Lights, Virtual Camera, Action!

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Abstract: The recent commercialisation and affordability of virtual reality technology has enabled widespread exploration of some rather advanced methods of developing new visual experiences. In December of 2016 Kert Gartner (Techrunch 2016) tweeted his success with a virtual camera assembled together using an HTC Vive VR Headset, an iPhone, and three Vive hand controllers. This performs the same essential function as the virtual cameras developed by large studios, where the camera operator or director films the artificial world and its animations through a hand-held screen, referred as a virtual camera. Gartner's prototype represents a democratisation of this technology that enables smaller studios and individuals to adopt a similar approach – to film their animations in real time, using the same actions and behaviours of a real film camera. When this creative approach to technology is then combined with the new recent cinematic tools in game building engines, the possibilities for animation production is game-changing. Post-production demands such as rendering and compositing will move into the creation space, merging animation, lighting, editing and rendering all into one real-time creative experience.

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1. Democratisation of technology

When Kert Gartner demonstrated his home-made virtual camera in 2016 [1], he exemplified the recent advances and democratisation of digital film and game production. He pointed a DSLR camera to a screen that displayed a game environment and sent this video feed by wireless to his phone, which was gum stuck to a Vice controller, which was controlling the view of that scene. He could, therefore, view the virtual game environment on this screen as he waved the controller around his room. Other players could enter that same game environment, by playing the game with other controllers and be "filmed" virtually.

Figure 1: Kert Gartner

Virtual cameras are used in this way to recreate the natural camera characteristics of real cameras. This is especially pertinent when creating the hand-held in-scene camera technique, which can be difficult and time-consuming to create using a 3D or game design programme.

Figure 2: Warner Bros

Virtual cameras are used extensively in large budget movies and were extensively developed in the making of the *Lord of the Rings* [2] and *Avatar* [3]. Apart from the technological inventiveness of Mr. Gartner, this innovation demonstrates how recent technology can provide unique solutions to the cinematic production process.

This virtual camera innovation is made possible by the relatively recent availability of consumer-level virtual reality (VR) headsets, such as the Oculus Rift and the HTC Vive, and the associated VR game development tools such as Unreal Engine 4 and Unity. The advent of VR has already challenged the linear nature of storytelling, and presented a new format of 360 degree narrative engagement. In the case of animation storytelling, VR has posed several challenges, the most pertinent being the loss of narrative control. Companies such as Google Spotlight are experimenting with making use of the "gaze" – the direction that the headset wearer is looking – to direct the progress of a narrative. In animated stories such as *Rain or Shine* [4] the central story action is paused when the viewer's gaze is not focused on the central action. In this way, the viewer will always see the narrative, even if their gaze wanders away to examine other areas. This keeps the full flow of the story intact, even though the timing and pace will be affected. In other productions, such as *Buggy Night* [4] the viewer needs to gaze at characters or objects for the story to progress. However, this degree of interaction changes the experience of the story to more of an interactive game (5). Without question, when VR is considered as part of the production pipeline, more opportunities arise.

2. Cinematic game trailers and cut scenes

Alongside the recent developments of VR have also come major improvements in the speed and quality of real-time game rendering. This has changed the way game trailers and cut scenes are being produced. Ten years ago, these mini-movies were created using pre-rendered 3D animation software and had little similarity to actual game aesthetics. The cut scenes of trailers such as *Final Fantasy* VIII create their own fandoms, separate from the game [6]. Currently, game trailers are made intentionally using the same engine as the game in a bid to show off the game and imply that the impressive quality of the trailer is also in the gameplay. This is not entirely accurate, as there are two levels of game engine trailer and cut scene production. The first is "in-engine" or "pre-rendered". This uses the game's engine technology creatively and with modification. E.g. some assets may be turned off to allow greater CPU for FX processing. And lighting may be manipulated per shot, to maximise effect. The second approach is to use "in-game" (as distinct from "in-engine"). In-game creates a trailer or cut scene by running the game and recording it. Although directors can still tweak some settings such as exposure and lighting, this approach is often favoured by gamers as it gives a true representation of the actual game they intend to purchase.

From an animation production point of view, both approaches provide exciting possibilities. The pre-rendered option most closely simulates a conventional animation pipeline, with all assets and actions organised and keyframed, which is then activated and recorded as a real-time screen capture. The second option, however, allows for user input. The scene is effectively acted by players, and the whole performance is recorded live. This most closely simulates a real-life, real actor film set.

In 2015 Epic Games released *A Boy and His Kite* [7] – an animated short story rendered entirely using Epic's Unreal Engine 4 game engine. Epic built the short story as a demo to showcase Unreal's realistic world building and rendering features across a fully constructed 100sq mile in-game landscape. The demo highlights dynamic lighting, indirect illumination, cinematic depth of field, high-quality motion blur and procedurally placed trees and foliage, all rendered in real time. The work received the award for best interactive real-time experience at SIGGRAPH 2015 an Honorable Mention Award at NYC Downtown Short Film Festival, as well as acceptance into 10 other international film festivals [8]. It is significant that the festival appearances were for an animated movie, not the technical accomplishments of the game engine.

Figure 3: ***A boy and his kite.*** **Epic.**

Stics, by independent creator Hanway Lin, [9] is an animated short filmed in Unreal Engine 4 using the game engine's built-in cameras and the built-in editing tool. Animations were created in the 3D animation program Maya, and the geometry and movements imported as FBX format files into Unreal. In this scenario, Unreal Engine 4 is used as the filming environment, with all geometry and actions pre-constructed, then imported for final shooting. Director Hanway Lin describes how his small team of three chose this approach for the fast iteration of rendering alterations. This also gave them extra weeks of production, as time was not required for rendering.

Figure 4: ***Stics*****. Hanway Lin, Derek Ho**

June 2016 saw the release of *Adam*, by Unity Technologies [10], a short film about inmates' minds which are uploaded into robots, and then led away into the wilderness by two mysterious figures. The Unity engine included real-time lights, tube lights and volumetric fog. The movements were all motion captured, combined with procedural animation in 3Ds Max. The eyes were the only things keyframed in 3Ds Max.

Figure 5: ***Adam*****, Unity**

More recently the trailer *Hard Day's Night* for the game *Fortnite* was released by Epic Games [11]. Andrew Harris of Epic Games speaks of their intention to produce an animated trailer as much like a conventional pre-rendered work but rendered in real-time (SIGGRAPH 2017). Video editing and compositing were largely handled by the Sequencer tool in Unreal. Instead of video clips, the Sequencer holds libraries of actions. Overall, Harris speaks of the considerable time and costs saving, as studios are under increased pressure to produce higher quality faster and at the reasonable price.

Figure 6: ***A Hard Day's Night*****, Epic**

Game rendering is also finding favour for an animated TV series *Zafari*, produced by Digital Mansion, Montreal. Peter Skovsbo, an Executive Producer, talks of completely bypassing the render farm, reducing lighting and shots time by 75%, with an overall 300% increase in productivity. At 1 second per frame, a full 9 hour season can be rendered in one week. [12]. Zafari has pre-sold to a number of broadcasters, including France TV, Lagardere TIJI, SRC Radio Canada and SpaceToon. NBCUniversal has acquired global distribution rights, and the first season is set to premiere across France and MENA in November.

Figure 7: *Zafari*, Digital Mansion

3. Real-time acting to real-time rendering

In the examples above, all animation is created prior to import- in the game engine. In the project *Focused* by Luke Mathews [13], character actions were created in real-time by real actors playing in-game characters. Luke Mathews used the Battlefield 4 multi-player game engine, Maya and Unreal Engine to create a game-based film set. In this film set, other players participated in a choreographed action scene, while Luke moved about filming the action. Luke operated as a film director, choregraphing 30 participants, with multiple run-throughs, in order to get the shots he wanted. He was also his own wardrobe and props manager, ensuring the participants' characters were dressed properly with the correct props. His was also able to manipulate some of the game's camera controls, such as wide angle, depth, exposure. Once recorded, the clips were composed in a conventional editing program, and final VFX were added.

Figure 8: ***Focused*****. Luke Mathews.**

The only pre-made animations were those used to provide movement loops – walk and run cycles, shooting actions, crouch etc. The full actions were played out by the participants, controlling their characters using hand-held game controllers or PC keyboards. Movement variations were limited by the amount of variation offered by the players' controllers, and so as a result, the movie has an in-game capture feel. The unique aspect of this project was the use of real players to act out the scene, and simulates a real-life direction of an action scene. This approach provides an affordable alternative to the use of real-time mo-cap participation – an option that was technically too complex, too slow, and too expensive at the time.

The use of game engine rendering technology recently took another step in the *Rogue One: A Star Wars Story,* with the robot character K-2SO. At the Games Designers Conference in 2017, John Knoll, Chief Creative Office from Industrial Light and Magic, revealed that K-2SO was rendered in real-time by using a modified version of Unreal Engine 4, and then composited into the final movie shots [14]. This production team was able to see the final appearance while it was being performed by an actor in motion capture, without having to send it to animation or post-production. While this example is at the top professional level, this same technology is generally available to all, and opens up possibilities for smaller groups and creative individuals. In the same way that Gartner hacked together a home-made solution for a virtual camera, game engine rendering and VR offers new opportunities for digital film-making and animation.

Figure 9: *Rogue One: A Star Wars Story.* Lucasfilm

4. Alternative pipeline

At present, game engines such as Unreal Engine 4 and Unity clearly offer an alternative pipeline for digital animation production. The chief advantage of a game engine is real-time rendering, which is now at a quality level that is appropriate for many animation styles. A game engine can manage lighting, light effects, volumetrics, camera, editing and rendering. While this new pipeline requires new skills, the pre-production stages largely remain the same – such as modelling, texturing, normal mapping, blend shapes and animation baking – and these stages can continue to use the conventional processes such as Autodesk Maya.

Concurrent to this development to game engine production we have also witnessed the arrival of consumer assessable VR. VR viewing and authoring is now built into mainstream game engines. As Kert Gartner demonstrated [1], this provides opportunities to hack VR for uses not originally intended. Even without being technically savvy, it would be quite feasible to construct a game, don the VR headset, and enter your production in the VR state. Here you could examine your set, view your animations, place cameras and supervise the action. It would be an interesting project to test how VR directing differed from screen-based directing for an animated production. VR cameras have proven their worth in high budget titles such as Avatar. Would the same usefulness apply to an animation production? Even though we are familiar with the mouse as an interactive instrument, it is not a natural interface to navigate a 3D space. If the director can wear a VR headset, and move around the set freely, this may simulate natural behaviour enough to result in easier or different cinematic considerations and engagement.

5. Limitations

While there are very real limitations to a game engine production pipeline, the speed of current technological advancements would suggest that these limitations will soon be overcome. At present, limitations include:

- Polygon limits: which require polygon management. This same issue once applied to 3D animation, but has now been overcome, as polygon numbers and the use of normal displacement now exceed to the capacity of the eye to distinguish. Game engines still have real polygon limitations.
- Texture and lighting pre-computing. Similar to baking in 3D environments. Baking is still used in 3D to reduce CPU demand, but can also be picked up by the rendering process instead. Game level design requires pre-calculation of lighting and other environmental factors, which can take anything from 5 – 30 minutes depending on the scene.
- Level load times: a complex game level can take many minutes to load. The more complex the level, the longer the load time. Conventional animation can make use of layers, references and compositing to break up complex shots into manageable portions.

These and other limitations do restrict the more rapid adoption of game-engine production. However, as Veselin Efremov from Adam's Demo Team states "real-time technology is the way to go. It allows for fast iteration, which enables creative people to spend much more time exploring and trying out ideas, instead of waiting for hours for a single frame to render" [10].

6. Interactive Animation Production: A proposed combination

There are more combinations of technology that may offer unique contributions to animation production. For example, a combination of pre-rendered animations, with the game play actions, played out in a game environment, recorded with VR controlled game cameras. At first glance this scenario would be similar to any game which includes non-playing characters (NPCs). However, the addition of VR brings a new cinematographic contribution. As discussed above, VR camera operation may sufficiently simulate real-word camera operation, and provide a natural interactive method of placing and controlling cameras. Furthermore, the degree of character playability could be varied. The main character actions essential to the story may all be pre-keyed, either in a 3D program or as loops in the game engine. The player could then potentially contribute in real-time an extra layer of actions, such as head movements, or stumbling, jumping, any kind of movement. This may add an extra layer of naturalness, all in real time, as opposed to the slow keyframe process. One could call this game-controller motion capture.

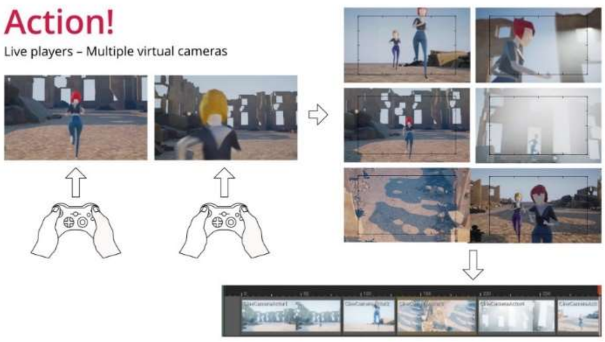

Figure 10: Interactive Animation Production

7. Conclusion

There is no doubt that recent technology from game engines will influence the production of 3D animations. Any 3D short form animation production would have to consider using a game engine approach. The acquisition of new skillsets will prevent an immediate cross-over, but as industry creatives cross boundaries, and new graduates leave art & design schools with both skillsets, it is likely we will see increased numbers of 3D animation/game engine hybrid productions. The makers of conventional 3D programs will also, no doubt, be seriously trying to speed up their own rendering processes, although they will be far behind the game engine industry leaders. For long-form production, very little will change for the moment, as the production pipelines involve the high commitment to staff, technologies, and capital investment. The big studios are not agile enough to jump just yet. But as more and more short productions reveal the potential of game engine production, it is just a matter of time before large studios take notice. We have seen this sea-change before – e.g with the first 3D animation feature production of *Toy Story* [15], and the first "hyper-real" animation feature of *Final Fantasy: Spirits Within* [16]. Full feature 3D animations, both cartoon or hyper real, are now commonplace. Game engine production is in the same place that those ground-breaking movies were in. Once the first "big title" is produced using game engine technology, the sea-change will take place.

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Biographies

Gray Hodgkinson is a digital media designer and researcher, with a specific interest in visual research methods and computer animation. Gray has been developing and leading animation education for 17 years, 14 of those at Massey University, New Zealand, and now at Nanyang School of Art, Design and Media. He has been instrumental in creating links between tertiary institutes and industry in New Zealand and internationally. Gray has presented papers on animation research and pedagogy at Melbourne, Germany, the U.K., Japan, Taiwan and South Korea. In recent work, Gray has been exploring the inclusion of 3D virtual reality to animation. Animation and virtual reality share a common fundamental in that they both take place inside an artificially constructed world. This commonality provides a starting point to explore how narrative and direction is affected when virtual reality is employed.