VPET – A Toolset for Collaborative Virtual Filmmaking

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Abstract

Over the last decades the process of filmmaking has been subject to constant virtualization. Empty green screen stages leave the entire on-set crew clueless as real props are often replaced with virtual elements in later stages of production. With the development of virtual production workflows, solutions that enable the decision-makers to explore the virtually augmented reality have been introduced. However, current environments are either proprietary or lack usability, particularly when used by filmmakers without a specialized knowledge of computer graphics and 3D software.

As part of the EU funded project *Dreamspace*, we have developed VPET (Virtual Production Editing Tool), a holistic approach for established film pipelines that allow on-set light, asset and animation editing via an intuitive interface.

VPET is a tablet-based on-set editing application that works within a real-time virtual production environment. It is designed to run on mobile and head mounted devices (HMD), and communicates through a network interface with Digital Content Creation (DCC) tools and other VPET clients. The tool also provides functionality to interact with digital assets during a film production and synchronises changes within the film pipeline.

This work represents a novel approach to interact collaboratively with film assets in real-time by maintaining fundamental parts of production pipelines. Our vision is to establish an on-set situation comparable to the early days of filmmaking where all creative decisions were made directly on set. Additionally, this will contribute to the democratisation of virtual production.

Keywords: *virtual production, filmmaking, on-set editing, collaborative work, production pipeline*

1 Related Work

In 2012, the visual effects company Zoic Studios published the tablet application *ZEUS:Scout*. It provided a physically correct view into the virtual world and enabled the user to perform modifications in the scene by tapping on the multi-touch screen. Another real-time tool called *RTFX* [Northam et.al. 11] constituted a more generic framework. While most of the existing toolsets were designed to perform only one particular task, like editing or rendering, the *RTFX* application built up a client-server architecture to address any DCC tool or game engine. Those solutions were optimized merely for previsualization and thus could not meet the demands of real on-set virtual productions.

ILM's *xLAB* is currently developing a variety of on-set tools for scene viewing and manipulation in virtual production and mixed reality. Most recent work combines a tablet with a virtual reality controller for positional tracking [Wooley 16]. Unfortunately none of these developments are available publicly. It is also unclear how much impact those demonstrated tools had on the actual production process.

Another example is the short film project *Adam* [Efremov 16], which was realized using game engine technology. While this is visually a very convincing demonstration, it does not show how real-time technology enhances the creative filmmaking process in a collaborative manner. *Adam* is also constraint to the use of one specific technology including its asset creation pipeline.

The main difference of our approach, in comparison to the above mentioned examples, is that it can be applied to any central production system.

A previous prototype within our project Dreamspace combined a gesture-recognition controller and a HMD tracked via a motion capture system (Figure 1). The user was able to access all three axes simultaneously while being able to examine the virtual world in a most immersive manner. This approach and its use cases already introduced some promising advancements in the fields of asset modification and pipeline integration. However, concluding surveys on the gesture-recognition approach for example revealed that untrained personnel were barely capable of performing even basic transform tasks like selecting or positioning an object in space [Trottnow et al. 15]. The HMD proved to be a potential solution at first, but it seemed inappropriate for on-set productions as long as gesture-based input devices lack usability.

To solve the problem with gesture recognition, VPET builds on a user-friendly tablet interface. This allows tasks of production and post-production to happen in one logical (data) space where different technologies can be combined. VPET also provides an architecture for using a variety of real-time input and output devices.

Figure 1: *Evaluation of early prototype.*

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2 VPET – A Holistic Approach to Established Offline Pipelines

Various virtual production pipelines have been built around game engine technology, taking advantage of the development capabilities they offer. While this certainly makes sense, it also means a tremendous effort to adapt existing offline pipelines and established tool chains. In this sense, the main novelty of VPET is that it constitutes a generic, real-time, and open framework that can be integrated into any existing workflow.
As a user-friendly alternative, our tool supports trained talent, and also those without exhaustive experience (like the director or other set staff), who being subject to completely new authoring processes might slow down the production. This opens the possibilities to use VPET not only in highly budgeted productions, but also in more amateur ones that do not count with professional staff, leading to the democratisation of virtual production methodologies. Moreover, it allows the people involved in the production to communicate ideas quickly and visually, making the whole process more efficient and effective.
As a collaborative tool, VPET has been built to enable real-time editing of streamed virtual scenes, and can be used with Katana, our own software prototype called LiveView, or any other similar software alike. VPET can also be adapted to any central production software that supports the necessary functions for accessing scene data, allowing VPET to be used in a wide variety of production scenarios. This would require writing a dedicated *scene distribution plugin*.
LiveView combines technology from The Foundry's products *Katana* and *Nuke*. LiveView also includes implementations from several research partners on novel light capture and compiler technology for real-time ray tracing [Leißa et al. 15].

3 VPET - Overview

VPET is an application for tablets running Android, Windows or iOS and has been developed based on the *Unity* engine to explore possibilities for collaborative on-set editing of virtual content. Users can grab a tablet at the film set and start exploring and editing the virtual content, performing simple edit tasks of the virtual elements of the shot in a fast and intuitive way directly on set (Figure 2, left).

Figure 2: *Director using VPET (left). User Interface (right).*

3.1 Supported Features

3.1.1 Virtual Camera

VPET affords to synchronize the virtual camera with the real production camera by streaming tracking data to the tablets. Thereby it is possible to see the virtual elements of the scene on the tablets from the perspective of the principal production camera.
Changing the position of the virtual camera in the scene is possible with multi touch gestures. By rotating the tablet the virtual view is rotated as well. Latest hardware such as Google *Project Tango* can be used to track the position of the tablet allowing the user to explore the scene interactively. Professional camera tracking equipment like *ncam* is also supported.

3.1.2 Object Editing

An intuitive interface reflects the potential and complexity of the underlying architecture. It enables anyone to edit position, rotation and scale of objects present in the streamed scene as well as parameters of the virtual lights.
To further enhance the user experience, alternative interaction approaches uncommon in typical DCC applications have been developed. For instance, scene objects can be either carried around in the scene by attaching them to the tablet's viewport or repositioned by simply tapping on the ground. Additionally, an orthographic top-down view is provided to offer a better scene overview and organisation.

3.1.3 Animation

The user is able to create and modify keyframe based animations on scene objects. Those animations are then playable on a global timeline which is synchronized between all participating clients. Animation queuing allows to author a specific animation and trigger it on demand. This feature was implemented upon request from one of our project partners, as it was a functionality they were missing in established virtual production tools.

3.2 Graphical User Interface

The user interface builds on icons and navigation principles common in state-of-the-art applications [Bowman 05]. Menus and buttons are designed for a two-handed tablet resting position and occupy as little screen space as possible. A context-dependent circular menu encompasses the most important functionality for asset transformation and animation editing while less frequently used features remain hidden in a menu accessible through a button in the upper right corner (Figure 2, right).

3.3 Architecture and Integration

The architecture of the proposed system is based on the three main components: *scene distribution plugin, synchronization server* and *VPET application* (Figure 3).

3.3.1 Scene Distribution

Upon initial start-up of VPET the *scene distribution plugin* streams the scene-relevant data to the clients. This is an essential novelty in terms of pipelining and data preparation. Once the scenes are prepared using Katana, an established software for look development, lighting and shading, no complicated setup process is needed to transfer load and configure a client.
A scene that is intended to be used in a VPET real-time environment must contain relatively lightweight versions of assets in terms of textures and polygonal count. These low-res versions are streamed to the mobile client instead of the full geometries. To achieve this, additional steps have to be performed to provide real-time optimized assets. This has proven to be a time

consuming task and could be improved by directly implementing an automated process during export.
Compared to current approaches, where all production data needs to be shifted to a game engine, our solution presents the advantage of allowing a selection of an asset subset that are editable in real-time with reduced overhead cost. Furthermore, it gives the opportunity to return to the final offline production process afterwards.
This is a general approach and needs to be implemented through the plug-in interface at the main application. The plug-in identifies assets to be streamed and converts the meshes, the textures and the scene topology in a format handled by the Unity 3D Engine without further processing on the tablet side. To overcome the boundaries of different data representation between the C++ server plugin and the C# client, an additional reinterpretation of the streamed data is realized. Every incoming data block is split into chunks, which are then interpreted as scene, mesh or texture data.
All changes performed during the production are recorded and can be fed back to the production pipeline, in our case LiveView, where further postproduction steps are carried out. Objects that shall later be edited via VPET receive a special attribute.

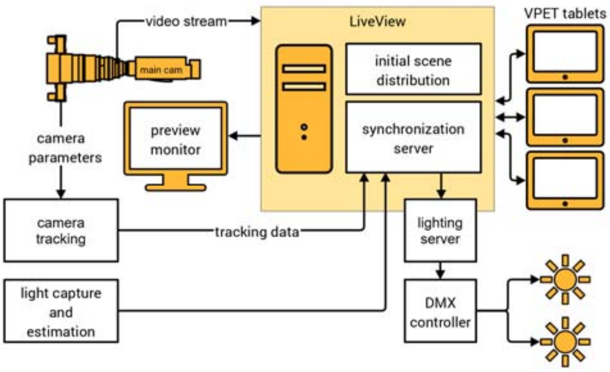

Figure 3: *Schematic view of the production setup.*

3.3.2 Scene Synchronisation

Multiple *tablets* running the VPET application can be used in parallel to explore and edit the virtual scene simultaneously. All changes made to the scene on one VPET tablet are immediately sent to the *synchronization server,* which then communicates those changes to all other attached clients (tablets, LiveView or Katana). In this sense, it works as a fan-out server for all incoming messages. All communication is implemented through the *ZeroMQ* distributed messaging library. A publish-and-subscribe pattern is used to provide the possibility to only send the relevant messages for each individually configured message-receiving client.
The synchronization server also provides an interface to receive real-time camera tracking data. The camera data is transferred to every subscribed client and can be used to simulate the main camera in the virtual scenery.
Thanks to the communication through network sockets, VPET can be connected to any application that provides a formatted scene description and accepts messages carrying parameter updates.
Currently a direct interface to LiveView/Katana exists, and it is capable of streaming assets to the clients, as well as receiving changes made by VPET. It prepares and holds the asset data and sends a binary package to a client on request. A real-time scene holding 180k vertices and 10MB textures requires about 10 seconds for transfer and recreation on the device. LiveView/Katana listens on a second port for incoming parameter updates and immediately applies them.
Synchronisation of animated content turned out to be a major challenge because animations are authored on the individual client tablets, which run at arbitrary frame rates. As such, the broadcast of updates to LiveView and other clients can produce undesired artefacts in the recorded data. A possible solution is to interpolate the animation data based on a global time code.

4 Light Capture and Harmonisation

Another branch of the project focused on novel light capture with particular scope on estimating the position, falloff and cone angle of multiple light sources on a set [Einabadi and Grau 2015]. This information is used to harmonise real and virtual lights for better integration of computer generated content. A set survey is performed to estimate the light situation. This process takes about 15 minutes. The results are fed into the LiveView system where they can be distributed to the VPET clients. Light parameters like intensity and colour can now be edited using the tablet. In return, the real light parameters are updated via a DMX controller interface, for instance, when using LED panels. One big challenge was the varying interpretations of light parameters across offline render and real-time engines, resulting in scenes that appeared too dark or too bright.

5 Production Evaluation

VPET has been evaluated by experts and novices alike in various productions along different stages of development (Figure 4).
A practical use case of our project developments was the documentary film *Skywriters*. The director used VPET for fine-tuning position and animation of CG planes while constantly reviewing the composited output. The Skywriters crew highlighted the image quality of the Live View render as surprisingly good in comparison with other available solutions. In general, the VPET setup convinced the team of the feasibility of having a virtual production as an interactive and collaborative workspace.
Another positive experience was undergone during the public at the FMX2016, where an evaluation questionnaire was conducted among a group of experts. 80% confirmed an advance to the current state-of-the-art tools, 10% did not agree, and the remaining 10% left a clear open answer. Performance of the system was rated on a scale from 1 (poor) to 5 (highly efficient). 50% rated with a 3 and another 50% with a 4, meaning that the system performed quite efficiently. 70% agreed that this technology could change and improve the preproduction process, 10% negated it, and 20% were undecided. When asked if the technology could improve onset and post-production processes and in general enhance creativity, 90% agreed, while 10% did not share this point of view.
A final evaluation was carried out during a five day co-production of a pilot for a new TV series format. The partner was *Stargate*, a commercial company with branches worldwide and major expertise in virtual production. While evaluation was not solely focused on VPET, the feedback on this particular aspect was very positive. The VPET tools were intentionally used for light, set and animation editing. On the last day of this production VFX and animation companies of the region Stuttgart (*AMCRS*) were invited to get to know the technologies and perform an expert user evaluation. The results of this evaluation pointed out that the

proposed system offers an intuitive solution to interact with the digital elements of a virtual production, maintaining at the same time flexibility on the central production system.
In general the feedback was positive in terms of usability and ease of access. One of the elements that underwent multiple redesigns based on output of the evaluation process was the graphical user interface. Also, setup times between scenes and preparation of content is a point for future improvement.
Among the most relevant features requested by the expert user group were improvements regarding the viewport navigation and extended features for virtual scouting (e.g. lens simulation).
Future developments could address complex character animation capabilities and a constant mapping of light parameters across the entire production system.
Within our project another major strand researches immersive experiences and its application in performing arts through a series of artistic installations. VPET was also successfully used in such environments.

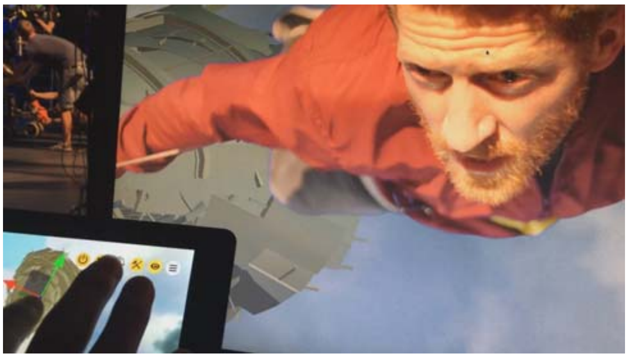

Figure 4: *Evaluation during Filmakademie production, actor in flight rig in front of back projection, VPET controlling debris.*

6 Democratisation of Virtual Production

The majority of the existent virtual production pipelines are proprietary and mostly apply for large scale productions with big budgets. Through the holistic approach of VPET it is now feasible to realize virtual production-like scenarios at much lower costs and efforts. For instance, Katana is used to define the look of a shot. By using VPET, a collaborative session could be established where all creative team members can interactively edit the content of this specific scene. An offline renderer connected to the system will reflect these updates and provide high quality results. This will ideally lead to the establishment of new production processes that will enormously enhance creativity by creating a truly collaborative environment with reduced post-production cycles.
VPET is released under an open-source license to share the tools with a wider user group and to take advantage of collaboration with the community. This aims at improving the editing tools for a wider audience and developing new plug-ins for different main applications.

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