions using the dolly.

Passive markers mounted on the ALEXA body were tracked by the OptiTrack cameras positioned all around the top edges of the walls. The physical camera's position in 3D space was relayed to Unreal Engine to mimic these movements with a virtual camera that looked into the virtual world in the exact same manner as its physical counterpart would have observed the environment if it existed in the real world. That image is shown within the inner frustum, which moves on the LED walls to always match exactly where the physical camera is pointed. All of this happens in real time.

CREW MEMBERS STAND IN ON A PRE-LIGHT DAY WHEN BOYD-BATSTONE AND TEAM WORKED CLOSELY WITH THE STAGE TEAM TO SET UP THE PHYSICAL LIGHTS AND CREATE CUSTOM SOLUTIONS TO USE THE WALL EFFECTIVELY AS A LIGHT SOURCE.

HERE, THE TRANSLUCENT BLACK CIRCLE ON THE CEILING WAS USED TO CREATE NEGATIVE FILL.



CINEMATOGRAPHER BOYD-BATSTONE IS SEEN HERE OPERATING THE ARRI ALEXA MINI LF FITTED WITH PASSIVE MARKERS. OPTITRACK CAMERAS LOCATED ALONG THE SEAMS WHERE THE LED WALLS MEET THE CEILING CAPTURE AND RELAY THE POSITION OF THE MARKERS WITHIN 3D SPACE TO A VIRTUAL CAMERA WITHIN UNREAL ENGINE THAT CONTROLS THE INNER FRUSTUM.

Boyd-Batstone said, "We got to see the virtual world and how it would react as the camera moves. The perspective of the virtual environment on the wall also changed and reflected those movements. It helped everything look more realistic." She communicated with Smiczek, who'd relay instructions to his team, and depending on the lens being used, the depth of field or the amount of blur in the virtual world was adjusted to have things feel more real so the solid piece of LED wall in the background disappeared and the virtual environment had the same fall off that would happen if it were there practically.

"We chose the ZEISS Compact Prime CP.3 XD lenses because of the smart technology built into them," Boyd-Batstone explained. The camera and lenses were able to communicate useful metadata. With this information about the lenses and metadata received in real time, the virtual camera in Unreal Engine was not only looking within the virtual environment in the exact direction as its physical counterpart, but now it could mimic the depth of field and all other lens parameters to accurately generate an image within the inner frustum on the LED walls. She observed, "The wall could adjust and create this fall off that would look more natural, like we were in a practical environment versus just trying to focus on a solid LED wall a few feet away from us."

LED VOLUME IMPRESSIONS

"Being able to film at the ASVP volume stage was an incredible opportunity that I would have never imagined," said Boyd-Batstone. "My early impressions of filming *Fathead* were that we might be a little limited in camera movement because of the wall, but being able to shoot at such a large volume with such an incredible team of people was such an eye-opening experience."

She assisted on *Ripple Effect*, the previous installment from ETC that also utilized virtual production when it was all too new. She witnessed how much the technology had changed in just under a year or two.

UNREAL SESSIONS & TEST DAYS

The *Fathead* team relied heavily on storyboards and setting up a virtual camera in Unreal Engine to visualize the shots and forecast how to interact with the wall. "Because things became a sprint to the finish for production filming, we, unfortunately, weren't able to do as much previs; however, because of the nature of the project with so many children, a lot changed on the day," said Boyd-Batstone. "We also utilized a lot of our test days to practically try out our shots and anticipate any issues we might have."

WIDE OPEN EXTERIORS & A CAVE INTERIOR

Fathead featured two wide-open exterior environments (Mother's Grassland and Ragamuffin Camp, aka Junkyard Paradise) and a darkened cave interior. The diverse cast introduced a wide gamut of skin tones, and the sequences happened at different times of day and night, requiring varied lighting scenarios with unique approaches — accomplishing these on an LED volume adds another layer of complexity.

Boyd-Batstone shared her approach to tackling some of these lighting scenarios:

For Ragamuffin Camp, the plan was to try to mimic an overcast day and shape the light with negative fill and small additional soft sources. The spaciousness of the volume and the wrap-around light helped create a daytime feel despite us being inside. I tried to treat that scene as if we were outside and the wall was the sun, so the team just walked in flags and diffusion to create shapes on our actor's faces, and the wall did the rest.

Things were a bit more complicated for the Cave because we wanted the environment to feel very dimly lit but still have enough information to color. I had to balance the light from the LED wall and the practical amount of light so that if we brought down the exposure in post, the wall would still have information and was not too underexposed. After reviewing the test footage, I asked for the wall to be brighter so the detail remained.

For our final environment, Ragamuffin Camp sunset, we recreated Golden Hour. This was my favorite environment because of the warm light and long shadows we could play with. We used our biggest sources of light for this because although the wall wrapped beautiful golden hour light on everyone, we needed additional hard light to mimic the sun and cast warm hair light on our actors.

BOYD-BATSTONE HAD SEVERAL BLOCKS OF CEILING TILES REMOVED TO MAKE ROOM FOR PRODUCTION LIGHTS.

OVERHEAD BY BOYD-BATSTONE FOR ONE OF THE SCENES AT THE MOTHER'S GRASSLAND WITH UNREAL PREVIS FOR SHOT BREAKDOWN.

KEY LEARNINGS TO CARRY FORWARD

Boyd-Batstone shared some key learnings she plans to carry over to her next virtual production venture:

- "I found that the environments that had the most depth to them were the easiest to blend from virtual to practical and looked the most real. Moving forward, when helping craft the virtual environments I want to make sure I push more for lighting that helps have depth to the scene to trick the eye into thinking the world is, in fact, very expansive and doesn't end with the wall."
- "I also want to push myself to find more camera angles. I found that I felt slightly limited by only being able to shoot wides from the opening of the stage behind me, but moving forward, I'd like to push for more world resetting, so we aren't limited to only seeing the world from one 180-degree angle."
- "Learning how to not have light spill onto the screen was definitely a learning curve and made moving lights quickly a bit harder, but once we figured out how to anticipate that, we were able to move fast."

FIVE MILESTONE MOMENTS

1. "The first time we did a read-through with the actors, I felt the story come to life. It was so great to hear the actor's enthusiasm and energy that they brought to the characters. It helped me visually see the world come to life and be able to fully imagine what the world should look like."
2. "When we first went to see the Amazon Studios Virtual Production LED volume, it was an incredible experience. Seeing how large the space was and how real the environments looked on the wall made me realize the possibilities we had with filming."
3. "During one of the test shoots, we practiced a shot where we used a circular track and boomed up on the dolly as Ragamuffins cheered in the background. The screen's parallax movement tracked beautifully, creating an incredibly dynamic shot where the background moved in time with the camera, and the actor faced a pivotal story beat. During that shot, I saw how we could use the wall's features to enhance the story in a way that before would have taken tremendous work for post-production."
4. "There was a moment when we were filming Tudaloo, and the whole stage got quiet. All we could hear was Tudaloo humming. In a studio full of 100-plus people, to have everyone quiet and listening intently to this young boy hum was a magical moment and made me believe in the power of the story to make us all feel."
5. "Filming the final scene of *Fathead* leaving the tunnel was a milestone moment. The shot featured the depth of the environment, Metahumans, and warm golden light that reflected the scene's victorious story beat. From a technical standpoint, it was also exciting because we saw how much we could blend worlds, use Metahumans in real time on the wall, and light for golden hour. Additionally, we filmed this scene for the full day, which meant we had access to golden hour for the full day. As a cinematographer, this was an exciting feat for sure." ■

Scott Squires' INSIGHTS on VIRTUAL PRODUCTION ON FATHEAD

JOURNEY TO VIRTUAL PRODUCTION SUPERVISOR

A blend of opportunity and necessity marked three-time Academy Award-nominated VFX Supervisor Scott Squires' transition to the role of virtual production supervisor. He recalled, "I joined *Fathead* with the intention of consulting, but soon realized the project needed a firm direction in virtual production." His expertise, honed through the Unreal Fellowship and an extensive VFX career, uniquely positioned him for this role. Squires' involvement evolved from consulting to leading the virtual production efforts, driven by his desire to apply the latest methodologies in a real-world setting.

OVERCOMING PRODUCTION CHALLENGES

Faced with a team structure that relied heavily on volunteers, Squires noted the disparity between professional expectations and the reality of production. He reflected, "The challenge wasn't just technical, but logistical. It required juggling various aspects like environment creation and previsualization, often with limited resources." Squires' approach was hands-on, tackling technical and creative issues and showcasing his versatility and commitment to the project's success.

EVOLUTION OF VIRTUAL PRODUCTION TECHNIQUES

Squires observed the incremental evolution of virtual production, relating it to his previous experiences at ILM. "What we see now as groundbreaking in virtual production is built upon years of technological advancements," he explained. His insights draw a parallel between past and present, highlighting how each technological step has opened new creative avenues.

DEALING WITH CONSTRAINTS & VOLUNTEER CONTRIBUTIONS

Squires faced significant challenges due to the project's reliance on volunteer efforts and the absence of a structured schedule. "The key was adaptability," Squires noted, emphasizing the importance of being flexible and responsive to the evolving needs of the production. He also stressed the need for early commitment and structured planning, especially in virtual environments where previsualization plays a crucial role.

ASSET QUALITY & INTEGRATION

When discussing digital asset fidelity, Squires highlighted the importance of quality and resolution in assets used for virtual production. "Every element on the screen must withstand the camera's scrutiny," he explained. This focus on quality was pivotal in ensuring the virtual elements blended seamlessly with the live-action footage.

EFFECTIVE COMMUNCIATION & RESOURCE MANAGEMENT

Squires recognized the challenges posed by fragmented communication and resource management. He emphasized the importance of a centralized system for information and assets, noting that effective leadership is vital to a smooth production process.

IMPORTANCE OF TIME ALLOCATION IN ASSET MANAGEMENT

Discussing the time-intensive nature of asset creation and integration, Squires underscored the importance of allocating sufficient time for these processes. "In virtual production, every second counts," he shared. "We learned the hard way that rushing through asset creation can lead to compromises in quality."

STRUCTURAL ORGANIZATION & WORKFLOW

Drawing from his extensive experience, Squires advocated for a well-defined structure and workflow. "In virtual production, just like in traditional filmmaking, roles need to be clearly defined and structured," he said. This approach ensures that every team member understands their responsibilities and contributes effectively to the production.

PREVISUALIZATION & DESIGNING DIGITAL ENVIRONMENTS

Squires stressed the significance of previsualization in the virtual production process. He explained, "Previs helps visualize the scenes and identify potential issues early in the process." His approach used basic 3D geometry as a foundation, which was refined as the script and creative direction evolved.

INTEGRATING VIRTUAL & PHYSICAL REALMS

Discussing the integration of virtual and physical elements, Squires shared his insights on the importance of thorough testing and preparation. "Blending these two worlds seamlessly is one of the biggest challenges in virtual production," he noted, heightening the need for meticulous preparation and testing to achieve realism.

INNOVATIONS IN VIRTUAL PRODUCTION

Reflecting on the innovations explored during *Fathead*, Squires shared, "We pushed the boundaries of what was possible with current technology." His team experimented with real-time compositing and integrating animated characters, learning valuable lessons about the capabilities and limitations of the technology.

CRITICAL ROLE OF PRE-PRODUCTION

Squires underscored the critical role of pre-production in virtual filmmaking. "Detailed planning in pre-production is not just beneficial, it's essential," he said. This phase sets the foundation for the entire production. He emphasized the need for thorough planning and testing.

FUTURE PROSPECTS & TOOL DEVELOPMENT

In conclusion, Squires expresses interest in developing new tools to address the challenges encountered during *Fathead*. He sees potential for innovation in virtual production tools and methodologies, drawing on his experiences to inform future developments. ▪

Essential Checklist for virtual production

- ☐ **Evaluate Budget and Scene Requirements**: Determine if LED virtual production is feasible for the project.
- ☐ **Include Key Personnel in Pre-Production**: Ensure the director, producers, cinematographer, and production designer are involved.
- ☐ **Allocate Sufficient Time for Environment Building**: Schedule adequate time for building and testing the virtual environment.
- ☐ **Centralize Communication**: Use a single platform for all communication to avoid confusion.
- ☐ **Assign a Dedicated Asset Wrangler**: Have a point person to manage and organize assets.
- ☐ **Conduct Thorough Pre-Shoot Testing**: Ensure seamless blending of virtual and physical elements.
- ☐ **Incorporate Physical Elements on Stage**: Add physical dressing to the stage, including the ground, for realism.
- ☐ **Utilize the LED Wall Effectively**: Use the LED wall for backgrounds that match the ambient lighting and camera perspective.
- ☐ **Prioritize Wide Shots on the LED Wall**: Focus on shots that fully exploit the LED wall's capabilities.
- ☐ **Address Audio Challenges**: Implement sound-absorbing measures to counteract the reflective nature of LED walls.

KOINA FREEMAN

FROM PREVISUALIZATION TO THE SCREEN

Koina Freeman worked on visualization, cinematics, and digital humans on *Fathead*. She came to the project via the Fellowship. When she was working on the Writing in Unreal project for Epic Games at the Tribeca Festival in New York, she met Executive Producer Ben Baker.

Freeman was excited to learn about other Fellowship alums who'd joined the project and the level of commitment and time they'd all put in. She was especially impressed that Scott Squires had volunteered to lead the charge on *Fathead* as the virtual production supervisor. "He's brilliant," she said. "Scott would jump on a Zoom call if you posted a question on Slack."

Freeman enjoys doing visualization work and problem-solving. "The Tribeca experience was a lightbulb moment," she noted, "because as much as I love doing visualization, the idea of taking filmmakers by the hand and showing them how to navigate this world, how to translate the vision through Unreal onto the screen" excites her greatly. She has been teaching filmmaking at a community college for five and a half years, where she has started an XR lab for augmented reality and virtual reality.

STAYING CONNECTED REMOTELY

While Slack was used to exchange information, Perforce was needed for Unreal Engine remote collaboration. However, Freeman and her colleagues had some bumps in getting used to Perforce. She likes the Perforce team. They were on the Slack channel and would respond immediately when problems arose. She remembered, "Scott would ping them immediately, and they would jump right back on." On one occasion, Squires and two other colleagues were up at 10 p.m., West Coast time, for about two hours with Ryan L'Italien from Perforce, who got on the call from the East Coast, three hours ahead of California.

The team used 5th Kind to look at the dailies. She found it helpful because she was in the Bay Area for the early part of the shoot. She drove down for the later part of the production dates. While she was remote, she found that the witness camera kept getting turned away from the stage, which was frustrating because "you want to be right there and see what's going on."

DIGITAL ACTORS FOR BACKGROUND CROWDS

Freeman had worked on some of the previs for scenes involving digital humans. She said, "I did some full cinematics for that using mannequins and MetaHumans." It helped with trouble-shooting and problem-solving, identifying how the digital extras would be placed in the frame compositionally to add value to those frames.

"I was tasked with doing the animations for that scene for the MetaHumans, placing them in the [Unreal] level and making sure that [digital actors] were where they're supposed to be," she explained. "I did a cinematic and animations with blueprints. Erica Penk worked on those blueprints."

Freeman worked from Oakland and Penk was in Atlanta, and Pavan Balagam, who worked on the photogrammetry for scanned actors and optimization of MetaHumans, operated from London. "When we got here on stage, we were supposed to trigger the animations, which didn't work," Freeman said.

In her discussions with Engine Supervisor Jesus "Chui" Munoz, Freeman found that "the blueprint needed to be made a public function so that it can be used in the editor." She explained that the code had to be made visible for the person operating at the stage to open up the code and work with it. That's called a public function. The blueprint was written as a private function.

The other part was that it needed to be made public for multiplayer use because several people needed access. She added, "He had to rewrite the blueprint, making it so that it would function in a multiplayer environment, in a way like a game does — then making the function public so that it could be accessed and executed publicly."

The animations had to run as sequences with multiple different animations stitched together and having some degree of randomness so they could play out for several digital actors in the scene and seem natural. It had to have some offsets as they can't all simultaneously do the same thing.

The digital characters were also meant to be reacting to an event on the physical stage, which is the focal point of the shot. Some characters were sitting down and had to jump up at some point. There were various trigger points for when these characters had to listen in or lean over. At some point, they'd all boo and gesture with a thumbs down or a thumbs up. They'd all cheer. These reaction gestures were all animation sequences versus just a single action.

Freeman pointed out that if these animations didn't trigger at the right time or were out of sync for any reason, regardless of how shallow the depth of field was, we'd still notice it, which would be distracting and jarring for the viewer. She has since spent much time thinking about this problem and how to resolve it. She said, "That's going to come up a lot more because they are the cheapest extras you can find — digital humans in the background, especially in virtual production."

She noted that, at the moment, while the MetaHumans are pleasing to look at, they don't have optimal fidelity of movement "because you go back to your animation principles of silhouettes — movement and poses."

There are many exceptional use cases, from safety to financial. There are a whole lot of reasons for this to work. Tom Thudiyanplackal, the project's virtual production producer, and Executive Producer Erik Weaver pushed this idea and said, "Okay, let's do this." Freeman said, "It sounds like a small thing, but when you look at the economy of scale, of what it means, it's quite a big deal."

She compared it to the first people on the moon or the first one who made it to California in search of gold. She said, "Those are the people that win — the first ones there. That's what matters."

"You have an opportunity to shape the direction," she added. "Think about extras and talent — you're talking economies of scale."

NEW FRONTIERS NEEDING FRESH APPROACHES

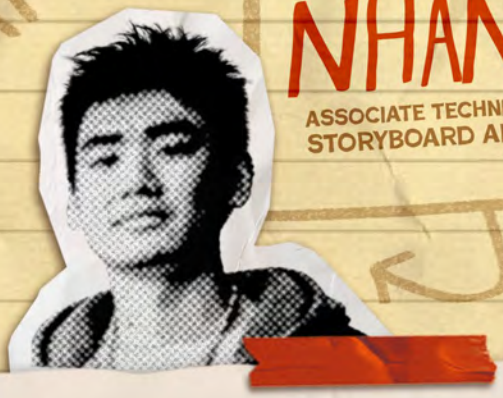
Meanwhile, virtual production stages invest heavily in LED walls, facing the biggest challenge of getting the best talent to operate them. "You don't necessarily need the most experienced person to do the job," Freeman explained. "You need a person who wants to do the job and is willing to sit up and burn the midnight oil to find the answers — curiosity, passion, and commitment to getting the job done."

She wondered, "Where are the experts? Because you could bring in an animator who's done 20 years at Pixar, and they wouldn't be able to resolve this issue." She cited the example of Munoz, who is not a traditionally trained animator but probably started with cinematics for games. He's an Unreal developer and engine supervisor — a blend of creativity and technical expertise. "There was no job title for what he does. They're inventing it," observed Freeman.

She'd never heard of an Engine supervisor before. But now that she'd met Munoz, she feels "he exemplifies that role and is excellent at it." In comparison, she pondered about her journey into virtual production. "I came traditionally from filmmaking and started as a director for *America's Most Wanted*," she reminisced. She gradually moved into "doing XR, augmented reality, and virtual reality in a different game niche."

"I had to teach myself these technologies — to code in C#," said Freeman. "When the [virtual] production Fellowship came along, I jumped at the opportunity because finally, filmmaker and the technology come together."

"I knew game engines, and these technologies have been evolving in that direction," she said. "But it takes a while for them to get close enough that you can bridge the gap." ▪



NHAN LE

ASSOCIATE TECHNICAL DIRECTOR, STORYBOARD ARTIST

INNOVATING THROUGH CHALLENGES

Nhan Le, an associate technical director and storyboard artist for *Fathead*, adapted to his roles with fluidity. Initially, he focused on storyboarding but seamlessly transitioned into 3D previsualization and gray box environment building. Le's journey was marked by constant adaptation to new information from vendors concerning technological constraints, reshaping his responsibilities throughout the project. Le reflected on this process: "With every new challenge, I found a way to incorporate it into my workflow, making me not just a storyboard artist but a more dynamic part of the team."

THE ART OF STORYBOARDING

Le's initial contribution as a storyboard artist was integral to visualizing the evolving narrative. He created hundreds of storyboards, adapting to numerous script revisions and visual changes. This process, although laborious, was vital in providing a visual foundation for the film's development. "Each storyboard was a stepping stone in the evolving story of *Fathead*. It was like painting the first strokes of a much larger canvas," Le stated.

TRANSITION TO 3D PREVISUALIZATION

As the project progressed, Le delved into 3D by building environments in Unreal Engine. His shift from 2D storyboarding to 3D previs was a technical transition and a strategic move to enhance communication and visualization of the film's evolving concept. "Moving into 3D was like opening a new dimension of creativity," Le remarked. "It allowed us to explore the narrative space in ways we couldn't have imagined before."

METAHUMAN INTEGRATION & TESTING

In the later stages, Le contributed to MetaHuman tests, collaborating with specialists like Erica Penk. This phase involved developing blueprints for MetaHumans and integrating motion capture data to refine their performance, showcasing Le's versatility in embracing new technologies. "Working with MetaHumans wasn't just about technology; it was about bringing digital characters to life, making them a real part of our story," said Le.

NAVIGATING THE R&D LANDSCAPE

Le's experience highlights the dynamic nature of film production in the digital age. His role evolved from traditional storyboarding to engaging with cutting-edge virtual production technologies, underscoring the need for continuous learning and adaptation in creative fields. "The landscape of filmmaking is evolving rapidly. Embracing these changes is not just necessary; it's exciting," Le explained.

Le's journey in *Fathead* exemplifies the intersection of creativity and technology in modern filmmaking, where traditional roles often expand to embrace new digital tools and techniques. ■

IN AN ENGAGING CONVERSATION, ICVR CEO **IHAR HENERALAU** OFFERED A VIVID NARRATIVE ON THE EVOLUTION OF VIRTUAL PRODUCTION, ITS INTERSECTION WITH GAMING AND VIRTUAL REALITY, AND THE FUTURE OF FILM PRODUCTION TECHNOLOGY. HENERALAU RECALLED THE EARLY DAYS OF ICVR, WHEN HE CO-FOUNDED THE COMPANY WITH CHRIS SWIATEK IN 2016. "WE WERE WORKING TOGETHER FOR A GAME PUBLISHER," HE SHARED, OUTLINING THEIR INITIAL FORAY INTO BLENDING INTERACTIVE AND NARRATIVE ELEMENTS IN VR.

HENERALAU THEN PIVOTED TO DISCUSS THE TRANSITION FROM GAMING TO FILM PRODUCTION. HE CLARIFIED THAT ICVR'S FOCUS WAS NOT ON FILM PRODUCTION BUT THE TECHNOLOGICAL BACKBONE SUPPORTING IT. "OUR TEAM SPECIALIZES IN ENGINEERING, TOOLING, PIPELINE... EXPANDING INTO THE FILM PRODUCTION BECAUSE THE SAME GAME ENGINE'S BEING USED," HE EXPLAINED.

COMING IN PREPARED

Expanding on the topic of previs and techvis, Heneralau imparted crucial insights reflecting the significance of these processes in modern film production. He keenly observed the common shortcomings in this area, emphasizing the lack of adequate emphasis and preparation. "Not enough importance is given to do previsualization and techvis," he stated, underscoring a prevalent oversight in the industry.

Heneralau elaborated on the practical implications of this neglect, particularly highlighting the challenges faced during shoot days. He described a typical scenario: "It's easy for productions to go into shoot days with the DP, who may be coming in for about one day of testing at the stage." This brief engagement of key personnel, like the director of photography in the previsualization stage, according to Heneralau, often leads to under-preparedness and inefficiency.

"That selection process has continued to evolve," he remarked, pointing out the evolving nature of film production and the increasing reliance on sophisticated previsualization techniques.

Heneralau also drew attention to the disparity between high-end VFX-heavy film production and other types of productions. In his view, the former usually has a very heavy focus on previs, benefiting from a more structured approach to crafting scenes. "They are a specific group of directors and DPs who know how to work with green screen and blue screen," he added, highlighting the specialized skills required in such productions.

REAL-TIME PRODUCTION

In the realm of real-time rendering, Heneralau provided a nuanced perspective on its practical application in film production. He clarified the specific scenarios where real-time engines are most beneficial. "You use real-time engines whenever you need motion or parallax or if you need to achieve a specific shot," he explained, underscoring the strategic use of these technologies tailored to particular needs in filmmaking.

Heneralau further elaborated on the decision-making process involved in choosing real-time rendering. He shared, "It's really about figuring out the combination of these techniques and how best to use them." He shed light on the complexities filmmakers face in integrating real-time rendering with other techniques, like using plates or green screens.

Addressing the limitations of real-time engines, Heneralau pointed out the challenges in achieving photorealism. "Often, you still need to throw a green screen behind the talent," he said, indicating that despite advancements, real-time rendering doesn't always eliminate the need for traditional methods.

He also touched on the constraints imposed by the technology itself, such as shooting angles and ranges, as well as the limitations of the hardware. "You have the limitation of what dimensions can do or what technique you pre-select," he noted, highlighting the necessity for careful planning and selecting the right technology based on the project's requirements.

GET PROPER TRAINING

Regarding education and skill development in the industry, Heneralau stressed the necessity of cross-disciplinary education. "The majority of the virtual production pipeline comes from animation and CG," he pointed out, advocating for a blend of film, TV, and software engineering knowledge.

Heneralau delved deeper into the skills required in today's rapidly evolving film industry. He emphasized the growing importance of software proficiency among traditional creatives. "A lot of people I've spoken to, I think educators especially, didn't understand the necessity of software skills in modern filmmaking," he remarked, shedding light on a gap in the current educational approach. This statement underscores the need for a curriculum that blends artistic vision with technical know-how, preparing professionals for the demands of contemporary production environments.

Furthermore, Heneralau highlighted the practical implications of this skill gap. "A 3D artist today," he noted, "is pretty much forced by the industry to learn Python to optimize workflows." This comment points to the evolving nature of industry roles, where technical skills are becoming indispensable even in traditionally creative positions. Heneralau's observations suggest an industry at a crossroads, where integrating technological skills with artistic talent is essential for success in virtual production.

Heneralau expressed excitement about the advancements in AR extensions and their implications for virtual production. "We already see it with companies using it on small stages, 20 feet wide," he remarked, envisioning a future with more accessible virtual production setups.

He also reflected on the challenge of integrating different departments in film production, observing a gap between on-set crews and visual effects teams, stating, "There is such a massive separation gap... there needs to be cross-education."

Building on this theme, Heneralau underscored the critical role of hands-on experience in mastering these new tools. "The best way to learn is by doing," he said, suggesting that practical exposure is crucial to understanding and effectively utilizing advanced software in production. He stressed the value of immersive learning experiences that go beyond theoretical knowledge, offering insights into the pragmatic aspects of film production.

Heneralau also discussed the future trajectory of skill development in the industry. "We are seeing more and more convergence between different fields," he observed. This convergence necessitates a more holistic approach to education and training, one that equips professionals with a versatile skill set that spans various aspects of film production, from creative storytelling to technical execution. His insights paint a picture of an industry in transition, moving towards a more integrated and multifaceted approach to skill development. ▪

"WE ARE SEEING MORE & MORE CONVERGENCE BETWEEN DIFFERENT FIELDS."

MARK REISCH

VIRTUAL PRODUCTION PROLIFERATION & EDUCATION

Erik Weaver and Ben Baker, the executive producers of *Fathead*, had contacted David Long (director of the MAGIC Center at the Rochester Institute of Technology) because they learned about the Epic MegaGrant received by RIT for virtual production education. Long reached out to the team at RIT that had helped write the grant application, including Mark Reisch, an associate professor at RIT's School of Film and Animation, College of Art and Design.

The original goal was to wrap up in November 2021. Reisch understood that "there's going to be a real quick turnaround." But later, he found out that the project had already been pushed. One of Reisch's recently graduated students on a break, Shanee Gordon, volunteered to help. Soon, Yieyang Ye joined the team. He understood the role involved taking meetings to figure out the tasks and guiding them as part of the VAD team to create the Ragamuffin Camp in Unreal Engine.

A MOVING TARGET IS HARD TO ACHIEVE

Reisch took weekly meetings with Baker, which would end up being two meetings a week at times. Production Designer Miranda Friel, he said, "was a powerhouse getting all those directions for layout and assets." Unreal Artist Nhan Le laid down some quick previs and gray box environments that were "super helpful to have." It conveyed the vision that Friel would present with CAD models she created based on extensive research of images. "We were looking at a reference library on Airtable," he noted. "If something wasn't clear, she would be there."

"The biggest thing I can say is to lock down your story," cautioned Reisch. Getting things into production and having it change throughout is hard to keep up. "It changed three times while we worked on it," he explained. "That became one of the main sources of frustration."

At the start of the project, a few artists were looking at doing different areas of the environment. The junkyard was one of those areas within the Ragamuffin Camp. Another area was a mine shaft entrance. The outside region had the throne seating area. Reisch noted, "As time passed, all of these were combined into one area."

PHOTOGRAMMETRY NEEDS TONS OF POST-PRODUCTION

Some assets were to be created by a photogrammetry team that would be kitbashed in the junkyard. However, the photogrammetry team didn't materialize. "We got the photogrammetry assets, and they were trimmed a bit but needed to be scaled or optimized," he said. "We waited on that for a while."

"The biggest thing for us was that we were suddenly waiting on photogrammetry assets, and there was meant to be

a photogrammetry army that never showed up," Reisch added. He had to do all the scaling and decimating of photogrammetry assets but understood it was necessary.

The problem with some of those assets was surfaces that couldn't be cleaned much, which Reisch felt still worked, as they were placed in a junkyard. He said, "We got away with some of that looking junkyard-ish. It took me a good couple of months to get through everything — doing photogrammetry cleanup, scaling, and everything else."

Many of the cars Reisch worked on ended up in the Junkyard Paradise (a.k.a. Ragamuffin Camp). "At least 90% of the photogrammetry I cleaned up got used in the Ragamuffin Camp," he explained. "There were a couple of extra pieces in the Grassland environment, like the big airplane nose that another team took care of."

VERSION CONTROL FOR MULTI-SITE REMOTE TEAMS

"It was the first time we worked with Perforce," admitted Reisch. "It took some time for us to work through some of those issues. Once we were up, more assets were needed for the layout." The team didn't want to mess something up for others working on the same project further down the line. He added, "One of the problems we had initially that took a bit of time to solve was that we could all open up our projects, and then one day, we couldn't open them up."

He shared that when Epic Games released a new version of Unreal Engine, somebody had upgraded to that version (4.27.2). Everyone else was forced to upgrade as a result of it. "That was a learning curve," Reisch said. "Once you get that at the start, you don't want to make changes that could drag the rest of the team down."

The team developed a decent discipline for checking out and then checking in back to the depot. If a set of assets or levels were checked out by someone for too long and the team needed access to it, they'd get in touch with Ihar Heneralau (CEO, ICVR), who could resolve it remotely. Citing one such event, Reisch mentioned, "One of our team members accidentally checked something out and then had to go away. But we had Ihar. He went in as an administrator and got it working. We only had a few of those problems."

DIVIDE & RULE

One of the cool things Reisch learned on *Fathead* was how to use the streaming levels. He said, "We set our Ragamuffin Camp so each artist had a level they would work on." Ye worked with the backgrounds and would take care of things further away inside the virtual world on the LED wall. What he appreciated most about this method was "having the ability to check out things for that level and not screwing up whatever somebody else is working on."

Initially, the teams were to work based on directions such as east and west. Each artist had to work on either the east or the west side of the camp. But then it was merged. "We broke it up into distances, which worked well," he explained.

Reisch logged in using the Perforce Helix Visual Client (P4V) and opened Unreal Engine. He said, "After that, it was all right-clicking, checking in, and checking out through Unreal." However, he noticed that once he'd closed things out, he still had to push files he'd imagined would go through the Unreal Engine Source Control. "But it was sitting there in a queue," he added. "Then, before I checked out, I pushed that again. That worked out well."

He finds the Perforce interface to be engineer-centric, especially for artists. He'd like to see some visual cues to clarify what happens when a stream is duplicated: How does that affect the rest of the team? What are the ramifications?

Reisch cleaned up the Unreal content browser. Occasionally, moved files were never cleaned up; temporary bits were still left behind. He explained, "The content explorer kept all the stuff that I moved from that area, like ghost empty folders that I couldn't quite get rid of."

Beyond having an established naming convention, Reisch proposed having a directory tree that highlights who's in charge of what — having roles and responsibilities listed. Who do you go to if there's a problem? Who do you escalate things to, going up the chain, to get things fixed?

FINAL PIXEL CONTENT FOR THE LED WALLS

Once these environments were handed over to Narwhal Studios (formerly Happy Mushroom), they achieved final pixel resolution. The set ended up getting changed a lot. Virtual Production Supervisor Scott Squires stepped in to help organize that set. Reisch said, "Big props to him for getting it to where it was." Narwhal added a boat in there and a lot of industrial assets. "It was a cool learning experience to see where they took that and pushed it in a more cinematic direction," noted Reisch. "That's what they do."

"It's hard because we're on shifting sand as we were going through all the story changes. The sets were changing. It took much work for me to go back to my team with what we would make, and in the next meeting, we're changing all that stuff around. That was hard."

Once The Third Floor and Happy Mushroom came in, things tightened, and there were no more changing things around. He explained, "This is what we are locking into for them. It was easier to get in on that. What they did was not easy, but it's easier when it's staying the same."

Reisch pointed out that getting lighting in sooner would have helped his team see the dynamic changes suited for what was visible versus the darkened regions. He said it helps to "visualize that in real-time" in a low-light environment, which is much easier in Unreal Engine 5 with its Nanite virtualized geometry system. "You can throw the whole kitchen sink at it to make it look pretty in a relatively short time."

KNOW THE BOUNDARIES OF NEW TECHNOLOGY

He presented an analogy to explain why learning about the limits of new technologies is vital, especially within academia. Hence, students understand where things are before stepping out into professional scenarios. When he was first exposed to 3D printing, the MakerBot wowed him. But when it came to producing a part to fix a broken-down vacuum cleaner, he realized there were limits to what could be accomplished with the technology. He concluded, "It's not until you see what it is and what it isn't — how much you can get away with? Our students find out what they want to do and what they can do with that." ■

ORIGIN & EVOLUTION OF *FATHEAD*: THE VIRTUAL ART DEPARTMENT'S (VAD'S) PIVOTAL ROLE

Erik Castellanos, with a background enriched by experiences in both gaming and film, played a pivotal role in the creative journey of *Fathead*. His transition from Fox VFX Lab to Happy Mushroom, now known as Narwhal Studios, marked a significant step in his career. At Narwhal Studios, Castellanos and his team were tasked with a challenging yet exhilarating mission: to take the already-established world of *Fathead* and elevate it to new artistic heights.

Castellanos brought a unique perspective to the project. He emphasized the importance of asset fidelity and optimization, crucial skills he honed in the gaming industry. This expertise was instrumental in addressing the challenges of virtual art development, such as creating a 'sea of tires' scene from a virtually blank slate. He used gaming tactics, optimizing for visual diversity while being computationally efficient.

One key element that Castellanos focused on was the bridging of skills between gaming and movies. He believed that the knowledge and techniques acquired in gaming could significantly enhance movie production quality, particularly in creating high-fidelity assets and optimizing them for the best performance.

In his role at Narwhal Studios, Castellanos was not just creating another version of *Fathead* but materializing the director's vision. This involved closely collaborating with the key creative team, including the director and cinematographer, to ensure that every aspect of the virtual environment matched their expectations.

The collaboration extended beyond the Narwhal Studios team to include Production Designer Miranda Friel, who adapted quickly and effectively despite being new to virtual production. She ensured that the base colors of digital assets matched the practical elements and provided essential input for set colors and textures.

The process of creating *Fathead* also highlighted the need for careful planning and execution in virtual production. Castellanos noted the importance of photogrammetry in creating photorealistic recreations of practical sets and the necessity of planning assets well in advance. This foresight allowed for a more seamless integration of digital and practical elements in the final production.

Managing expectations and maintaining a balance between production's creative and technical aspects were crucial. Castellanos discussed the challenges of color matching and fine-tuning between digital and physical elements, emphasizing the importance of getting these elements as close as possible before reaching the stage.

Ultimately, the creation of *Fathead* was a testament to the evolving field of virtual art departments. Castellanos and his small but dedicated team at Narwhal Studios showcased their ability to adapt, innovate, and deliver under tight deadlines, reinforcing the significance of VADs in modern filmmaking.

ERIK CASTELLANOS

Virtual Art Department, Narwhal Studios

WORKFLOW OVERVIEW

1. **Initial Conceptualization and Asset Planning:** Castellanos emphasized the importance of starting with a clear vision and understanding the director's requirements. He mentioned using gaming tactics like building a library of assets for creating diverse yet computationally efficient scenes.
2. **Optimization and Asset Fidelity:** Castellanos highlighted the crucial role of asset optimization for rendering efficiency. "It's really just our job to push it as far as we can in the time allotted," he stated, underscoring the need to balance quality with performance.
3. **Collaboration with Production Designers:** Working with production designers like Miranda Friel was vital. Castellanos praised Friel for her quick adaptation to virtual production, ensuring that digital assets matched the practical elements in color and texture.
4. **Pre-Production Planning:** The pre-production phase involved careful planning of assets and photogrammetry. This phase was critical for ensuring seamless integration of digital and practical elements in the final production.
5. **Color Matching and Fine-Tuning:** Castellanos discussed the challenges of color matching between digital and physical elements under LED lights. This process required fine-tuning to ensure coherence in the final output.
6. **Continuous Feedback and Adjustments:** The process was iterative, with continuous feedback and adjustments based on directorial input. Castellanos highlighted the dynamic nature of this workflow, adapting to the director's vision throughout the project.
7. **Communication and Collaboration Tools:** Utilizing digital communication platforms like Discord was crucial for maintaining team cohesion and facilitating quick problem-solving.
8. **Final Execution and Delivery:** The final stage involved bringing together all elements, ensuring that every aspect of the virtual environment matched the creative vision, and delivering the project within the set timeline.

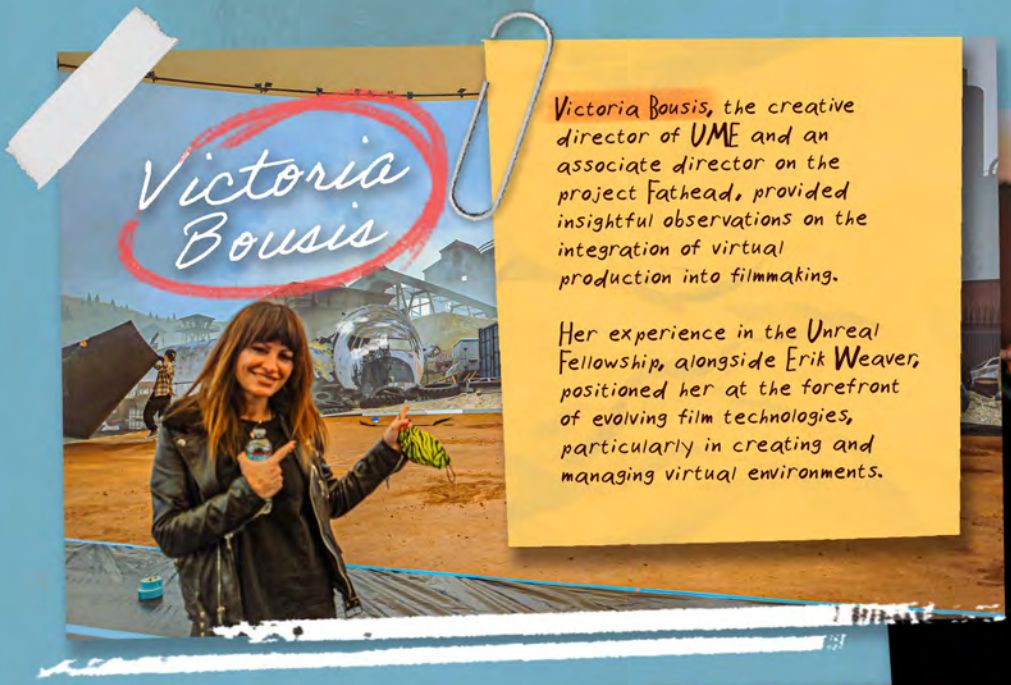
These insights from Castellanos reveal a meticulous and adaptive workflow, balancing creative vision with technical expertise.

CONCLUSION: VISION & INNOVATION IN VIRTUAL ART

In concluding his reflections on the *Fathead* project, Castellanos underscored the dynamic and evolving nature of virtual art departments. He emphasized the importance of a visionary approach, the significance of adapting gaming tactics for film production, and the necessity of bridging skills across different media.

Castellanos highlighted the crucial role of collaborative efforts, particularly in working with production designers and directors to realize a shared creative vision. He stressed the value of meticulous planning in pre-production, the art of fine-tuning visual elements, and the importance of continuous feedback for achieving the highest quality in virtual production. The journey of *Fathead*, as recounted by Castellanos, serves as a testament to the resilience, adaptability, and creative prowess of Narwhal Studios' team. It exemplifies the significant strides in virtual production, where technical expertise meets artistic imagination to create immersive and captivating cinematic experiences.

From Castellanos's perspective, the success of such projects hinges on the seamless integration of various aspects of virtual and practical production, a challenge that he and his team met with enthusiasm and ingenuity. The narrative of *Fathead* is not just about completing a project; it's about setting new benchmarks in the industry and pushing the boundaries of what's possible in the realm of virtual art and filmmaking. ▪



Victoria Bousis, the creative director of UME and an associate director on the project Fathead, provided insightful observations on the integration of virtual production into filmmaking.

Her experience in the Unreal Fellowship, alongside Erik Weaver, positioned her at the forefront of evolving film technologies, particularly in creating and managing virtual environments.

UME Studios/ Grasslands VAD Build

BRIDGING VIRTUAL & PHYSICAL WORLDS

Bousis discussed the challenges of transforming a screenplay's concept into tangible visual environments. She illustrated the task of converting a "junkyard paradise" into distinct areas, including Mother's Camp, Grasslands, Ragamuffins, and the Cave. This task required a meticulous bridging of virtual and physical realms to create believable, immersive settings on the screen. Bousis's role involved conceptualizing these environments in a way that both resonated with the script and leveraged the possibilities of virtual production.

CRAFTING REALISTIC VIRTUAL ENVIRONMENTS

A significant part of Bousis's work entailed replicating natural decay and human influence in the virtual junkyard, ensuring assets appeared organically placed and weathered by time. This process involved detailed texturing and creating environments that reflected the characteristics of their inhabitants – from the innocence of the Grasslands to the roughness of the Ragamuffin area. This nuanced approach to virtual set design was critical in bringing depth and realism to the film's visual storytelling.

ADVANTAGES OF VIRTUAL PRODUCTION

Bousis emphasized the stark contrast between traditional green screen methods and the advanced virtual production used in *Fathead*. She highlighted the benefits of real-time environmental interaction for actors, the efficiency of capturing multiple shots, and the seamless integration of virtual and physical elements. This approach enhanced the actors' performances by providing tangible settings and streamlined the filmmaking process, allowing for more creative flexibility and rapid adjustments.

PIONEERING WITH METAHUMANS

In a bold creative decision, the team utilized Epic Games' MetaHumans to portray the Ragamuffin camp's inhabitants. This choice addressed the logistical challenge of populating scenes with a large number of characters while maintaining production design integrity. The use of MetaHumans – sophisticated virtual humans – contributed to the film's realism and narrative depth, marking a significant advancement in blending technology with storytelling.

Bousis's role in *Fathead* exemplifies the innovative spirit driving modern filmmaking. Her insights reveal a deep understanding of virtual production's capabilities and challenges, showcasing her pivotal role in crafting a visually compelling and technologically groundbreaking film. ▪

BECCA SUN-HEE HAN

1ST ASSISTANT DIRECTOR

Becca Suh-Hee Han, as the first assistant director on *Fathead*, faced the intricate task of balancing narrative integrity with the advanced technical elements integral to virtual production. This challenge was about managing schedules and logistics and ensuring that the director's creative vision was effectively realized within the technical confines of virtual filmmaking.

c. Craig Patterson, the writer-director of *Fathead*, played a significant role in shaping this balance. His vision for the film was ambitious, blending imaginative storytelling with the innovative possibilities of virtual production techniques. Han's responsibility was translating Patterson's conceptual ideas into practical, executable plans on set, a task requiring creative insight and technical understanding.

Reflecting on this experience, Han noted the complexity of bringing Patterson's vision to life. "We kind of look at c. Craig's vision. And this is how he envisions it, and then putting it up on its feet," she observed. This process involved a constant interplay between the director's artistic aspirations and the realities of virtual production technology.

Han's role was crucial in navigating these dynamics, ensuring that the story remained the central focus even as the team pushed the boundaries of what was technically possible. Her insights and decisions were instrumental in melding *Fathead*'s artistic and technological aspects, creating a cohesive and compelling narrative that remained true to Patterson's original vision.

In managing the collaborative dynamics on the set of *Fathead*, Han navigated the complexities of integrating virtual elements into the production. This integration included coordinating with remote teams and ensuring that the on-site crew's actions were harmoniously aligned with the virtual production team's inputs. She encapsulated this thought: "It's like the same workflow, I would just say, just a few more boxes along the way to check every time."

The virtual production of *Fathead* not only challenged traditional filmmaking norms but opened up a realm of creative possibilities. Han saw this as a significant shift, noting, "I do think there's a lot you can do that wasn't possible before." This sentiment reflected the expanded creative scope made possible by the virtual environments.

One of the unique challenges Han faced was managing sound within the virtual production environment. The balance between sound quality and the visual and lighting requirements of virtual spaces presented a complex scenario. She successfully navigated these challenges, acknowledging the difficulty and accomplishment: "It was not the easiest challenge we've had, but we made it to the end."

Looking towards future projects after her experience on *Fathead*, Han's perspective on filmmaking has been significantly shaped by the challenges and opportunities of virtual production. Her successful navigation through the complex blend of traditional and virtual filmmaking methodologies has equipped her with valuable insights and skills that will likely influence her approach in upcoming endeavors.

With the knowledge gained from *Fathead*, Han is poised to bring a forward-thinking approach to future productions, potentially exploring further the possibilities of virtual technology in storytelling. Her experience in managing the unique demands of virtual production, from intricate sound challenges to the integration of advanced technical elements, positions her to be an innovator in the evolving filmmaking landscape. ■

PHOTOGRAMMETRY SET SCANNING: PRESERVING THE PHYSICAL PRODUCTION DESIGN FOR THE RAGAMUFFIN CAMP

In an illuminating discussion about *Fathead*, the speakers delved into the intricate world of photogrammetry, exploring its applications, challenges, and future in various fields. With his geography and urban planning background, Kurt Wyatt was fascinated with photogrammetry's potential for historical preservation and spatial interaction. He pondered digital asset ownership's philosophical and ethical implications, stating, "It is a huge philosophical question...What does it mean to own the maple tree in the physical world inside of your film?"

Kaisey McCallion, from an animation perspective, highlighted the accessibility of photogrammetry. McCallion noted its ease of use even with basic equipment, emphasizing its significance in quickly developing layouts and designs: "As long as you have a camera...the software is free. It makes it very accessible." They also discussed the democratization of media production through photogrammetry, observing how it breaks traditional hierarchical structures, allowing for a more dynamic and synergistic workflow.

Nate Fairchild, approaching from a filmmaker's standpoint, spoke about the transition from 360 video to photogrammetry in VR. He emphasized the allure of photorealism in filmmaking and the technical challenges encountered in outdoor captures and reflective surfaces.

The group also discussed the implications of photogrammetry in the metaverse and VR, discussing the limitations posed by computing power and broadband accessibility. Wyatt observed that while the concept is exciting, the reality is hindered by technical bottlenecks, stating, "We can't access them from like a 3080 or a 3090 graphics card and like Google Fiber backbone to your home."

Reflecting on their experiences with the *Fathead* project, the speakers discussed the practical challenges in asset capture and the comparative study of photogrammetry and LIDAR technologies. McCallion shared insights into the decision-making process during asset capture, emphasizing the importance of understanding project goals and the potential for increased pixel density in individual asset capture.

Overall, the conversation with Wyatt, McCallion, and Fairchild offered a rich exploration of photogrammetry's growing role across various disciplines, its potential to revolutionize traditional media production processes, and the evolving ethical and technical questions it poses. ▪

Tom Thudiyanplackal, the virtual production producer of *Fathead*, streamlined the virtual human pipeline, among other things. "We were lucky to get a great team to help us out with the different features of this pipeline," he said.

"I had just completed the Unreal Fellowship for virtual production," he noted. Executive Producer Erik Weaver is also a Fellowship alum, and he'd posted on the Fellowship Slack channel about "a wonderful short film to explore several aspects of virtual production."

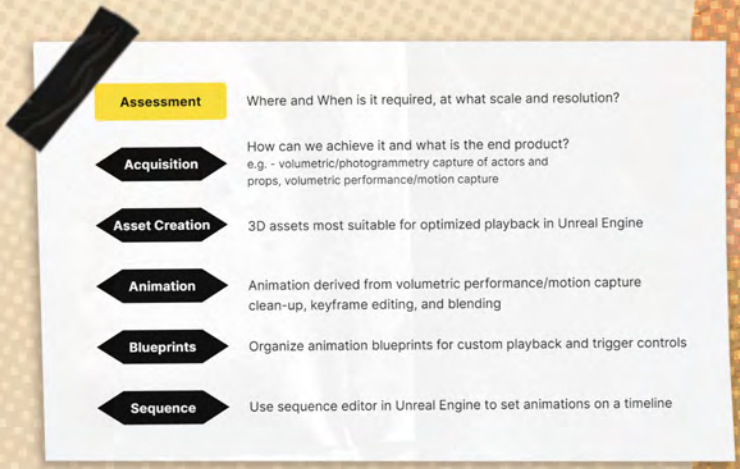
Thudiyanplackal saw an innovation-driven, experimental virtual production short as an obvious next step to the Fellowship. He responded to Weaver's post. "It'll be like a Fellowship, 2.0," he said. "Let me jump on board and see where I can fill some spots."

The movie needed virtual humans to fill the Junkyard Paradise with a Ragamuffin Army. At the time, it was a feat that hadn't been achieved yet.

DIGITAL EXTRAS FOR THE VIRTUAL ENVIRONMENT

It's a large junkyard with rogue kids running a militia to defend their ideology for how they want to run the place. "It naturally needed an army of scale, which couldn't be had in a COVID environment," explained Thudiyanplackal. "A set with 30-plus kids running around wasn't going to happen."

Digital extras would be needed to create that reality. "We looked at what MetaHumans could do within Unreal Engine," he said. "We also wanted to explore what else could be done in the space." Actors from the supporting cast were given a new look designed by Costume Designer Maddi Mays. Then at The Scan Truck, these background characters were scanned volumetrically to create their digital doubles.



"The whole process has to start with an understanding of where and why these digital humans will be required and how do they serve the story," said Thudiyanplackal. The next set of questions should be about how much they contribute to the scene in terms of performance. How close are they to the camera? Do the details matter or are they far enough to not need as much definition? These answers will be valuable in estimating the right method for creation or acquisition of the physical assets and animation data. The degree of effort required to finesse until the desired output is delivered will also depend on those responses. "What the camera sees should always be your point of reference," Thudiyanplackal concluded.

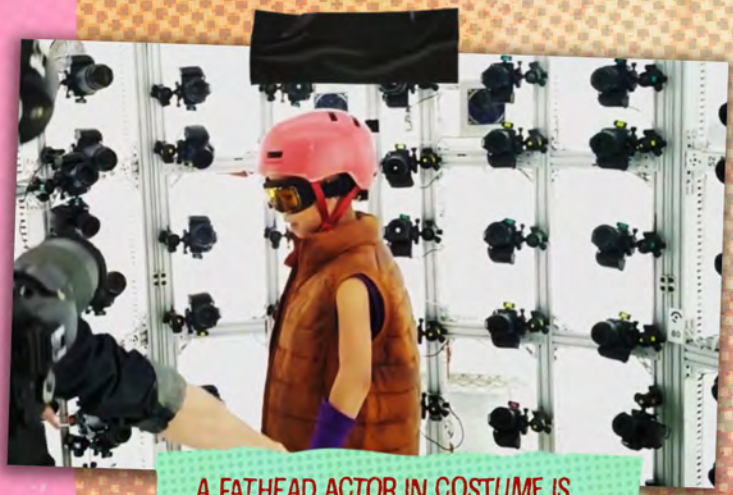
PHOTOGRAMMETRY

Using photogrammetry to capture humans poses a challenge compared to still life objects. "You cannot grab hundreds of images manually from every angle and position around a person without them moving," Thudiyanplackal said. To solve this issue, the team used **The Scan Truck**, a volumetric scanning studio that sits on a truck, just as the name suggests. It was engineered by CEO Jiggs Love and CTO Vladimir Galat and consists of 210 DSLR cameras assembled on a grid, each connected to a tiny Raspberry Pi computer for synchronizing image capture at the precise moment.

METAHUMAN 1.0.0 EARLY ACCESS WAS RELEASED IN APRIL 2021 BY EPIC GAMES.

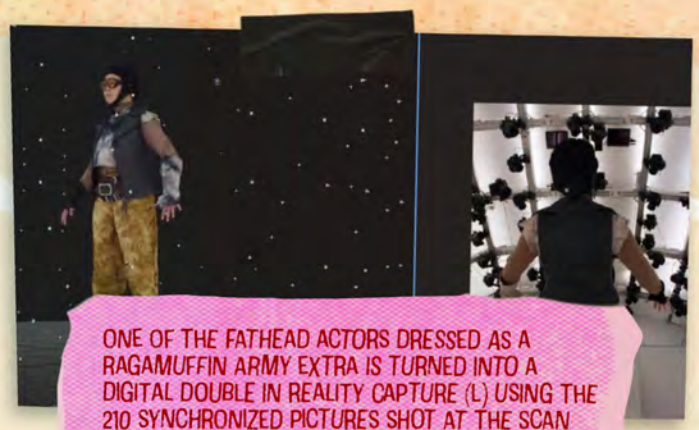
Reality Capture was used to generate 3D models and textures from the captured images. The 3D mesh must first be cleaned up and **retopologized** to reduce the number of polygons to simplify the geometry. The original textures can then be **reprojected** onto the finished model. The model is thus readied for **rigging and skinning** to prepare it to apply the animations.

Animation retargeting is a method employed to use animation data across multiple characters of varying proportions to ensure that they are mapped accurately to the skeletal data for the desired outcome. If the bone names differ from the original skeletal configuration used in the animation, then the retargeting process allows us to map the bones between the differing configurations to build an accurate correlation.



A FATHEAD ACTOR IN COSTUME IS GETTING READY TO BE CAPTURED VOLUMETRICALLY INSIDE THE SCAN TRUCK CAMERA BOOTH.

COSTUME DESIGNER MADDI MAYS CREATED A COLOR SWATCH & BRUSH, TEXTURE, & DIRT REFERENCE LIBRARY TO CUSTOMIZE THE METAHUMAN DIGITAL CLOTHING TO FIT INTO THE WORLD OF FATHEAD.



ONE OF THE FATHEAD ACTORS DRESSED AS A RAGAMUFFIN ARMY EXTRA IS TURNED INTO A DIGITAL DOUBLE IN REALITY CAPTURE (L) USING THE 210 SYNCHRONIZED PICTURES SHOT AT THE SCAN TRUCK INSIDE THE CUSTOM-BUILT BOOTH (R).

NHAN LE USED THE APP PROCREATE ON AN IPAD TO CUSTOMIZE THE METAHUMAN PULLOVERS (L) THAT DID NOT FIT THE THEME & WORLD OF FATHEAD, BUT IT SHOWED US WHAT WAS POSSIBLE. USING THE COLOR SWATCH & BRUSH, TEXTURE, & DIRT REFERENCE LIBRARY PROVIDED BY THE COSTUME DESIGNER HE CREATED MORE APPROPRIATE VERSIONS (R).

GAINING ACCESS TO A WEALTH OF KNOWLEDGE FROM TOP PROFESSIONALS IN THE FIELD WITH EXPERTISE IN SPECIFIC ASPECTS OF THE PIPELINE WAS ONE OF THE MOST BENEFICIAL ASPECTS OF THE PROJECT AT ETC.

BRAIN TRUST

Cory Strassburger	Niall Hendry
David Breaux	Jack Broome
Addy Ghani	Jiggs Love
Jet Olaño	Vlad Galat
Benjamin Roffee	Roch Nakajima
Kourosh Pirnazar	James Croak
Rebecca Perry	Daniele Federico

DIGITAL CLOTHING

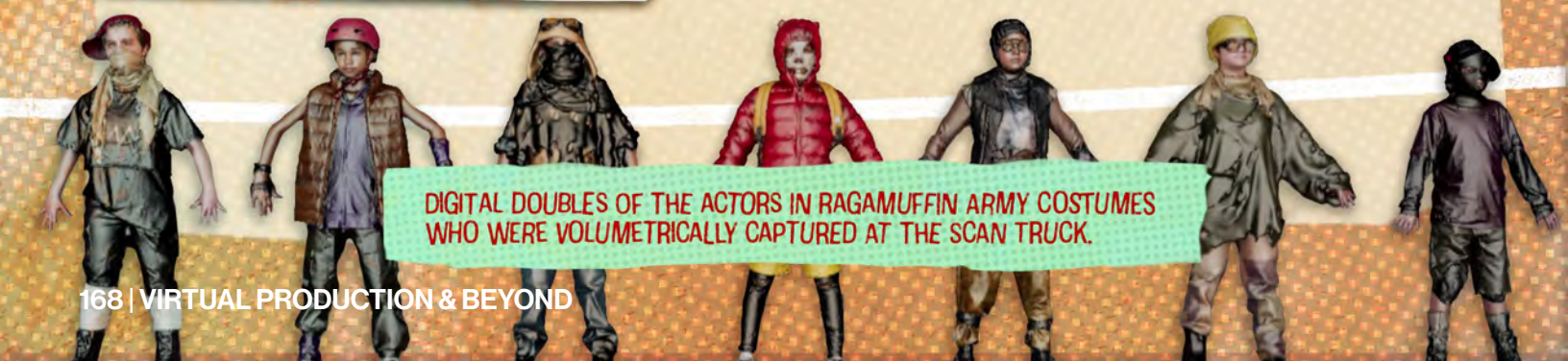
"Loose clothing and face coverings posed a challenge for rigging the 3D models accurately," Thudiyanplackal noted. "It took much work to isolate the triangles and map them correctly to the bones that caused undesired stretching or deformation of the geometry once the animation data was applied."

According to Thudiyanplackal, actors should be captured in "body-hugging, tight-fitting clothing without loose or open fabric or materials dangling freely. Getting clean geometry around the joints will improve the results."

Thudiyanplackal also noted that ideally, clothing should be added separately in 3D with the benefits of real-time cloth simulation in Unreal Engine. However, the team found that the intense processing requirements of simulating 3D clothing in real time on LED walls made this approach unfeasible. "We tried out 3D clothing software, such as Marvelous Designer and triMirror uDraper, but had to stick to the scanned digital actors and MetaHuman models because of the intense processing requirements," he said.

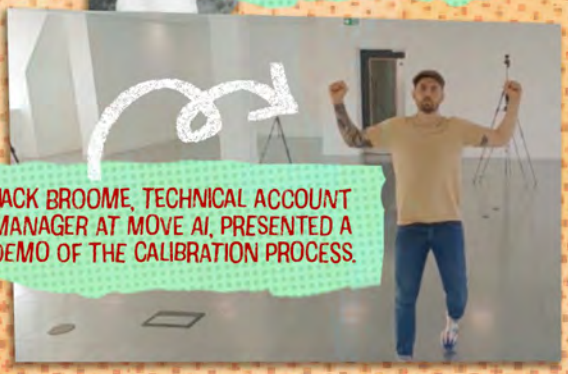
MOTION CAPTURE

"We used a new technology called Move AI to get the animation data," said Thudiyanplackal. It is a markerless, suitless motion capture system. For this use case, eight Sony RX0 II action cameras were positioned in a circle with up to five actors performing in the center. "Not having to use suits, gloves, or bands that actors would exchange



DIGITAL DOUBLES OF THE ACTORS IN RAGAMUFFIN ARMY COSTUMES WHO WERE VOLUMETRICALLY CAPTURED AT THE SCAN TRUCK.

THE MOVE AI ANIMATION DATA IS TARGETED ON A 3D MODEL TO PREVIEW THE QUALITY OF THE PROCESSED DATA.



JACK BROOME, TECHNICAL ACCOUNT MANAGER AT MOVE AI, PRESENTED A DEMO OF THE CALIBRATION PROCESS.

ADDITIONAL MOTION CAPTURE DATA WAS GATHERED USING THE PERCEPTION NEURON STUDIO INERTIAL TRACKERS & GLOVES AT NOITOM STUDIOS.

PHYSICAL COSTUMES WERE MIXED & MATCHED TO CREATE LOOKS DESIGNED BY COSTUME DESIGNER MADDI MAYS & VOLUMETRICALLY SCANNED BY PERIS DIGITAL IN MADRID, SPAIN.

made working with the new system the preferred method due to the ongoing COVID restrictions at the time of pre-production," he explained.

To animate the virtual humans in a way that followed how the scene played out during production, the team used animation blueprints and relied on code to control the animation data. "We had to follow the director and time the actions to match the real actors on stage," Thudiyanplackal said. Between takes, Patterson would reset the actors and let the camera roll for multiple takes back-to-back. "That required us to rely on code to control the animation data supplied to the digital characters so they could also be reset and brought back to start specific actions on command each time," he explained.

The team found novel ways to achieve their goals in this pipeline, using a combination of real-world costumes, 3D scanning, and advanced animation techniques.

VIRTUAL HUMANS WORKGROUP

"The Unreal Fellowship became a great tool for us to find the talent needed to make this possible," Thudiyanplackal said. The team started with Pavan Balagam, who served as the supervisor of the virtual humans' workgroup. Erica Penk, an instructor for animation blueprints in the Fellowship, also contributed her time and expertise. "She comes from a gaming background that uses a different coding approach," he clarified. "We had to investigate how to get the code to line up with how a film production operates on stage."

Balagam is an Unreal fellow and serves as a teaching assistant and an instructor for the fellowships. As the virtual humans' supervisor and lead artist, he was responsible for the photogrammetry of the volumetric scans of actors that required retopology, cleaner textures, rigging, animation retargeting, custom clothing, and crowd simulations. He has over 25 years of experience in VFX for films and commercials and has worked with major visual effects studios, including Cinesite, Moving Picture Company, The Mill, Rhythm & Hues Studios, and others.

Penk is an Unreal Authorized Instructor with a background in motion capture and voice acting. She has worked in digital media since 2012 with companies such as Trick 3D, WarnerMedia, and Profile Studios. On *Fathead*, Penk designed custom animation blueprints for the digital actors on the LED wall to play specific animations that had to be triggered in conjunction with the actions performed by the live actors on stage.

PAVAN BALAGAM
TA at Epic Games UNREAL Fellowship
Founder, VFX Sup. - Tattva/ Elements VFX
London, England, United Kingdom

Virtual Humans Supervisor

ERICA PENK
Unreal Authorized Instructor, Storyteller, Actor
Dacula, Georgia, United States

Virtual Humans Animator
(Blueprints)

PAVAN BALAGAM AND ERICA PENK WORKED REMOTELY THROUGH PRE-PRODUCTION & PRODUCTION FROM LONDON, UNITED KINGDOM, & ATLANTA, GEORGIA, USA, RESPECTIVELY.

L TO R: VIRTUAL HUMANS' TEAM MEMBERS NHAN LE, REBECCA PERRY, KOINA FREEMAN, & TOM THUDIYANPLACKAL POSED WITH THE DIGITAL EXTRAS IN THE BACKGROUND AT THE AMAZON STUDIOS VIRTUAL PRODUCTION LED VOLUME STAGE AFTER PRODUCTION WRAPPED ON FATHEAD.

Rebecca Perry, an administrator at the Fellowship, joined the team as a volunteer. "She was influential in bringing on many of these wonderful people who helped us from the Fellowship," Thudiyanplackal said. Nhan Le had been involved in the film from the pitch phase and helped design the pitch materials and various aspects of pre-production. He also worked on texturing the MetaHuman clothing and organized the shot breakdown for the virtual humans based on Patterson's directions.

Koina Freemen, an Unreal fellow, and mentor at the Tribeca 'Writing in Unreal' program, also contributed to the previs for some key shots featuring virtual humans. "Big kudos to this team," Thudiyanplackal said. "Without them, none of it would have been possible."

"The processes involved are intricate and bespoke, which requires a lot of experimentation to identify the right mix and combinations of tools and methods to achieve specific results. You must plan in advance for any aspect of virtual production, and that is just amplified with the virtual humans' pipeline," said Thudiyanplackal. "There are several moving parts, and critically, having these digital doubles blend in and mirror the realism of the physical actors is something that will need special attention to engineer the nuances that we associate with humanness."

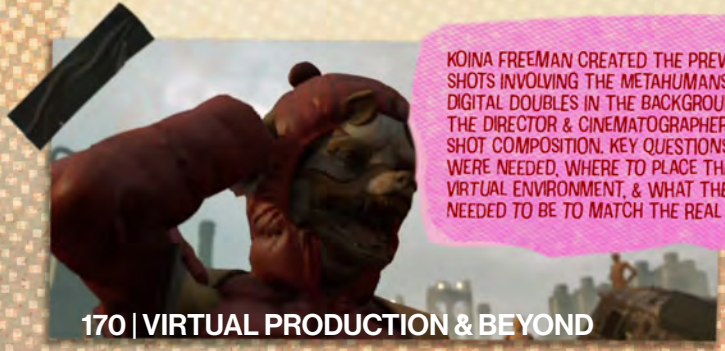
Thudiyanplackal added, "The technology in this space is rapidly improving and newer tools that can do more and get it done better are always coming around, so it's hard to establish a baseline and stick to it. The search is constant, for that next best thing to achieve something that offers the audience a new experience." On *Fathead*, just within the virtual humans' pipeline, at least a dozen new tools and approaches were tested. Eventually, only a handful were a good fit for this project.

"In the end, everything we do is about getting a scene to work," said Thudiyanplackal. "No amount of artistry and beauty will blind the audience to the lack of emotional connection. That is where all our attention needs to remain focused as we get lost in the ever-emerging discovery of technology and workflow."

SYNTHETIC BEINGS

"A world without synthetic humans is not an option anymore," expalined Thudiyanplackal. "We are already inundated with these artificially engineered digital humanoids aimed at eliciting intimate responses. Whether it is to augment the appearance of a real person or to produce a digital double, or if the entity is an original creation, regardless of the purpose, subtle nuances are responsible for how well this illusion will hold."

He pointed to successfully executed versions in movies and commercials where larger budgets have allowed for the painstakingly achieved details to blend the artificial and the real without it breaking at the seams. "However, with virtual production, the goal is to deliver a degree of believability in real time for in-camera visual effects," he said. "Here, it becomes a fine balance between achieving fidelity and having the right optimization for lag-free playback."



KOINA FREEMAN CREATED THE PREVIS TO TEST THE SHOTS INVOLVING THE METAHUMANS & SCANNED DIGITAL DOUBLES IN THE BACKGROUND TO HELP THE DIRECTOR & CINEMATOGRAPHER DECIDE THE SHOT COMPOSITION. KEY QUESTIONS: HOW MANY WERE NEEDED, WHERE TO PLACE THEM IN THE VIRTUAL ENVIRONMENT, & WHAT THEIR ACTIONS NEEDED TO BE TO MATCH THE REAL ACTORS?

SKY FERREN
Art Director at Pytheas
Los Angeles, California, United States

Virtual Humans Artist
(Clothing)

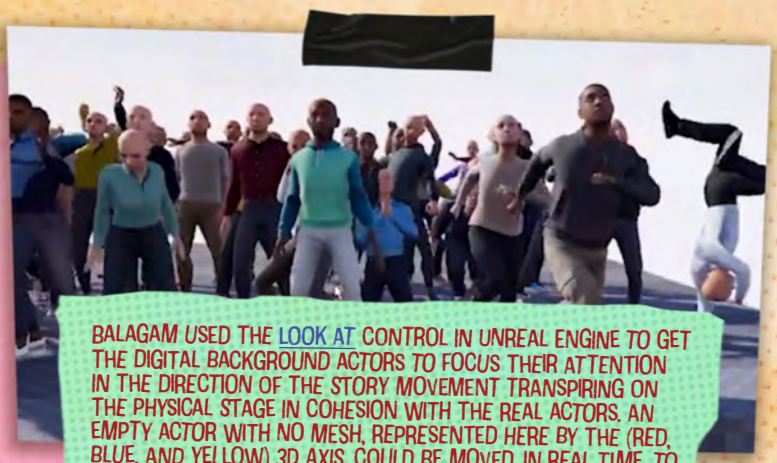
SKY FERREN VOLUNTEERED TO HELP CREATE DIGITAL COSTUMES IN MARVELOUS DESIGNER & TEST THE UDRAPER PLUGIN IN UNREAL ENGINE. WHILE THE CLOTHING WAS FAR MORE RESPONSIVE & ATTRACTIVE WITH ALL THE CREASES IN THE FLOWING MATERIAL, THE PROCESSING POWER REQUIRED TO HAVE 30 OR MORE DIGITAL ACTORS COSTUMED THIS WAY WAS EXORBITANT.

"If these technologies were solely developed to cater to this one industry, it would be exorbitant and would take forever," said Thudiyanplackal. He explained how synthetic beings ranging from virtual characters to digitally morphed or modified avatars and all sorts of AI-generated or augmented features that complement the appearance such as text to speech, lip sync for dubbed languages, deep fake, etc., are use cases being explored across a range of applications for gaming, VR, AR, XR, customer support, education, medicine, metaverse, and other industries that are all rapidly and simultaneously emerging.

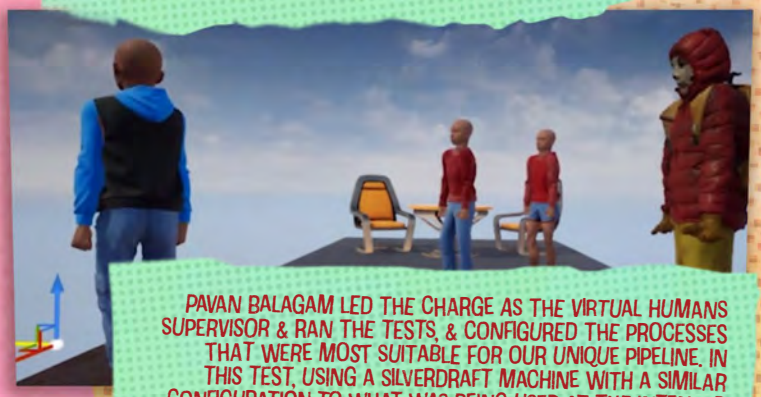
"That convergence of shared interests is what is expediting these advancements and increasing the range of what is becoming possible to achieve at lowered time, labor, and processing costs," he added.

"As a producer, my instinct is to help the director achieve the shots needed to convey the story," Thudiyanplackal said. "In this instance, with *Fathead*, c. Craig required a world populated with a large number of Ragamuffins in a junkyard paradise." Shooting these scenes at an LED volume meant that the only way to achieve this was to introduce virtual humans in the 3D environment displayed on the LED walls.

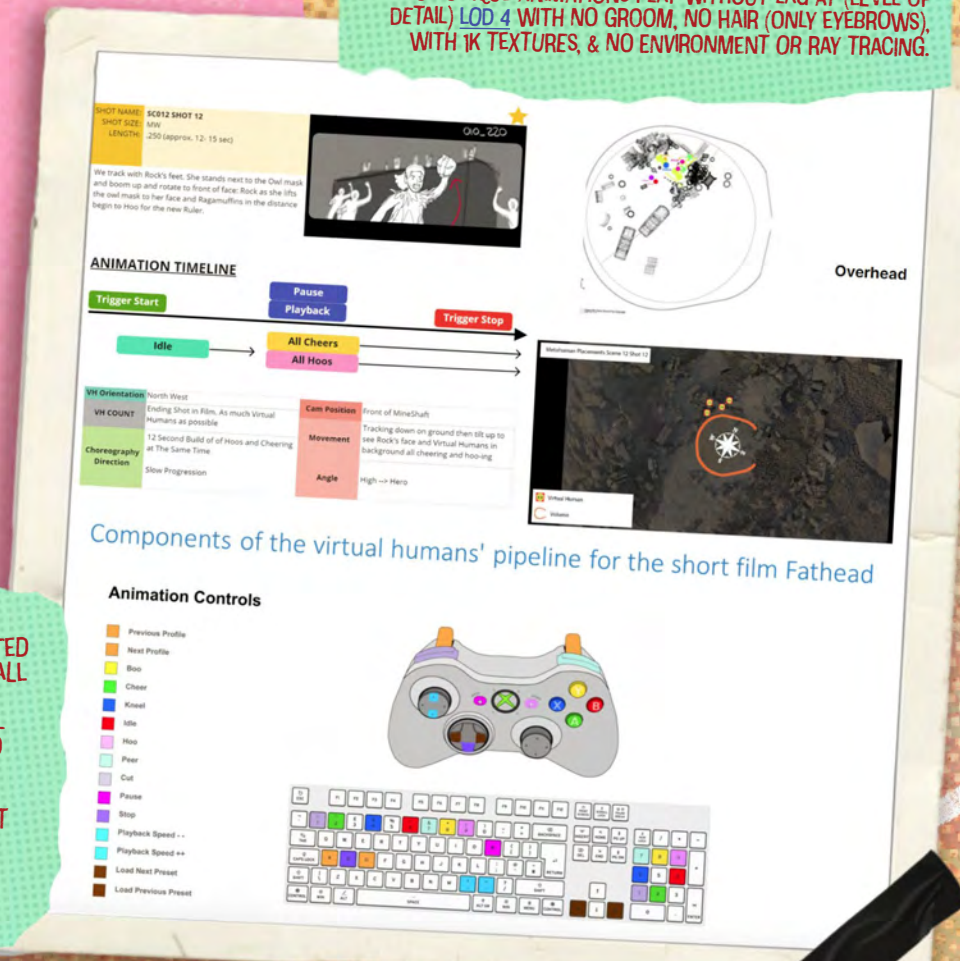
The team explored several options and looked at various solutions before sticking to the few that got integrated into this pipeline. "Everything we did came from the script and discussions with the director on how he wished to film these scenes," he explained. Extensive amounts of detail about these shots were extracted from numerous Zoom calls and Slack channel exchanges that were compiled into a PDF workflow diagram by Nhan Le that got translated into previs by Le and Koina Freeman. Later, they were translated into animation blueprints by Erica Penk to get these digital extras ready for placement in the 3D environment on the LED walls.



BALAGAM USED THE LOOK AT CONTROL IN UNREAL ENGINE TO GET THE DIGITAL BACKGROUND ACTORS TO FOCUS THEIR ATTENTION IN THE DIRECTION OF THE STORY MOVEMENT TRANSPIRING ON THE PHYSICAL STAGE IN COHESION WITH THE REAL ACTORS. AN EMPTY ACTOR WITH NO MESH, REPRESENTED HERE BY THE (RED, BLUE, AND YELLOW) 3D AXIS, COULD BE MOVED, IN REAL TIME, TO COINCIDE WITH THE ACTIONS ON THE STAGE TO CONTROL WHERE THE DIGITAL ACTORS WOULD TURN TO & LOOK AT.



PAVAN BALAGAM LED THE CHARGE AS THE VIRTUAL HUMANS SUPERVISOR & RAN THE TESTS, & CONFIGURED THE PROCESSES THAT WERE MOST SUITABLE FOR OUR UNIQUE PIPELINE. IN THIS TEST, USING A SILVERDRAFT MACHINE WITH A SIMILAR CONFIGURATION TO WHAT WAS BEING USED AT THE INTENDED LED STAGE, BALAGAM HAD 62 UNIQUE METAHUMANS WITH 40 PLUS UNIQUE ANIMATIONS PLAY WITHOUT LAG AT (LEVEL OF DETAIL) LOD 4 WITH NO GROOM, NO HAIR (ONLY EYEBROWS), WITH 1K TEXTURES, & NO ENVIRONMENT OR RAY TRACING.



THE VIRTUAL HUMANS' WORKGROUP CLOSELY COLLABORATED WITH THE DIRECTOR & CINEMATOGRAPHER THROUGHOUT ALL STAGES OF PRODUCTION, ENSURING THAT THEIR CREATIVE VISION WAS REFLECTED IN THE PLACEMENT OF THE DIGITAL ACTORS WITHIN THE VIRTUAL ENVIRONMENTS. THIS HELPED TO EFFECTIVELY CONVEY THE STORY BEATS & EMOTIONAL CORE OF EACH SCENE. INTRICATE STORYBOARDS & PREVIS HELPED NAIL THE PERFORMANCES REQUIRED IN EACH SHOT BY MAPPING OUT SPECIFIC ACTIONS TO CREATE COMPLEX ANIMATION SEQUENCES CONTROLLED ON THE FLY WITH CUSTOM BLUEPRINTS USING A GAME CONTROLLER OR ASSIGNED KEYBOARD STROKES.

"The director's shooting style also affected how we approached the workflow," said Thudiyanplackal. Patterson has a natural gift for working with children (the primary cast members of this show). Once he has attained the required tonality and momentum in the performances, he likes to keep the takes going and doesn't call cut until a few variations satisfy his goals for the shot. "This introduced a unique challenge in how we designed the animation blueprints," explained Thudiyanplackal. He shared how to build endlessly loopable animations that smoothly transition into one another. The team at the stage had various buttons assigned with triggers to launch an animation in conjunction with the action on stage with the live actors. While these actors would reset between takes to return to the start position of a scene, the virtual actors were also required to do the same.

END-TO-END VIRTUAL PRODUCTION

Thudiyanplackal has presented findings around the virtual humans' pipeline, the future of synthetic humans, and many of the other end-to-end virtual production workflow accomplishments and learning acquired from *Fathead* at various industry events, including the HPA Tech Retreat 2022, NAB Las Vegas '22, and vETC at SIGGRAPH '22.

"One of the important things about these projects at ETC is that beyond the short film, all of the learning gathered along the way from the different contributors and partners, this beautiful collaboration of great minds that come together gets captured and shared in an open-source document with the industry so they can pick what they need and contribute toward filling the gaps in technology and the ongoing conversation," Thudiyanplackal said. The ETC's previous project, *Ripple Effect*, had a white paper that was widely circulated and contributed to informed discussions about virtual production.

With the *Fathead* white paper, the team aims to go even further and delve into the technology being adopted widely in the industry. "Our goal is to identify the areas where we can introduce standardization," Thudiyanplackal explained. "The other objective is to identify how to create a good transition for people from other fields and industries who take this on as a second career." These individuals bring new perspectives to the pipeline but may require education and training.

"One of those things is culture," Thudiyanplackal stated. "We have people from technology, the traditional film business, gaming, and visual effects — all of these must come together for a show like this to happen." These different industries have their own cultural mindsets and ways of communicating, making it difficult to prioritize and communicate effectively. The team aims to identify a standard way of operating that allows all partners to communicate efficiently and avoid redundancy or missed opportunities.

One important aspect of the project is the participation of manufacturers and technology providers who join the film

to battle-test their products and services and better align their roadmap to where the industry is heading. One example of such a manufacturer is Stratasys which was brought onto the project by Wacom to 3D print assets created by the production designer. This saved time and labor compared to custom-building them. "These kinds of innovative ways of using technology that is out there to help a production move faster and create more believable and engaging things — that's been a journey," Thudiyanplackal said. "We want to ensure that the white paper translates all this into great learning for the community."

BLEND IN TO LET THE SCENE SHINE

"Gaming and filmmaking use two different languages," Thudiyanplackal explained. "In gaming, the focus remains to engage the user in an immediate way. You're responding to something. Things are always happening. You're always on the move, and your body and mind engage at that level. With movies, it's the other way around. Your body remains passive, but your mind and heart are actively engaged with the emotions of the characters and the overall story."

In film production, all elements, such as music, camera, sound, and other departments, must play a supporting role and remain invisible, with just enough presence to fully immerse the audience in the story. "If any one thing stands out on its own, the film fails," Thudiyanplackal said. "Everything has to play a supporting role and stay invisible. There is just enough of it to put you in the story. Across all teams, that understanding and proficiency in film language and grammar is necessary for meaningful and effective communication."

NEXT BIG BENCHMARK

Thudiyanplackal stated, "Humans are unpredictable and vulnerable. Simple events to some, may easily cripple others. Our gifts are unique, and we have flaws that are unlike others. Despite this, we fall in love, we survive many failures, and collectively, we have remained a resilient species." As the world enters the age of the Metaverse, he wonders whether virtual worlds will reflect human society as we know it or if it will take a different path.

He explained further, "Machine learning may be employed to learn from large data sets, but how do you capture the subconscious aspects of humans that are not captured externally, and yet, it is known to influence who we are by about 90%-95% of why we feel, think, and behave a certain way. The ethical and moral questions are more critical than the commercial ones. We have to be bold enough to ask hard questions and to point out the elephant in the room. No one person or corporation can be handed the authority to operate with complete impunity in how this future is written."

DO IT DIFFERENTLY NEXT TIME

"Creating believable synthetic beings requires a lot of work," Thudiyanplackal said. "It's important to have access to the resources and time to make it happen."

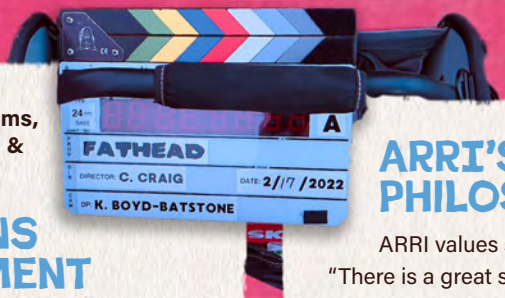
"Working on a volunteer-supported short film may give us some answers, but it doesn't provide the quality we want," he added. "This is not a reflection of the contributors' abilities. In fact, what they've achieved is remarkable given the limited resources they had."

"To make progress, we need to address the budget first," he concluded. "This way, everyone involved can fully engage and put in the necessary effort and time to make the product the best it can be." ▪

ADDITIONAL LINKS

- Fathead: End-to-End Workflow (vETC@Siggraph2022, Day 2 - Wednesday, August 10th, 2022)
- Future of Synthetic Beings in Digital Entertainment (HPA Tech Retreat 2022, Virtual Production Supersession - Tuesday, February 22nd, 2022)
- Creativity in the Age of Real-Time Photo-Real World-Building for Virtual Production (NAB 2022, Monday, April 25, 2022)

REVOLUTIONIZING FILM TECHNOLOGY: ARRI's Impact on Fathead & Beyond



ARRI, a leader in camera and lighting systems, has significantly contributed to filmmaking & virtual production advancements.

ARRI'S LEGACY IN LENS & CAMERA DEVELOPMENT

As a leading designer and manufacturer, ARRI has provided system solutions for film, broadcast, and media industries, earning 19 Scientific and Technical Awards from AMPAS for its contributions.

THE ARRI ALEXA MINI LF'S ROLE IN *FATHEAD*

For *Fathead*, "The ARRI ALEXA Mini LF was an obvious choice," said an ARRI spokesperson. Its built-in real-time camera and lens metadata through ARRI's UMC-4 ARRI Live Link Metadata Plug-in for Unreal Engine and native genlock made it ideal for accurate synchronization in virtual production.

INNOVATIVE FEAUTRES OF THE ALEXA MINI LF

The Mini LF uses the same large format ALEV 3 A2X sensor as the ALEXA LF, limiting the depth of field and minimizing moiré artifacts. "It is a 4.5K sensor with 4448 x 3096 photosites," the spokesperson detailed, highlighting the sensor's dimensions and image circle requirements.

RECORDING MEDIA: CODEX COMPACT DRIVE

The ALEXA Mini LF utilizes the Codex Compact Drive in 1 TB and 2 TB sizes, "specifically designed in the small form factor with a newer flash technology," according to the ARRI representative. This development demonstrates ARRI's commitment to efficient and adaptable recording media.

CODEX HIGH DENSITY ENCODING (HDE) EFFICIENCY

Dane Brehm, a production technologist, emphasized, "Codex HDE is an effective way to reduce the data footprint of ARRIRAW." He recognized its ability to maintain quality while reducing file sizes, thus enhancing workflow efficiency. However, for *Fathead*, "ARRIRAW was the fastest way to offload multiple mags at once," Brehm explained, choosing it over HDE due to software compatibility concerns.

ARRI'S SUPPORTIVE PHILOSOPHY IN FILMMAKING

ARRI values supporting storytellers with innovative tools. "There is a great sense of community and nurture," the company expressed, reflecting on welcoming the *Fathead* team to their Burbank Creative Space's virtual production stage for testing and experimentation.

GUIDANCE FROM STEPHAN UKAS-BRADLEY FOR FILMMAKERS

Stephan Ukas-Bradley, ARRI VP of strategic business development and technical marketing, highlighted the importance of testing virtual production technologies. "Communication is key on any set," Ukas-Bradley advised, underscoring the need for a strong relationship between the AD and virtual production supervisor.

EMPHASIZING PREPAREDNESS IN VIRTUAL PRODUCTION

Ukas-Bradley recommended understanding fixed and flexible aspects while shooting on a volume. "A failure to communicate those variables ahead of time can lead to unexpected outcomes," he cautioned, advising on the importance of preparing models, textures, lighting, and scene operations well in advance.

THE POTENTIAL OF VIRTUAL PRODUCTION

"Virtual production is a unique exercise as it truly takes seeing it to believe it," Ukas-Bradley said, highlighting the transformative potential of virtual production in filmmaking. He encouraged traditional filmmakers to engage with virtual production gear to understand its benefits and adapt current workflows to new environments.

ARRI'S REVEAL COLOR SCIENCE & CURRENT PRODUCTS

"Current ARRI products lend well to this type of environment for their high dynamic range," Ukas-Bradley observed, referring to LED volume shooting. He also introduced ARRI's REVEAL Color Science, utilized by ALEXA 35 and accessible in post-production for other ARRI cameras, which brings filmed imagery closer to human perception. ■

MOVE.AI

THE GENESIS OF MOVE AI: LAYING THE GROUNDWORK FOR INNOVATION

John Grabowski, commercial director at Move AI, recounted the motion capture firm's inception, which began with a focus on sports tracking and biomechanical analysis. This venture quickly adapted to the burgeoning demands of virtual experiences and 3D worlds, expanding its reach and capabilities. "Since then, the business has developed to address several opportunities in the market," Grabowski noted, highlighting Move AI's evolution and diversification.

CARVING A NICHE IN MOTION CAPTURE: DEFINING MOVE AI'S UNIQUE POSITION

Grabowski emphasized Move AI's role in democratizing motion capture technology, broadening its application beyond film and video game development. The company's entry into industries like sports, fashion, and music signifies its success in making motion capture more accessible. He stressed the importance of high-quality content in digital and virtual worlds, asserting that excellence in content is crucial for user engagement.

ENHANCING VIRTUAL PRODUCTION: MOVE AI'S USER-CENTRIC APPROACH

Niall Hendry, VP of partnerships at Move AI, elaborated on the company's efforts to streamline their technology for better user experience and results. He highlighted the significance of their new user documentation site (**https://developers.move.ai/docs/welcome/**) in assisting users in achieving optimal outcomes. "We've found that when users follow the docs precisely, they have a great user experience and result," Hendry explained. Additionally, he mentioned the time spent honing workflows and making their documentation more accessible online since the *Fathead* project.

THE FUTURE OF REAL-TIME MOTION CAPTURE: MOVE AI'S INNOVATION

Hendry shared insights into Move AI's upcoming real-time system, set to be deployed in April 2022. This system is expected to run at an initial maximum of 60 fps with approximately a 300ms delay, connecting directly to Unreal Engine via Live Link. This innovation aims to enable real-time character animation of up to five performers, signifying a leap in motion capture technology. Hendry also mentioned ongoing efforts to store higher frame rate data locally and push it to the cloud during production, a step towards achieving enhanced results in real-time applications.

THE ROAD AHEAD: PIONEERING IN VIRTUAL INTERACTION

Hendry discussed the importance of synchronizing data feeds for successful virtual production and the need for low-latency systems, stating, "All systems will need to run at as low-latency as possible (sub-3 frames) to achieve this." This focus on minimizing latency is part of Move AI's commitment to pushing the boundaries of virtual production and motion capture technology. ■

EMPOWERING CREATIVITY & INNOVATION: WACOM'S ROLE IN VIRTUAL PRODUCTION

WACOM, A LEADER IN DIGITAL TECHNOLOGY, REVEALS ITS CONTRIBUTIONS TO THE CREATIVE PROCESS & ITS COLLABORATION WITH THE FATHEAD PROJECT.

WACOM'S PRINCIPLE OF INNOVATION

Wacom's guiding principle is putting the customer, user, and creator first. They focus on delivering a harmonious experience between the artist and the digital world. Their approach involves working backward from user needs and integrating their technology pipeline to enhance the artistic experience.

COLLABORATING WITH THE FATHEAD TEAM

Wacom's involvement with the *Fathead* project began with an introduction by Erik Weaver of ETC. Recognizing the innovative efforts of the *Fathead* team, Wacom dedicated resources to working closely with them. "Our motivation was to support innovation in the creative process—providing creators more control over the content pipeline," Wacom explained. "This partnership aimed to address present challenges and anticipate future opportunities in creative storytelling."

ENHANCING THE ROLE OF TECHNICAL ARTISTS

In collaboration with the *Fathead* team, Wacom identified critical insights for enhancing virtual production. They emphasized understanding the creators' needs and integrating suitable technology to support these requirements. Wacom has supported technical artists, providing tools like flexible control surfaces for real-time engines and LED walls. This support enables artists to create control interfaces with familiar Wacom pen and touch devices, streamlining virtual production's creative and technical processes.

RECOGNIZING CONTRIBUTIONS & FOSTERING INNOVATION

Wacom acknowledged the contributions of Tim Reha, a contractor for a specific project, and highlighted the importance of crediting both Wacom and Tim Reha Digital for their collaborative efforts leading up to HPA Tech Retreat 2022.

FORMING THE WACOM THINK TANK

The Wacom think tank, formed by ETC and *Fathead* production participants, is a hub for sharing experiences and insights in virtual production pipelines. This network of global innovators discusses the use of Wacom products, like the Cintiq Pro, to improve interactivity and idea execution. The think tank aims to foster open conversation and innovation in virtual production, continually pushing the boundaries of creativity and filmmaking. ■

REVOLUTIONIZING COSTUME DESIGN IN FILM & MEDIA: PERIS DIGITAL'S JOURNEY

Peris Digital, a spin-off from Peris Costumes, pioneers the digital transformation of costume design through advanced photogrammetry.

UNVEILING PERIS DIGITAL'S ORIGIN & VISION

Peris Digital, emerging as a leader in digital costume creation, originated as a spin-off from Peris Costumes, the world's largest costume rental company. With a vision set in September 2020, the company began utilizing photogrammetry for costume transformation. "Our main goal is scalability," the team explained, emphasizing their online operational model and the swift incorporation of new artists into their production team.

EMBRACING CUTTING-EDGE TECHNOLOGY IN WORKFLOW

Integrating Wacom tools into Peris Digital's workflow underscores their commitment to precision and innovation. "Wacom is 'the tool' for any digital artist," they stated, highlighting how the Cintiq Pro 32 enhances precision in photogrammetry and software like Blender and Reality Capture.

EXPANDING REACH ACROSS INDUSTRIES

Peris Digital has expanded its services to cater to various industries, riding the wave of metaverse creation and media expansion. Their engagement with media creation, retail, and collaboration with universities for R&D demonstrates a multifaceted approach to digital costume creation.

THE ART OF PHOTOGRAMMETRY IN COSTUME DESIGN

The team elaborated on their vast collection of over 10 million costume elements, valued at 300 million euros, and their meticulous cataloging process. They highlighted the importance of photogrammetry as a fundamental step in their workflow, emphasizing the necessity of preparing materials specifically for each post-production company's workflow. "All the instances with which the 3D artists work are in AWS," they noted, illustrating their efficient and scalable production process.

FUTURE ASPIRATIONS: LAUNCHING A DIGITAL COSTUME MARKETPLACE

Looking ahead, Peris Digital plans to launch the most extensive digital costume marketplace, featuring over 2,000 references. This ambitious project aims to revolutionize the digital costume industry and showcases their commitment to quality and innovation.

GUIDING PRODUCERS & CREATORS IN THE DIGITAL REALM

Peris Digital offers simple yet profound advice to producers and creators planning to utilize their services: "Imagine, dream with your projects, and draw it." They promise to find matching outfits from their extensive warehouse, prepare them for preferred software, and ensure they are ready for use in various projects. ▪

REVOLUTIONIZING FILMMAKING WITH 3D PRINTING: STRATASYS' INNOVATIVE CONTRIBUTIONS

COLTON MEHLHOFF, APPLICATIONS ENGINEER AT STRATASYS FOR POLYJET – AMERICAS, EXPLORES THE COMPANY'S PIVOTAL ROLE IN THE EVOLUTION OF 3D PRINTING IN FILMMAKING & BEYOND.

STRATASYS: PIONEERING POLYMER 3D PRINTING

Mehlhoff introduced Stratasys as a comprehensive provider of polymer 3D printing solutions, supporting various stages of the product life cycle across design, manufacturing, and healthcare. He highlighted Stratasys' significant contributions to the film industry, including their work on LAIKA's stop motion films like *Kubo and the Two Strings* and *Missing Link*, where every character expression was printed in full color using Stratasys printers.

INTEGRATING WACOM TECHNOLOGY IN 3D DESIGN

Discussing the integration of Wacom technology, Mehlhoff emphasized its role in enhancing the relationship between artists and the virtual 3D world. "Just like an artist models with clay and paints in the physical world, the Wacom tablet can make the relationship between artist and virtual 3D world more intimate," he explained. This technology is essential in enabling high-quality files for 3D printing.

CUSTOM SOLUTIONS FOR FATHEAD: SAFE & CREATIVE DESIGNS

For *Fathead*, Mehlhoff detailed the collaboration with Costume Designer Maddi Mays and Production Designer Miranda Friel. Stratasys 3D printed unique elements like fence spikes, bolt heads, and bottle caps tailored to the film's aesthetic. "3D printing allowed for a complex shape to be produced at the scale needed in time for the film," Mehlhoff stated. He noted that using 3D-printed bottle caps as hair ties for a child actor is a safe alternative to potentially sharp, actual bottle caps.

CREATING SYMBOLIC PROPS: A BLEND OF SAFETY & REALISM

Stratasys also produced spikes/spearheads for *Fathead*, pinned with dolls to symbolize lost innocence. Mehlhoff described how these 3D-printed elements provided safety around children and maintained visual consistency between the physical and digital worlds. "The objective was to have the 3D digital versions...placed in the virtual world on the LED wall so that the eye would see the natural fidelity between the two," he explained.

EXPANDING 3D PRINTING BEYOND FILM

Mehlhoff discussed the broader applications of 3D printing, which extend far beyond filmmaking into industries like automotive and aerospace. He emphasized the potential of 3D printing technology to revolutionize not just on-screen visuals but also behind-the-scenes processes in filmmaking.

THE ART OF REALISTIC 3D-PRINTED PROPS

Highlighting the versatility of 3D printing, Mehlhoff described its use in creating lifelike props and custom embellishments for the film industry. "3D printing in color is a fun way to fool people," he said, noting its ability to print objects that closely resemble actual materials like wood, plastic, and fabric. This technology enables the creation of realistic props and novel designs never seen before in filmmaking. ▪

REVOLUTIONIZING VIRTUAL PRODUCTION: THE SILVERDRAFT PERSPECTIVE

Silverdraft, led by CEO Amy Gile and VP Hardie Tankersley, showcases its innovative computing technology, enhancing the creative process in filmmaking and beyond.

BROADENING THE SPECTRUM: SILVERDRAFT'S VARIED CLIENTELE

Tankersley outlined the diversity of Silverdraft's clientele, extending from high-end Hollywood productions to local TV stations and sports broadcasts. "It's anybody that owns and runs the facility, from rental stages to specific productions building their facilities," he explained, illustrating Silverdraft's wide-reaching impact across various sectors of video creation.

BEYOND THE PRICE TAG: COMPUTING'S VALUE IN PRODUCTION

Gile emphasized the need to look beyond the immediate cost of computing technology. "There are studies that analyze what you save across the board," she stated. Gile highlighted the significant workflow benefits of removing bottlenecks, which transform the overall production process and drive creative output.

FACILITATING ARTISTRY THROUGH SEAMLESS INTEGRATION

For Gile, enabling artists to work without technical constraints is paramount. "Our goal is to make it as simple and easy as possible," she said, underscoring the importance of a seamless, turnkey approach that allows artists to focus on creativity rather than technical challenges.

THE VERSATILITY OF VIRTUAL PRODUCTION IN BUSINESS

Gile noted the expansive potential of virtual production across different business verticals. "This level of virtual production can go across all different verticals of business," she remarked, acknowledging the broader range of opportunities for film professionals to apply their skills in various industries.

ENHANCING CREATIVE PROCESSES & WORKFLOWS

Tankersley spoke about virtual production as a multifaceted technology platform. "The virtual production technology platform is a very loose category of many different things," he noted, highlighting its role in reducing costs and empowering creative freedom.

EMPOWERING PRODUCERS WITH FLEXIBLE VIRTUAL SETS

Tankersley also pointed out the advantages of virtual sets over traditional ones. "The ease of changing virtual sets compared to practical sets," he said, provides producers greater flexibility and creative empowerment.

LOOKING TOWARDS THE FUTURE: SCALABLE SOLUTIONS & FUTURE-PROOFING

Gile stressed the importance of scalability and future-proofing in their technology solutions. "When we're architecting solutions, we architect a level of future-proofing and enable the system to scale up with the client," she conveyed, highlighting Silverdraft's forward-thinking approach to meet evolving industry demands. ■

ADVANCING CINEMATOGRAPHY w/ ZEISS:

A JOURNEY THROUGH LENS TECHNOLOGY

With its rich history and innovative spirit, ZEISS has significantly contributed to various fields, particularly in cinematography, through advanced lens technology.

ZEISS: PIONEERING OPTICS FOR OVER 175 YEARS

ZEISS, a 175-year-old company founded by Carl Zeiss, is a pioneer in lens technology. "ZEISS, headquartered in Germany, has been an industry leader in scientific research and development of optics," the company noted, underscoring its extensive contributions to various industries beyond media and entertainment.

INNOVATIONS IN LENS COATINGS: FROM SUBMARINES TO CINEMA

Snehal Patel, the head of cinema sales for the Americas at ZEISS, discussed the company's T* multilayer anti-reflective coating. Initially developed for submarine periscopes, this coating has become a vital component of ZEISS's photo and cine lenses, significantly impacting their performance and look.

LEADING THE LENS METADATA CONVERSATION

ZEISS has been at the forefront of lens metadata development, starting with its partnership with ARRI on the LDS Lens Data System. Patel elaborated, "More recently, ZEISS has been developing our eXtended Data system, building off a customized implementation of Cooke's /i protocol." This commitment to standardization and communication throughout production and post-workflows highlights ZEISS's leadership in advancing lens technology for various applications.

ZEISS EXTENDED DATA: ENHANCING VFX & VP WORKFLOWS

The ZEISS eXtended Data technology builds on the Cooke Optics /i protocol by adding additional data lines for shading and distortion characteristics. "This additional info is critical to faster, more accurate VFX and VP workflows," Patel emphasized. The technology has been instrumental in live composites, providing more accurate information and reducing guesswork.

COOKE /I TECHNOLOGY & ZEISS SMART LENSES

Cooke/i, a "smart lens" metadata system, plays a significant role in ZEISS's smart lens technology by supplying critical lens data to operators and recording metadata to the digital negative. ZEISS eXtended Data builds upon this system, incorporating optional features to enhance the capabilities of their lenses.

EDUCATIONAL RESOURCES & SOFTWARE FOR ZEISS LENSES

ZEISS provides extensive educational content on its YouTube channels, "ZEISS Cinematography" and "ZEISS Lenses Americas," focusing on XD Data and its applications. Additionally, the CinCraft Mapper software offers distortion and shading lens characteristics for VFX, compatible with various cameras and classic ZEISS lenses.

THE ROLE OF LENS METADATA IN VIRTUAL PRODUCTION

Lens metadata has become increasingly significant in virtual production pipelines. "Virtual Production shoots need as much lens data as possible to create realistic imagery," Patel stated. Live lens data that includes lens characteristics can significantly shorten lens calibration time during prep and filming, enhancing the efficiency of virtual production processes. ■

revolutionizing MOTION CAPTURE & ANIMATION

STREAMLINING DATA CAPTURE & PROCESSING

Croak described Noitom's setup, highlighting the integration of Axis Studio software with Unreal Engine for effective data capture. "We have a machine running our Axis Studio software, forwarded over the network to a machine running Unreal," he said. This allows simultaneous capture in both systems and the option to use Autodesk MotionBuilder for additional processing. Croak emphasized the capability to export data at various frame rates, aligning with different project needs, from up to 100 fps with gloves to 240 fps without.

CHOOSING THE RIGHT DATA APPROACH

Croak discussed Noitom's data approach, particularly the preference for inertial data over optical data in specific scenarios. "We offer inertial or hybrid data (optical + inertial)," he stated. This choice is guided by the digital actors' requirements and the capture stage's terrain, with hybrid data being ideal for tracking location data between characters and props.

FACIAL CAPTURE TECHNIQUES WITH IPHONE

Detailing facial capture techniques, Croak explained the integration of iPhone technology with Unreal's Live Link and Apple ARKit for real-time animation. "The pipeline would push motion capture data and face data into Unreal," he noted, outlining a process that simultaneously captures both body and facial animations. These animations become separate assets within Unreal, highlighting the versatility of Noitom's technology.

ENSURING AUTHENTICITY IN ANIMATION

Croak addressed the importance of maintaining realistic animations by matching the digital model's dimensions with the performer's physical proportions. "With software like MotionBuilder, you can animate any differences in sizing," he explained. However, he cautioned that animation flaws might occur without proper adjustments, emphasizing the need for precise **characterizing** to avoid issues like foot slides and jitters. ■

VISIONARY INTEGRATION: TOMAS MISURA'S PHOTOGRAMMETRY ODYSSEY

CHARTING THE COURSE OF PHOTOGRAMMETRY: FROM HISTORICAL PRESERVATION TO THE FRONTIERS OF THE METAVERSE & AI INTEGRATION

THE GENESIS OF A PHOTOGRAMMETRY PIONEER

In the field of photogrammetry, Tomas Misura, a Developer Relations (DevRel) engineer at Epic Games, is recognized as a key pioneer and advocate.

Misura said, "I started my photographic career in 2008... in 2013, I started working on a special project here in Slovakia for a digital heritage archival project." This project set the stage for his leadership in post-production and 3D scanning teams, focusing on integrating photography in 3D and the practical application of photogrammetry.

REVOLUTIONIZING ASSET DIGITIZATION

Misura discussed the shift from traditional, time-intensive methods to modern, expedited techniques, notably Reality Capture. Misura stated, "We created the same thing in one month instead of half a year... We digitized more than 25,000 assets this way."

EXPANDING PHOTOGRAMMETRY'S HORIZONS

The application of photogrammetry is not limited to a single field but spans various industries, including virtual reality, augmented reality, and even architectural engineering. Misura's insight into this vast application spectrum is encapsulated in his remark, "My knowledge is across all industries... even like VR, AR, media, entertainment, but also surveying, mapping, AEC." [AEC stands for Architecture, Engineering, and Construction.]

However, the journey of photogrammetry is not devoid of challenges. Misura addresses the complexities in capturing intricate geometries and reflective surfaces, revealing the utilization of specialized methods and materials to surmount these obstacles. He explained, "Photogrammetry does have issues with reflective surfaces... there are sprays, even like vanishing sprays, that you can use."

ENVISIONING THE METAVERSE

A critical aspect of Misura's vision involves integrating photogrammetry into the burgeoning metaverse and its potential synergy with Unreal Engine. "We want to create the metaverse and have all the feasible tools," he explained. "Reality capture is essentially one of them."

THE FUTURE: AI & EDUCATION

Looking towards the future, Misura anticipates the integration of AI in photogrammetry, recognizing its inevitability in enhancing and streamlining the process. He asserted, "AI is emerging and will be needed to integrate AI in all upcoming tools."

Misura emphasized the need for more accessible photogrammetry education catering to professionals and enthusiasts. He stressed the necessity "to invest more into teaching people how to shoot pictures... and even create things like environments." His aspirations for photogrammetry paint a picture of technology on the cusp of transforming numerous industries.

"I think we have a bright future," encapsulated Misura. ▪

Michael McKenna, CEO and co-founder of Final Pixel, is one of the early adopters of virtual production. He is a strong believer in the need for collective efforts to develop standardized workflows for the industry to achieve the true potential that such technology offers. He founded the company in 2020 with the vision of revolutionizing film production using new technologies.

Final Pixel has delivered cutting-edge virtual production solutions and other new technology applications for numerous clients, including Warner Bros. Discovery, Oracle, Red Bull Racing, BBC, Sky, and many more.

"We design the technology solution according to the script and creative needs and manage the process to achieve the highest production values possible within the budget," he explained.

CONSTANT LEARNING & GROWTH

Final Pixel operates globally and has developed unique workflows for film, episodic, and advertising productions that may benefit from virtual production techniques and real-time virtual art/world-building technologies.

To meet clients' high expectations, Final Pixel has relied heavily on R&D efforts from other experts, including ETC. The demand for such access to knowledge and experience has inspired McKenna to expand into delivering global virtual production education, training, and career-building initiatives through the Final Pixel Academy, where these experts are invited to provide lectures, workshops, and presentations.

"Inspired by the first [virtual production] white paper from the ETC, *Ripple Effect*, in 2021, Final Pixel funded and embarked on a research and development project," said McKenna. Workflow documentation and educational dissemination of practical applications for virtual production tools were scarce then, so he decided to publish a white paper and circulated it among the virtual production community for knowledge-sharing.

DIGITAL BACKGROUND ACTORS

McKenna said the focus of the exercise was "to deliver a real-time character motion capture workflow using LED walls and an extremely high-fidelity creature, rendered using cluster rendering in real-time." The impetus for this experiment came from a recurring request from creatives wanting digital background characters on the LED wall that could be controlled.

In previous attempts when clients demanded similar solutions, he noted it was always chal-

MICHAEL MCKENNA

CEO/COFOUNDER, FINAL PIXEL

lenging to achieve a photoreal output — a realistic human movement that was controllable and optimized to run on an LED wall without lag.

COLLABORATING ON FATHEAD

Final Pixel published the findings in a white paper that caught the attention of the *Fathead* team, which was evaluating similar workflows. "We shared our findings and offered whatever support we could," said McKenna, who applauded this collaborative nature "among its early adopters and pioneers," which helped drive innovation.

FATHEAD'S METAHUMAN ACTORS

"*Fathead* has proven to be something exceptional," said McKenna. "In particular, the progress on using Epic's MetaHuman Creator combined with realistic motion to achieve multiple real-time digital characters with unique clothing."

Such use cases, he noted, have exemplified the creative implementation of new tools to put control back into the hands of the filmmaker.

A FINISHED PRODUCT: THE PROOF

McKenna recognized, from the early discussions with the *Fathead* team, that the collective experience around the table would provide the ideal recipe for effective research and development for a high-quality film to result from those efforts.

He saw a screening of *Fathead* in London in 2023 and was taken by its poignant storytelling. He called it "a tech-based futuristic film rooted in human values."

GROWTH THROUGH COLLECTIVE KNOWLEDGE-GATHERING

Industry participants at the cutting edge of film production technology are urged by McKenna to "partner and share." He pointed out that access to new technologies and the time investment needed from industry professionals for such R&D is scarce, especially with the precarious economics of film production.

He is optimistic about the role virtual production technologies can play in enhancing creative options for filmmakers while boosting efficiency and budget savings for studios. "This unique combination may perhaps change the face of the industry in years to come," predicted McKenna. ▪

REVOLUTIONIZING LENS DATA INTEGRATION: INSIGHTS FROM GARY KELLER @DCS

STREAMLINING DATA CAPTURE & PROCESSING

Gary Keller, the operations manager at DCS (Digital Camera Systems), shed light on the company's journey from its inception as a lens data recording system to its evolution in the realm of virtual production. Keller emphasized that DCS initially catered to niche markets, focusing on systems like the ARRI LDS, where introducing elements such as follow focus would lead to the disappearance of valuable lens data.

This gap prompted the creation of the Lens Data Translator (LDT), a pivotal system in DCS's portfolio, which translates varying data languages and plugs gaps between disparate systems. "Our system...is about grabbing one set of data languages and translating them into another set," Keller explained.

ENHANCING VIRTUAL PRODUCTION WITH LDT

Keller described LDT as a groundbreaking development in their lineup, particularly for virtual production applications. The LDT V1, a newer model, incorporates additional ports to feed computers with lens data, which can also be recorded for further use. This advancement wasn't a significant pivot but an added functionality to their existing model.

Keller highlighted the practicality of this system in real-world scenarios, recounting a satisfying moment at Lux Machina in the UK, where the product seamlessly integrated with Unreal Engine, demonstrating its effectiveness and ease of use on set.

ON-SET & POST-PRODUCTION VERSATILITY

The versatility of DCS's products is evident in Keller's anecdotes from various productions. He spoke of instances where their systems have proven invaluable, particularly in challenging shots involving cranes or zoom lenses without tracking markers. "There's very little you can do with that without lens data," Keller asserted. The ability to provide frame-by-frame accurate lens data has been crucial for both on-set decision-making and post-production processes.

INTEGRATING TRADITIONAL SKILLS IN A NEW ERA

Keller discussed the importance of integrating traditional filmmaking skills within the modern virtual production environment. He mentioned how DCS's products fit seamlessly into this landscape, bridging the gap between classic filmmaking techniques and new technological advancements. "Our device fits very much into that world... It's very much from that, and for that," Keller remarked, highlighting the balance between respecting filmmaking's heritage and embracing innovation.

DATA STREAMING & RECORDING FLEXIBILITY

Keller noted the flexibility of DCS's systems in terms of data streaming and recording. He acknowledges that while their devices have primarily been used to stream lens data directly into Unreal Engine, there are also cases where the data is recorded via the device for later use. This dual capability allows DCS's products to adapt to different production needs, whether they involve virtual production exclusively or a mix of traditional and virtual techniques.

SHADING & DISTORTION DATA FOR SMART LENSES

Delving into the technical aspects, Keller explained that with smart lenses like Zeiss, their devices can capture shading and distortion data. However, for non-smart lenses, the focus is primarily on capturing focus, iris, and zoom data. He pointed out that their system is designed with the future in mind, leaving room for additional information as the demand and technology evolve.

ADAPTING TO VARIOUS PRODUCTION ENVIRONMENTS

Addressing the integration of their system in different production scenarios, Keller acknowledges the challenges and potential of adapting their analog system for various uses. He emphasizes the real-time digitization of analog information, which is a crucial feature of their system, allowing for flexibility in its application across different production environments.

LENS AGNOSTICISM: EMBRACING DIVERSITY IN LENS TYPES

Keller highlighted DCS's commitment to lens agnosticism, which allows their system to work with a wide range of lenses, including vintage and anamorphic ones. This capability is vital, as it enables filmmakers to use a diverse array of lenses without compromising on data capture. "Our system works with all hats," Keller said, emphasizing the versatility and inclusivity of their technology.

EVOLVING POST-PRODUCTION PROCESSES

Finally, Keller spoke about the evolution of post-production processes influenced by virtual production. He noted how virtual production has brought elements traditionally reserved for post-production onto the set, creating new dynamics and demands. This shift has necessitated a deeper understanding of these processes and how they interplay with on-set activities. ■

BRIDGING TECHNOLOGY & CREATIVITY: THE INSIGHTS OF JAMES UREN ON VIRTUAL PRODUCTION

mo-sys

AS THE TECHNICAL DIRECTOR OF VIRTUAL PRODUCTION AT MO-SYS ENGINEERING, JAMES UREN OFFERS A COMPREHENSIVE UNDERSTANDING OF THE EVOLVING LANDSCAPE OF VIRTUAL PRODUCTION & ITS IMPACT ON THE FILM INDUSTRY.

REDEFINING VIRTUAL PRODUCTION

Uren began by debunking the common misconception that virtual production is solely about LED walls like those seen in "The Mandalorian." Instead, he defines it as using real-time computer graphics in production, encompassing various techniques from green screen studios to augmented reality (AR) and extended reality (XR).

"Our definition for virtual production is using real-time computer graphics in production," Uren explained, emphasizing the diversity and depth of the field beyond just LED walls.

THE FLEXIBILITY OF VIRTUAL PRODUCTION TECHNIQUES

Highlighting the versatility of virtual production, Uren mentioned that it's a suite of tools allowing for a smooth transition between different techniques based on the needs of each specific shot, scene, or story. This adaptability provides filmmakers with a powerful toolkit to enhance their storytelling capabilities.

SMART GREEN: INNOVATING POST-PRODUCTION TECHNIQUES

Uren introduced "Smart Green," a technique that balances capturing dynamic lighting benefits and maintaining the ability for post-production manipulation. This method allows for a clean mat, as the green screen tracks with the camera and subject movements on the LED wall.

DEMOCRATIZING VIRTUAL PRODUCTION

Uren's philosophy centers around democratizing virtual production by bridging the knowledge gap between technology and users. He emphasizes the importance of training users and enhancing technology to make virtual production more accessible and user-friendly. "I want to democratize virtual production," Uren asserted, highlighting the need to make these technologies more intuitive and widespread.

THE REFINERY: A TESTING GROUND FOR VIRTUAL PRODUCTION

Mo-Sys Engineering's facility, The Refinery, is designed to enable practitioners to experiment and test ideas in a production context without the pressure of actual production demands. Uren sees this as a crucial step in fostering creativity and allowing for trial and error in a supportive environment.

NAVIGATING THE CHANGING LANDSCAPE OF PRODUCTION

Uren discussed the challenges faced by executive-level decision-makers in adapting to the new virtual production landscape. He noted the potential of virtual production as an opportunity for innovation and cost-effectiveness yet acknowledges the complexities involved in making informed decisions about its application.

NEAR-TIME RENDERING: BRIDGING REAL-TIME & POST-PRODUCTION

Exploring the concept of near-time rendering, Uren described a process where scenes are re-rendered in the cloud and delivered back to set within minutes, significantly enhancing the visual effects quality. This approach represents an intermediary step between real-time in-camera effects and traditional post-production visual effects, offering flexibility and efficiency in the production process.

ENVISIONING A COLLABORATIVE TRAINING ENVIRONMENT

Lastly, Uren desires to offer comprehensive training courses that delve into the impact of virtual production on the entire production pipeline. He acknowledges the need for collaboration with other partners to deliver such intensive training, seeing it as a vital step in advancing the industry's collective understanding and application of virtual production techniques. ▪