Film Virtual Production Based on Digital Twin

Jianjun Zhao[1,a], Jun Chen[1,b]

[1]Department of Film and TV Technology, Beijing Film Academy, Beijing, 100088, China.

[a]zhaojianjun@bfa.edu.cn, [b]chenjun@bfa.edu.cn

Abstract

With the development of virtual reality technology, film virtual production has become more and more popular. Virtual production combines virtual reality with real-time engine technologies to enable production crews to see their scenes unfold as they are on the set. However, due to the inconsistency between the real world and the virtual world, the design of the virtual space cannot be fully realized in the actual shooting. To solve the problems, this paper proposes a system of virtual production based on digital twin. By means of software and hardware co-simulation method based on digital twin, the changes in the virtual space correspond to the changes in the physical real space, and the changes in the actual physical world are synchronized to the virtual space. The method in this paper can ensure the consistency of the virtual and the real in the process of virtual production, thereby improving the feasibility and effective of virtual production.

Keywords

Digital twin, Virtual production, Virtual reality.

1. Introduction

Film is the combination of technology and art, and each major revolution in film technology is an extension of the industrial revolution. In recent years, with the explosive development of virtual reality technology, one of the latest technological revolutions in film production is virtual production.

Virtual production is a broad term that refers to the use of computer technology to assist in film production [1]. Different from the traditional film real-time shooting production, the virtual production technology is carried out in a fully digital virtual environment, involving virtual scenes, virtual characters, virtual lights, and virtual props. In the film production, virtual production is carried out during the early preparation stage. With different forms of visualization, it is convenient for filmmakers to preview the real shooting perfectly. Compared with the traditional film production process, virtual production means a leap in film technology in the direction of "more digitalization". It is also called "the next-generation film industry technology" by the industry. Process".

Virtual production technology can enhance creativity and save time by making visual previews in a virtual environment. Even using a real-time engine tool can transform a traditional linear pipeline into a parallel process [2], blurring the boundaries between pre-production, production and post-production, thereby improving the fluency and collaboration of the entire pipeline.

The development of this technical process has profoundly changed the film production process and composition [3,4]. There are special pre-animation animation short film production companies, which previews the whole film before filming. By designing 3D preview films, it can greatly dig out creativity and determine the overall process before the shooting starts. It also helps gain interest from investors and let the producers have some judgment. In the filming and even post-production, there is also the participation of the preview department, which can be a functional visual communication tool between the director and the visual effects team.

There are a large number of films that use this production method. in 2009, Avatar used virtual production technology [5], and Gravity performed a preview of the shots in the early stage[6], thereby saving time during the actual shooting phase, and its production process uses virtualization

technology has brought innovation and change to production methods. The Jungle Book guides actors to interact with virtual animals by watching real-time previews[7].

2. Workflow and problems of virtual production

As shown in Fig. 1, in the traditional film production process, film production usually progresses linearly, from pre-design to technical testing, on-site shooting, and finally to post-production. While in the virtual production, the technology such as visualization participates through workflow of film production [8], which makes film production more complicated, but also more efficient. After adding different types of visual preview in the film production process, in order to improve the effect of the preview and make it as consistent as possible with the final presentation, the virtual assets required by the film need to be prepared before the preview. The project was developed in the early stage of the project, so the post-production in the traditional process is gradually "front-end", which has also become a new production process for large-scale and high-standard films.

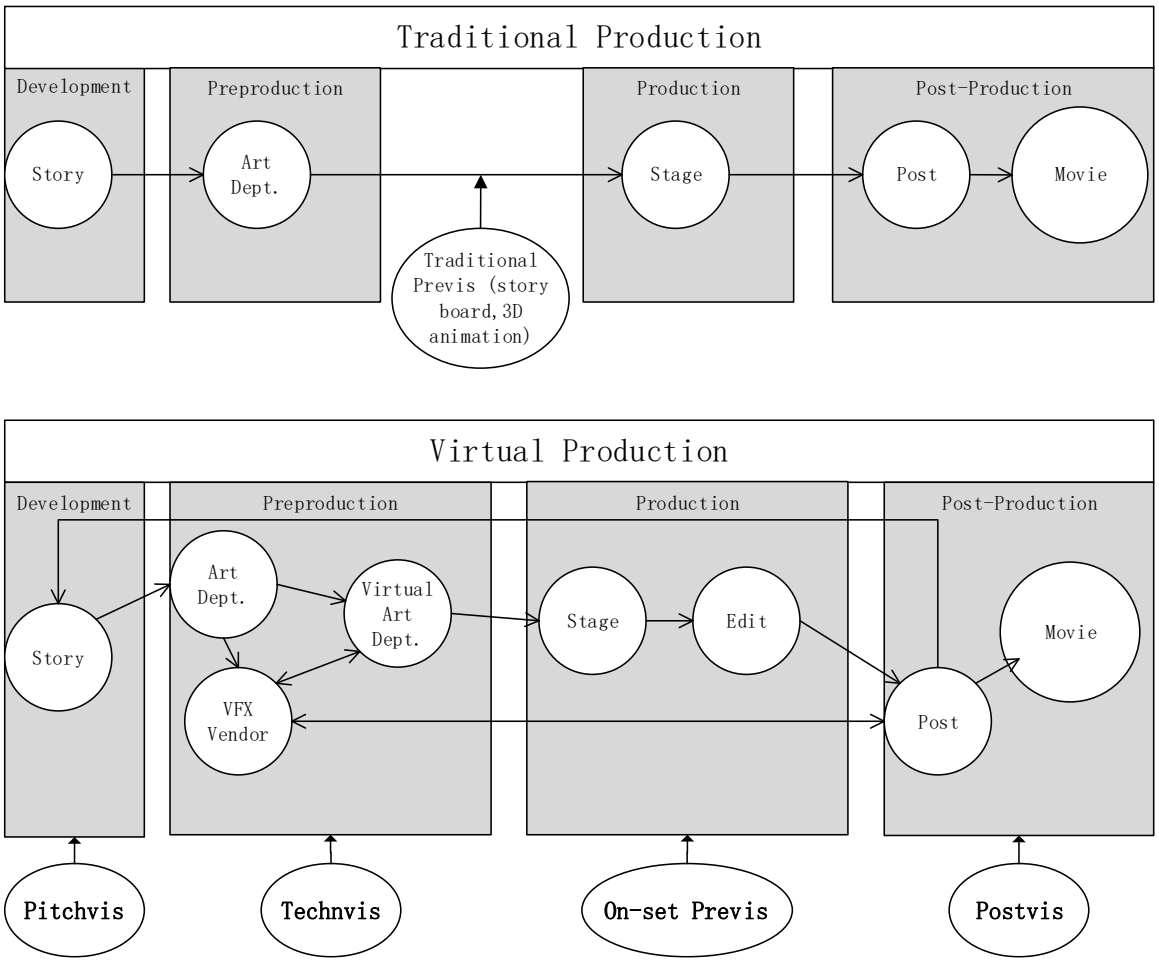

Fig 1. Workflow of Virtual Production and Visualization

Virtual production workflows are faster, more creative, and more iterative and collaborative, helping filmmaker better understand the final shots and scenes in the production process. By constructing a digital virtual scene in advance, the film production team can arbitrarily place the camera angle and position in the virtual space, and control the movement of the camera to shoot the preview shots. These virtual scenes and virtual cameras' setting can be changed in real time, providing more accurate real lighting and Photorealistic results. Virtual production workflows allow filmmakers to better understand the final shots and scenes early in the production process. Using pre-built virtual scenes, directors and cinematographers can discuss the different positions of the camera in a virtual reality

environment and compare different shots to achieve the best narrative effect. These technologies can not only help directors and cinematographers exert their creative power in real time through real-time display and control of narrative pictures, but also have a good guiding role for actors.

However, there also has some problems in virtual production as follows:

Firstly, film productions involve a large number of special effects material production, many of which are not without uncertainty. This production process is usually linear and includes development, pre-production, production, and post-production stages. For example, the virtual character movement generated in the previous special effects production cannot interact with the actor in actual shooting. The iterative modification of this part of the content is very challenging and costly, and it is often isolated from the actual shooting. It is a great challenge to get involved in real-time shooting in real time.

Secondly, it is difficult to Interactive control the lighting effects before and during shooting. how the lighting effects in the preliminary preview guide the lighting in the scene, and how the lighting adjustment on the scene can be matched with the virtual lighting. At present, these tasks require a lot of manual adjustment, which affects the shooting efficiency.

Thirdly, the camera's motion planning may not be fully realized during shooting. For example, designing a very complicated camera operation may not be able to be realized in the shooting scene. The creative ideas in the virtual production link cannot guarantee that the corresponding shots can be shot on the scene, and the special effects production of the film may not be completed.

In summary, the main problem of virtual production in the current virtual production is that the content of visual preview may not be realized, and even if it can be realized, it will cost a lot. Also, in real film shooting, related contents in virtual space and real world cannot be controlled synchronously. Like the problems in manufacturing industry, these problems are basically caused by the inconsistency between the content in the virtual space and the content in the physical real world. The digital assets in virtual production may not be completely applied correctly in the physical real environment. Most of these problems can be corrected or fixed in post-production. However, this not only requires high production costs, but also can only complete some major part modifications. In the worst case, due to time constraints, iterative modification cannot be performed at all, which leads to the failure of the entire project.

In the fields of industrial manufacturing, in order to meet the real-time monitoring and synchronization of the physical world activities in the virtual space, and to enhance the connection between the physical world and the virtual world, the concept of digital twin came into being ([9], [10]).

Digital twin refers to the establishment and simulation of a physical entity, process or system within an information-based digital platform. With the help of digital twin, it is possible to understand the status of its physical entities on an informatized digital platform and control the predefined interface elements in the physical entities.

The emergence and rapid development of digital twin technology have provided new ideas for solving the above problems in virtual production. This article hopes to use digital twin to implement digital asset management in virtual production, so that digital assets correspond to physical real world.

3. Digital twin-based film virtual production

The emergence and rapid development of digital twin technology have provided new ideas for solving the above problems in virtual production. This article hopes to use digital twin to implement digital asset management in virtual production, so that digital assets correspond to physical real world.

In virtual production, the key problem is the interaction between virtual elements and real elements. The interaction involves two aspects: the operations in virtual space can be realized in the whole process of film shooting, and the elements in the real world can be interactively controlled in the

virtual environment. This information consistency between virtual and real-world objects is the main problem that digital twin technology needs to solve in virtual production.

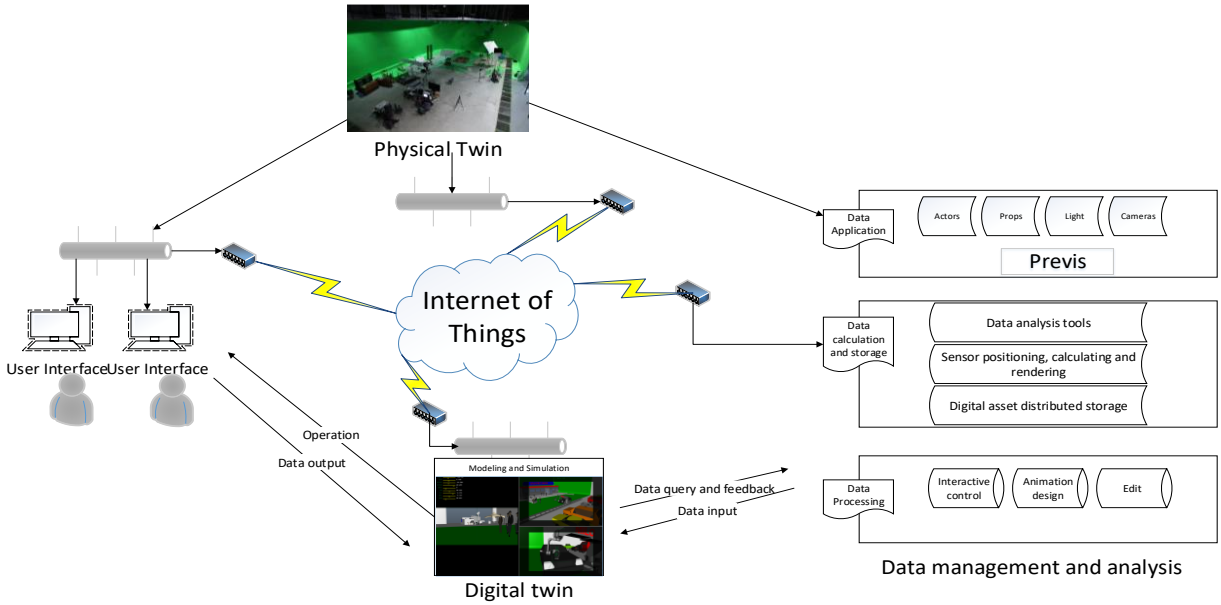

Fig 2. Digital Twin System for Virtual Production

To solve the problem, we propose the digital twin system for virtual production process. As shown in fig. 2, the shooting scene is a physical twin, which contains all the elements involved in real shooting. To ensure interactivity with the elements in the virtual scene, we build a digital twin containing digital sub-models of all the elements involved. By means of sensors, the information of all elements in the shooting scene can be shared and interconnected in real time in the local Internet of Things. In previs, in addition to visual effects and animation elements, all real live elements can also be displayed, and physical and virtual elements can be fully visualized in the preview.

From the perspective of virtual space mapping and collaboration, digital twin system of virtual production is shown as Fig. 3. In the virtual space, multi-level modeling and simulation capabilities are needed for shooting props, shooting scenes, shooting equipment, shooting lights, and shooting systems. In the physical space, a complete shooting system management capability, equipment for shooting various elements of the scene, perception and interconnection, and digital insertion analysis and service capabilities based on the Internet of Things are required. At the same time, in terms of connectivity and collaboration, information integration and closed-loop feedback capabilities in virtual and physical spaces are required.

Compared with the existing virtual production process, digital twin-based virtual production emphasizes visual preview, and attaches importance to tracking, matching and interaction between the virtual space and the real world. Through sensors and spatial positioning technology, objects in the virtual space are interacted with objects in the real world.

Digital twin technology focuses on solving the inconsistencies between the real world and the digital world. The most important content is the parameter connection of the camera, the interaction between actors, the control of props and lights, and the maintenance of the virtual scene.

The twin in the virtual production system is a hyper-realistic model of the entire shooting process. It can be used to simulate, visualize and judge whether the elements involved meet the shooting requirements in the virtual space. It is an integrated model composed of many sub-models, shown in Fig. 4. Especially, different with digital twin in industry, in the virtual production, in addition to the real-time feedback of the state of the physical space, it also needs to interact and render with the virtual special effects elements in real time.

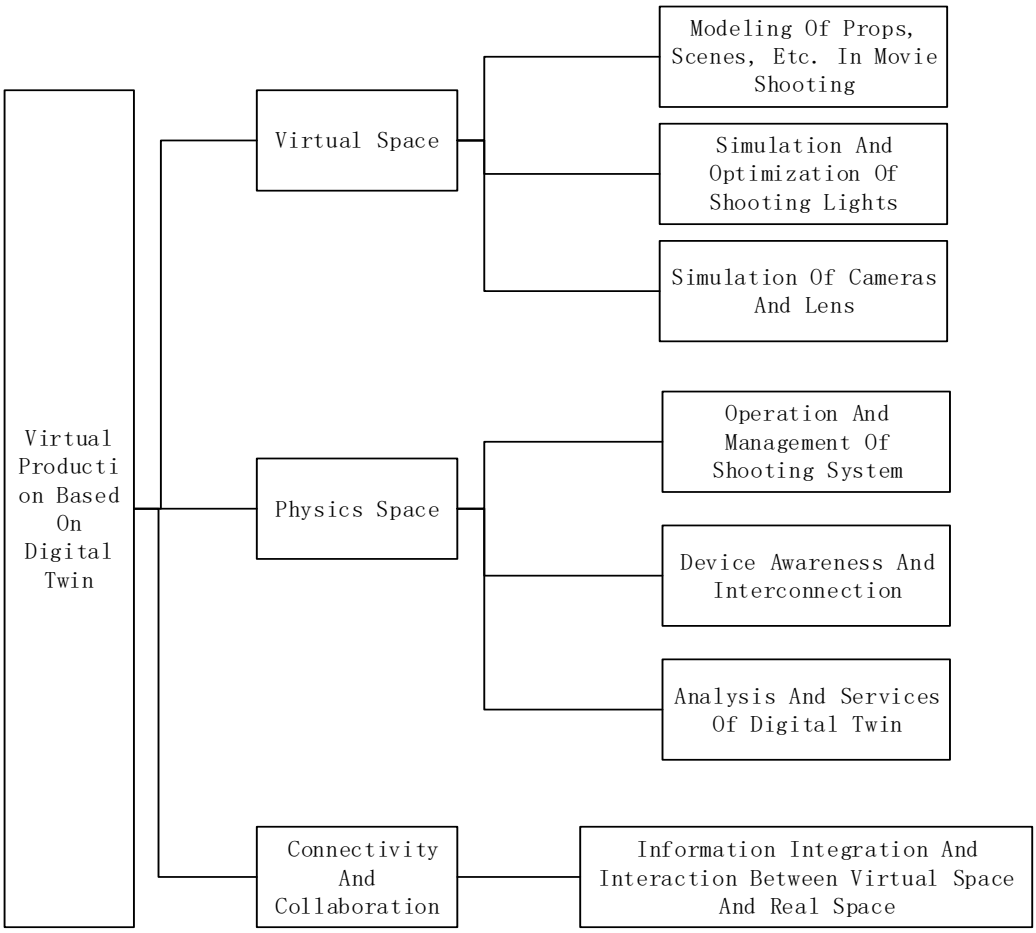

Fig 3. Technology System of Virtual Production Based On Digital Twin

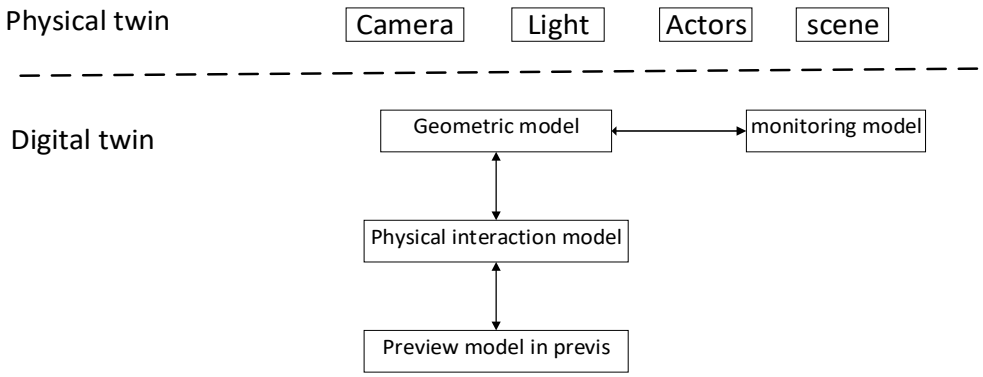

Fig 4. Model Elements of Digital Twin in Virtual Production

3.1 Camera

Sometimes, in pitchvis and previs of current virtual production, the positions of shooting camera are mainly obtained through the optical motion capture system to control the position of the virtual camera. This method can only make the cinematographers control the position of the camera, but not the internal parameters of the camera, such as focus focal length information.

Based on the concept of digital twin, we build a camera model and control various parameters of the camera through sensors. In addition to controlling the external parameters of the camera, we can also real-time control the internal parameters of the camera, using hardware-in-the-loop simulation equipment and TOF(Time of flight) camera. This simultaneous control of all parameters of the camera and lens can greatly improve the usability of the visualization.

In particular, the motion control system can be used to control the internal and external parameters of the camera in the virtual environment during live shooting. In the existing camera motion control system, with the help of computer-controlled camera motion, the user only needs to set a few key positions to allow the camera to accurately complete the corresponding motion, and this motion can be repeated accurately. Therefore, in the camera motion control system, digital twin technology can be used to monitor and adjust the position and orientation of the camera. The specific implementation method is to use a sensor to monitor the position and orientation of the camera, and transfer the data to the virtual space for processing in real time, and to correct and adjust the data of the motion control system in time when the position and orientation of the camera deviates. The use of digital twin can not only make the camera motion more accurate, but also better monitor the operation of the camera motion control system.

3.2 Light

In the current virtual production, in the early lighting design, the gaffer arranged the lighting completely according to the content of the virtual scene. When live shooting, the lighting of the virtual scene is often inconsistent with the lighting of the shooting scene, which requires manual adjustment. This adjustment is not only time-consuming and laborious, but also the virtual light and the actual light cannot be completely consistent, and the elements in the virtual scene and the real scene cannot be coordinated.

In this paper, based on digital lamps, interactive control of live lights is performed. In live shooting, digital lamps in virtual space and real world is connected and interactive controlled by sensors. In the preliminary preview, the lighting parameters in previs is set according to the real digital lamps. The adjustment of digital lamps in living shoot can also directly control the lights in the virtual scene through sensors. This interactive control method can ensure the consistency of lighting in virtual space and real world.

3.3 Interaction between actors and props

In the current virtual production, after the objects in the virtual scene are designed in the early stage, they generally no longer interact with the actors. If the items need to be interacted with actors, they need to be designed by post-animators, which carry out many manual iterative changes. Furthermore, when living shooting, the movement of virtual objects cannot be controlled in real time and it is hard for actors to interact with them in the virtual environment.

Based on the technique of digital twin, we install sensors on objects in the real world and bind them to objects in the virtual scene. The objects in the real world and the virtual environment have the same position and orientation. When the actors touch and move the objects in the reality, the objects in the virtual environment will also move, so that the animation of the virtual objects can be previewed in the virtual environment. Thus, it ensures the consistency of interactive control of roles.

3.4 Scene

In the current virtual production, in order to synthesize special effects shots of actors in virtual scenes, most of the actors perform in front of the green screen. The huge and bulky green or blue screen layout is a very laborious task, and when using the traditional green or blue screen, gaffers should light usually based on personal experience. In addition, when actors perform in front of the green screen, most of the crew can only see the green screen and cannot fully participate in the production of the film.

Based on the concept of digital twin, and current projection technologies such as Led screen display are used to project real-time images behind actors. This approach can bring huge advantages. It not only enables most people in the field to work in the virtual scenes that are shot, but also increases the immersion of the actors and avoids "green-screen fatigue".

In addition, when shooting in an actual scene, you can use 3D modeling to quickly generate a model of the actual scene and carry out preliminary design in the virtual engine.

The above-mentioned digital twin solution can interactively control various elements in the film production process, so that it maintains consistency between the virtual world and the physical real world in the film shooting process, thereby improving the efficiency of film shooting and ensuring the shooting progress.

4. Conclusion

Film production is a high-tech job. The continuous improvement of computer technology is a prerequisite for the development of virtual production. With the development of computer software and hardware, especially the outbreak of virtual reality technology, virtual production has brought a more collaborative workflow, in which various departments involved in the project can share resources and creative visions. With the continuous progress of technology, virtual production will be more and more widely used in film production.

Virtual production technology is a collaborative production technology in the virtual world and the physical real world. Virtual production involves many virtual assets, and there will also be an increasing number of virtual assets used in film production. How to manage, maintain, and detect these virtual assets will be an urgent problem in virtual production. Remotely managing these virtual assets based on digital twin technology is a feasible solution in the future.

Acknowledgements

This work has been supported by the Beijing Municipal Education Commission science and technology planning project (KM201810050001), Scientific and technological innovation service capacity building-High-tech discipline building-Film (PXM2019_014220_000096).

References

[1] Information on: https://80.lv/articles/epic-games-releases-free-virtual-production-field-guide/

[2] T. De Goussencourt, J. Dellac, and P. Bertolino. A game engine as ageneric platform for real-time previz-on-set in cinema visual effects. International Conference on Advanced Concepts for Intelligent Vision Systems. (Catania, Italy, Oct. 2015.), pp 883-894

[3] Q. Galvane, I.S. Lin, M. Christie and T. Li. Immersive previz: VR authoring for film previsualisation. ACM SIGGRAPH 2018 Studio, (New York, NY, USA, 2018). pp. 4:1–4:2.

[4] Q. Galvane, I. Lin, F. Argelaguet, T. Li and M. Christie, "VR as a Content Creation Tool for Movie Previsualisation," *2019 IEEE Conference on Virtual Reality and 3D User Interfaces (VR)*, (Osaka, Japan, 2019), pp. 303-311

[5] Information on: https://www.wired. com/2009/11/ ff_avatar_5steps/

[6] J. Sands, Technical filmmaking and scientific narratives: Has science overtaken fiction in recent science fiction? An analysis of Gravity, Interstellar, and The Martian. South African Journal of Philosophy (2018)37 (1):53-65

[7] E. Clark , D. Galella, S. A. Jones, and C. Young. 'I Wanna Be Like You': Negotiating. Race, Racism and Orientalism in The Jungle Book on Stage. The Disney Musical on Stage and Screen: Critical Approaches from 'Snow White' to 'Frozen'. (London: Bloomsbury.2017) pp. 185–204.

[8] T. Muender, T. Frohlich, and R. Malaka. Empowering creative people:Virtual reality for previsualization. the 2018 CHI Conference on Human Factors in Computing Systems, (New York, NY, USA, 2018). pp. 630:1–630:6.

[9] B. Schleich, N. Anwer, L. Mathieu and S. Wartzack. Shaping the digital twin for design and production engineering. CIRP Annals - Manufacturing Technology, Elsevier, (2017), 66 (1).pp. 141-144.

[10] F. Tao, J.F. Cheng, Q.L. Qi, and et al. Digital twin-driven product design, manufacturing and service with big data. Int J Adv Manuf Technol (2018) 94, 3563–3576.