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**Master of Arts thesis abstract**

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**Abstract**

This Master of Arts thesis is made for the New Media study programme in the School of Arts, Design and Architecture at Aalto University under the supervision of Matti Niinimäki and with advising from Nuno Antonio Do Nascimento Correia and Teemu Määttänen.

This study is focusing on the topic of real-time motion capture and game engine technologies in contemporary dance with the goal to discover how these technologies can augment contemporary dance, both in the visual and audio domains, in a way in which sound, visuals, and choreography influence one another.

The methods being used to achieve this goal include devising mixed reality audiovisual dance performance, as a part of practice-based research methodology, related work review as well as an interview with a field expert.

Although the topic of motion capture in contemporary dance is fairly well-researched there is a clear shortage of studies on the ways game engines could be utilized in this segment of art and even less studies are conducted on modern hybrid club music and its influence on contemporary dance. Current research fills these gaps.

This study includes a brief overview of Dance and Technology art movement, elucidates motion capture and game engine technologies as well as attempts to define modern hybrid club music. It covers a broad selection of case studies from contemporary dance segment related to each category as well as the writer's own perspective and experience with motion capture and modern hybrid club music. Furthermore, this research includes an interview with pioneering virtual performer, Sam Rolfes, who is actively using real-time motion capture, game engines, and other real-time tools in his artistic practice and finally, it explains in great detail the whole design process behind the mixed reality audio-visual dance performance piece "ROCK/STAR Vol.1", an artistic component of this research.

Using various game engine technologies together with the real-time motion captured data can help to establish a greater connection between different artistic domains of the performance, as well as provide a much stronger feeling of a world and a story for the performer who is wearing a suit. The ability to execute things in real-time, that this tech is offering makes it possible for performers to respond to one another, as well as the audience and the current moment in time, thus embracing and crystallizing the originality and specificity of the moment.

**Keywords** motion capture, game engines, contemporary dance, dance and technology, mixed reality, audio-visual art

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# PREFACE & ACKNOWLEDGEMENTS

I want to express my gratitude to my wonderful thesis advisors Nuno Antonio Do Nascimento Correia and Teemu Määttänen as well as my thesis supervisor, Matti Niinimäki, for their guidance, help and valuable advice with theoretical and practical parts of this research.

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Also my dear friends for their support!

*Helsinki, 31st of July 2023*

*Erika Rustamova*

# 1 INTRODUCTION

In recent years the world has seen numerous examples of using motion capture and game engine technologies outside of their direct and immediate application. Increasingly more professionals, working on the intersection of performing arts and technology have diverted their attention to this combination of mediums with the goal to create impressive stage performances, where the performer's motion captured with the help of specific devices affects the live visuals in real-time. One of the first performances of a kind was done in the segment of dance and technology already in the early 2000s: collaborations of OpenEndedGroup with Merce Cunningham and Trisha Brown along with other similar projects revealed a great potential and set the ground for using motion capture in the context of contemporary dance.

Motion capture or MoCap is the name for the technology that involves measuring the object's position and orientation in space and recording that information in digital form (Salter, 2010). It is based on tracking the motion of markers or sensors attached to the body, which are then translated into computer data, a digital representation of the movement. MoCap is used in many different fields starting from sports, health, and military to various entertainment sector fields such as TV, film, animated cartoon, and video games (Adobe, 2023). In those fields, MoCap is frequently used to produce realistic animations for movies, video games, as well as virtual reality experiences.

The usage of MoCap in performing arts is similar to the one in the entertainment sector: production of realistic animations and special effects for post-production as well as for real-time purposes. In theatre and stage performances, motion capture can be used to manipulate digital avatars or visual effects with the performer's movement input in real-time (Akbas et al., 2022). The process typically involves actors or artists wearing motion capture suits equipped with sensors that track their movement, which is then mapped onto digital characters in real-time or during post-production. This process facilitates integration of digital elements into live performances, which can create a much stronger connection between different elements of the performance.

As technology has improved and grown more accurate, accessible, and easy to use, motion capture has become even more significant in the performing arts. Active usage of motion capture in performing arts resulted in a larger variety of performances, including Virtual Reality(VR) and Extended Reality(XR) experiences, as well as enabled performers to collaborate remotely (Akbas et al., 2022). Therefore, motion capture opened a variety of exciting possibilities for performing arts, creating a new quality of interactivity and immersiveness (Salter, 2010).

In such form of performing arts as contemporary dance, MoCap is commonly used to record and analyse the movement of dancers. This information can then be used to create detailed animation, visualize and augment choreography. Through this process, dancers and choreographers can refine their movements, explore new creative possibilities, and document their work for future generations (Raheb et al., 2019). In the context of this research, I am particularly interested in combining motion capture with game engine technologies and exploring how together they could enrich contemporary dance.

Game engines have become an increasingly popular medium for artistic expression in recent years. For example, game engine mechanics allow artists to create responsive, immersive, and visually captivating experiences. Game engines facilitate combining elements of virtual reality, real-time rendering as well as experimental Visual effects (VFX) and storytelling, which expands the possibilities of artistic expression, making them truly limitless (01 Overview: Explore by industry, n.d). In the context of contemporary dance, game engines can for example be used to animate impressive special effects and avatars with the performer's movement input. They can be used to establish a stronger connection both between the performer and the live visuals, between the performer and the audience as well as between various parts of the performance. Furthermore, they can be used for visualizing choreography, experimenting with physics simulations, and creating VR dance pieces.

Along with motion capture and game engine technologies, another significant component of this research is a movement in contemporary electronic music, modern hybrid club music. This study attempts to explain this musical phenomenon through the concepts of 2 bigger musical movements: Deconstructed Club and Hyperpop. "Deconstructed Club is an experimental style of electronic music characterized by a post-modernist approach and an abrasive or dystopian tone." ("Deconstructed Club" n.d., Deconstructed Club section, para. 1) It breaks the conventions of dance music such as four-on-the-floor beats, steady tempo, and constant mix with uplifting "anarchy, proposing a sonic locus where ballroom breaks, field recordings, rap a cappellas and heavy metal are reconfigured" into eclectic dancefloor mashup (Nikolay, 2019). According to Courage, Hyperpop was born on the intersection of EDM and traditional pop music. It has influences of electroclash and witch house as well as dubstep, chiptune, and cloud rap (Courage, 2023). Both of the musical movements are characterized by eclectism, genre fluidity, and genrelessness.

All these elements introduced above are going to constitute the very essence of this study, namely: real-time motion capture and game engine technologies in the context of contemporary dance. Even though the subject of motion capture in contemporary dance is fairly well-researched, there is a clear shortage of academic studies on the integration of game engine technologies into contemporary dance. Even less research is carried out on the topic of modern hybrid club music and how it affects contemporary dance. Thus, this particular combination of research elements also determines the value of this study for academic discourse.

Besides there being a research gap on the stated topic, my motivation to explore it is also highly personal and started with me attending The "Opera + Flow" event hosted by Finnish National Opera in August 2019. The program showcased a real-time audiovisual performance by duo Fractal Fantasy and *Autobiography Edits*, "a dance show featuring live score by Jlin and 10 dancers performing choreography designed by Wayne McGregor" (Burgess, 2019). Both shows had a great emotional impact on me, not only because I was a fan of Fractal Fantasy's and Jlin's music from before, but also because of the level of connection between different mediums and the level of immersiveness that technology used in both performances could offer.

A year after the show I already found myself studying in Aalto Media Lab. Throughout my studies there all of my artistic projects and the majority of the courses I took focused on embodied interaction, and more specifically on motion capture. During my last year in Media Lab, I started to work with Game Engines as they proved to be the most sustainable and powerful in both working with

real-time MoCap as well as interactive mechanics and special effects. Thus, I find researching the subject of using real-time motion-capture and game engine mechanics in the context of audiovisual dance performances to be a logical continuation and completion of my studies in Aalto Media Lab.

In this research paper, I aim to explore the application of motion capture and game engines in the field of contemporary dance and audiovisual performances, answering the following research question: "How can real-time motion-capture and game engine technologies augment contemporary dance, both in the visual and audio domains, in a way in which sound and visuals influence each other"? In order to answer this question, I conduct a related work review, interview the expert in the field of virtual performance Sam Rolfes, and finally devise my own real-time audiovisual mixed reality dance production in collaboration with sound artist and choreographer as a part of my practice-based research methodology.

# 2 METHODOLOGY

Current research applies the following methods: Practice-based Research methodology, complemented by related work review and interview with excerpt in the field of virtual performance, Sam Rolfes. The artistic research, conducted according to Practice-based Research, became a main source of practical knowledge and insights on the topic of motion capture and game engines in contemporary dance. Related work review on the topic of Dance and Technology starting from the late 1980s helped to establish connection between my own practice and predecessors that were using similar technology already decades ago and understand the historical context, whereas the interview with Sam Rolfes helped me to get a state of art perspective on MoCap and game engine technologies in contemporary dance and performing arts in general, that is not necessarily available in the written sources.

I approached current research in the very order these methods are being introduced in this chapter, as first I aimed to obtain my own knowledge and insights from devising my own artistic production and only then was I ready to analyse my work and search for an answer to my research questions through a prism of historical and contemporary context on the topic of Dance and Technology.

## 2.1 PRACTICE-BASED RESEARCH

Practice-based Research methodology plays a central role in my thesis work, as I consider my thesis's artistic production to be a main source of knowledge and insights on my research topic. In her Practice-based Research guide, Linda Candy defines Practice-based Research as follows: "Practice-based Research (PBR) is an original investigation undertaken in order to gain new knowledge partly by means of practice. Claims of originality and contribution to knowledge may be demonstrated through creative outcomes in the form of artifacts such as painting, music, designs, models, digital media, or creative events such as performances, installations, and exhibitions" (Candy, 2006, p. 3). Even though the importance and specificity of that knowledge are articulated in words, it can

be fully understood only when experiencing the outcomes of research. Textual description should include the documentation and analysis of research process in order to prove the writer's position and demonstrate critical reflection (Candy, 2006). From the words of Barret and Bolt, in PBR, the practice itself becomes a primary means of inquiry and discovery, and the research process is integrated into the creative practice. PBR involves an iterative process of creating, reflecting, and refining, where the researcher generates new insights and understandings through their practice and then reflects on these insights to inform further development of the practice. Thus, the goal of PBR is to generate new knowledge or insights that can advance understanding of the relationship between theory and practice (Barret & Bolt, 2014).

Current research adopts PBR in several different ways. One PBR method I was actively practicing in my work was Reflective Documentation, which included a project diary, interviews and discussions with my collaborators as well as talks with my advisors and other field practitioners. Further PBR method that was really crucial for both the studio work and the academic part was unpurposeful experimentation with the medium. Instances of this experimentation included placing the 3D character into different Unreal Engine Blueprints (First-person shooter, Third-person shooter, spectator camera), making a human performer animate different 3D characters or multiple characters at once, and seeing, what value does it bring to the performance and where does it direct the process. Throughout the course of the studio work, I constantly returned to my research question, trying to keep it at the core of the creative decision-making process, which is also quite characteristic of Practice-based Research.

The artistic part of the research was planned to take place over a period of 2,5 months at first, which then was extended up to 4 months afterwards. Throughout the course of 4 months, I was working individually on my output 5 days a week on average and met my collaborators weekly, either once or twice a week for collaborative studio work. Every third week I and my collaborators met either in person or online to discuss our creative process as well as the dramaturgy of the performance as it was unfolding gradually in response to what we were doing.

Discussions with my collaborators were highly insightful and important for our creative process: some of the elements of performance dramaturgy were born during the quick experiments and exchanging our thoughts about them on the spot. Discussions with my advisors and field practitioners provided me with valuable knowledge and a fresh perspective on what could be improved, done differently, and more professionally.

The opportunity to break down the whole process of our collaborative creative work into parts and analyse how it was unfolding was really precious and had a lot of value not only for the current research but also for my future artistic work with these mediums. Now when I have executed my first collaborative audiovisual mixed reality dance performance and documented the whole process I feel more equipped and confident to continue working with these mediums.

## 2.2 RELATED WORK REVIEW

The related work analysis is represented in the background chapter and divided into four main parts along with the structure of the background chapter: Dance and Technology, Motion capture, Game engines, and Modern hybrid club music. In each subsection, I gathered the examples of pieces that are relevant for its category even though some of the performances could fall into many categories. The criteria for the selection of projects were their relevance to the category as well as to my own interests. Some of the performances I am writing about I was fortunate to experience live which offered a special value for conducting this research.

As far as the sources are concerned, to conduct related work review I was consulting books: Digital Performance by Steve Dixon and Entangled by Chris Salter, as well as journal articles, conference papers, and web pages. I found Chris Salter's book to be really helpful to visualize the timeline, the broad strokes of the development of the Dance and Technology movement, whereas Steve Dixon's research went into detail about each performance and helped to get a better understanding and feeling of how they were. Of the lack of research made on the topics of game engines in contemporary dance and modern hybrid club music to conduct the related work review, I was mainly consulting different internet publications.

## 2.3 INTERVIEW

According to Linda Candy, "the interview is a systematic collection of verbal information" (Candy, 2006, p.16). In its essence, the interviewer is asking users' opinions to obtain the information based on the list of prepared questions. The interview outcomes are usually either written or recorded and in case they are recorded, they should be then transcribed. Based on Linda Candy, interviews can be structured, which "implies that the content of the interview, in terms of the questions and their sequence, is predefined" or unstructured, where the structure of an interview is more open "and the interviewee develops the themes proposed by the interviewer." Due to its nature structured interview "offers the opportunity for more systematic collection of data" (Candy, 2006, p.16).

For the current research, I have applied a method of semi-structured interview with a list of questions that builds up towards the main question, the research question of this study: "How can real-time motion-capture and game engine technologies augment contemporary dance, both in the visual and audio domains, in a way in which sound and visuals influence each other"? For the full list of questions check APPENDIX A. Originally, I was aiming at interviewing Zora Jones and Sinjin Hawke from FRACTAL FANTASY audiovisual production unit as well as pioneering virtual performer Sam Rolfes from digital performance studio Team Rolfes. The reason why I have chosen these particular artists is that, first of all they both are working on the intersection of technology, music, and performing arts including dance in the very cultural segment that interests me a lot and secondly they are both using MoCap and game engines in their artistic practice.

Due to certain limits and time constraints, I had a chance to interview only Sam from Team Rolfes. Our conversation took place on the 9th of June 2023 over Zoom. I got permission to publish the outcomes of the interview in the current study. The interview was recorded and transcribed afterwards. In order to analyse the transcript of an interview I applied the method of finding recurring patterns or themes (Preece et al., 2015).

# 3 RESEARCH BACKGROUND

## 3.1 DANCE AND TECHNOLOGY: CASE STUDIES

Even though the origins of Dance and Technology or dance tech trace back all the way to 1960s, the name of this movement got established much later around 1990's with choreographic artists "seeking to use recently developed tools to reinvent the perceptual and ontological role of dance in the context of a digital zeitgeist" (Salter, 2010, p. 261). Among those tools were first prototypes of "worn and stationary sensing devices, 3D modelling softwares, and software control environments coupled with computer vision and motion data analysis techniques." (Salter, 2010, p. 261) This interest was highly encouraged by the scientific community, as they could finally test previously only lab-driven experiments in the "real world" in an artistic context.

As a result of this collaboration between academia and choreographic artists, such computer vision-based projects as Dance Space by Flavia Sparacino, sensor and accelerometer-focused work of Joseph Paradiso, and EyesWeb software-based projects by Antonio Camurri were born. Collaborative work between cultural and academic worlds was crucial for the establishment and development of Dance and Technology art movement.

One of the first choreographic artists to integrate technology into his practice was Merce Cunningham, mainly through his extensive use of 3D character animation software package Life Forms. "Life Forms is a figure animation package that enables the choreographer both to use the computer as a drawing board to conceive movements and sequences in animated form before going into the studio with dancers; and to use animations themselves as dance…." (Dixon, 2007, p.184)

The first choreographic piece that Cunningham created in Life Forms, was Trackers (1989). The software-based choreography in Trackers was awkward, nevertheless powerful. Most of the shapes and movements were "completely outside of the familiar universe of dance movement." (Dixon, 2007, p.185)

The architecture of the software largely influenced Cunnigham's choreographic approach in terms of visualizing movement in space. One of the intriguing examples of such influence according to Salter was the "computer's inherent cut and paste model", which transferred into Cunnigham's choreography making it more fragmented and shifting (Salter, 2010). Inspired by the software Cunningham often devised choreographic sequences that were physically impossible, and while working with the dancers they were trying different workarounds, how these sequences could be made to work (Dixon, 2007). This practice in particular had a tremendous impact on Cunningham's choreography.

Another remarkable choreographic piece made using Life Forms was Interference: A Performance Experiment in Internet Choreography (1998), curated by digital artist Guy Hilton. Interference was a mashup of various choreographic sequences, devised in Life Forms by more than 40 artists around the globe, including Cunningham. The sequences were merged together according to the 'cadavre exquis' surrealist game principle: each artist started to create their choreographic sequence based on

the last keyframe that they got from a previous participant, without knowing much of a context. The piece was performed by 3 dancers in September 1998 to a sold-out audience in Manchester (Dixon, 2007).

Software development played a huge role in the dance and tech movement in general, as many of the intermedia choreographic projects required very specific software functionality. Among others, such projects included Troika Ranch (New York), Palindrome (Nürnberg), and kondition pluriel (Montreal), which represented sensor-augmented choreographic scenes (Salter, 2010, p. 268). The softwares that were created in the framework of these projects were Isadora by Troika Ranch's member Mark Coniglio and EyeCon by Frieder Wiess, Palindrome associate.

According to Salter the logic of EyeCon and Isadora softwares was to connect with the sensor-based hardware in order to map dancer's movement into media output (Salter, 2010). The output varied from different sound and colour values to computer graphic structures and lighting, creating more subtle and surprising interactive relationships between the movement and the visuals. In such performances as Loop Driver by Troika Ranch, and Scheme I/II by kondition pluriel the visual media output was projected in front of the performers, blending them together, thus creating a constantly changing, movement-sensitive performance environment. Together with kondition pluriel, Susan Kozel's and Kirk Woolford's work within Mesh Performance Partnerships also focused on blurring the boundaries between performer and technologically augmented environment as well as engaging and giving the agency to the observer.

One of Palindrome's performances Touching (2003) is a good example of EyeCon software in action. In one section of the performance the camera was tracking the proximity of 2 dancers to one another and as it sensed the touch between different body parts the video image in the projection switched abruptly to a negative image, and when the contact was broken back to the normal positive image (Dixon, 2007). Steve Dixon in his book Digital Performance describes the performance in the following words:

> The dancers play skilfully with the dramatic tension before the point of touch, maintaining eye contact with each other as their hands draw slowly and inexorably closer, building the sense of corporeal electricity between them until the contact is made. The electrical charge suddenly ignites on screen as previously dark and dimly lit video bodies explode into the bright white heat of the video negative, infusing their videated forms with an intense light, while in turn the brightness of the projection floods the dimly lit live bodies on stage. (Dixon, 2007, p.201)

With the advancement of hardware and software, improvement of processing speeds and graphics cards as well as high-resolution projections, we saw the appearance of more precise graphically high-end dance tech pieces (Salter, 2010). One of the examples of such pieces is work by Klaus Obermaier Apparition (2004). "It's a stage work, integrating live performance, sound, projection, and an interactive system based on real-time image generation and computer vision" (Apparition: Klaus Obermaier, n.d). With Apparition "the goal was to create an interactive system that is much more than simply an extension of the performer, but is a potential performing partner" (Apparition: Klaus Obermaier, n.d, section 2, para 4). The effect that Apparition has on a viewer is tremendous

and wouldn't be as strong without the precision and quality of computer vision and graphic simulations used.

Another similar to Apparition dance and tech piece, where the interactive media system plays a role of a dance collaborator is work by Claire Bardainne and Adrienne Modot, Hakanaï. First shown in March 2015, Hakanaï is a "dance choreography performed in the immersive environment of a moving cube, to explore the fleeting nature of dreams and the fugacity of life" (Projects, n.d, Hakanaï, para. 1). Abstract computer-generated imagery in Hakanaï is being projected on the walls of the cube and depending on the movement of the performer in the space and different sound frequencies it is subject to a change. The performance is an attempt to visualize a transitory state of mind somewhere between a dream and reality, or imagination and reality, the very meaning of the Japanese word Hakanaï (Projects, n.d, Hakanaï, para. 2).

A further example that explores the topic of co-creation between human performers and technology in a dance piece is a phenomenal work by Rhizomatics collective and company ELEVENPLAY called multiplex (2021). Multiplex is not a live dance performance but an "installation featuring motion data from five dancers, projected images, and a mobile robot, presented in the physical exhibition space and also online" (Rhizomatics, n.d, Rhizomatics x ELEVENPLAY multiplex, para.1). It is relatively easy to confuse multiplex for the actual live dance performance as the quality of rendering of human figures and their movement in space looks very lifelike. The same applies to other objects and special effects in the scene: it is very hard to distinguish which elements are real palpable objects and which exist only in a form of a projection, a light trace on the retina. The only real objects, in the end, are the five cubes moving autonomously across the space. Their movement along with the movement of the AR dancers is heightened and elucidated by the numerous AR effects. According to Rhizomatics official website multiplex is a "hybridization that seeks to create an environment for a new breed of humanity from multiple perspectives" (Rhizomatics, n.d, Rhizomatics x ELEVENPLAY multiplex, para.1). The piece could be interpreted as a broader commentary on the co-existence between humans and technology.

## 3.2 MOTION CAPTURE

### 3.2.1 HISTORY AND DIFFERENT TYPES OF MOTION CAPTURE

Originally developed to meet the needs of US army to track the targets and head positions of pilots, the purpose of motion capture was to make traces of human and animal locomotion visible. Widely used in film, animation, gaming as well as sports and medicine since 1990, motion capture involves measuring the object's position and orientation in space and recording that information in the digital form to be manipulated on the computer. Objects that could be recorded include humans and animals, facial expressions as well as cameras, lights, and other elements in a scene (Dyer, et al., 1995). As a result of this recording one gets "highly detailed and precise locomotion data, that could be then stored, analysed and reassembled in real-time playback to create a ghostly, 3D-animated

body drained of muscles, nerves, and organs, replaced by an outline of phosphor dots that retraced an already vanished live movement" (Salter, 2010, p. 266).

There are four different types of motion capture: optical active, optical passive, markerless, and inertial. Optical passive method is the most flexible and the most commonly used, it utilizes infrared cameras to track retroreflective passive marker motion capture. The settings of the camera threshold in optical passive method are adjusted so that only bright reflective markers are being tracked, not the skin or fabric. In the optical active method, special cameras track LED motion capture markers when they emit light. Optical active system is considered to be good for real-time applications. When it comes to markerless systems, they usually do not require subjects to wear special equipment for tracking. Instead of using markers, they rely on software functionality and sometimes require specific hardware, like stereo cameras (Adobe, 2023). Along with the previously mentioned EyesWeb and EyeCon softwares, Microsoft Kinect is an example of a markerless motion capture system.

Microsoft Kinect is a series of motion-sensing input devices, originally developed for Xbox video game consoles and first released in 2010. The new generation of Kinect cameras the Azure Kinect "is a combination of different hardware components: a Time-of-Flight depth sensor, an RGB video camera, an array of seven microphones, and an inertial measurement unit with an accelerometer and a gyroscope" (Pterneas, 2022). According to Pterneas, the input gathered from these components is being fed into its AI Software to produce skeleton body tracking, voice recognition, and 3D point clouds (Pterneas, 2022).

Microsoft Kinect cameras, especially the older ones are much more affordable comparing to other MoCap solutions, which results in many individual creators using them for building DIY low-cost mocap systems for their creative projects. Depending on many factors, such as artistic goals, the way the data is manipulated, and the software being used to process the data, Microsoft Kinect could produce impressive results and even is being favored by some artists over other more precise MoCap solutions. Sinjin Hawke from FRACTAL FANTASY affirms that "Kinect is the best when it comes to conveying emotionality: you get a more live sense of the performer/facial expressions/outfit/ body movements" comparing to the data that one can get from the inertial MoCap systems (personal communication, June 30, 2023).

The last type of motion capture, the Inertial motion capture system uses IMUs (inertial measurement units) with built-in sensors to detect position and movement. These sensors typically include gyroscopes, for measuring angular rate and defining rotational orientation of IMU, accelerometers, that are detecting acceleration and gravitational force as well as magnetometers, which measure the Earth's magnetic field or an artificially created magnetic field (Solberg & Jensenius, 2016). These sensors are typically put into lycra suits or straps set into specific places to track the location of the strategic joints. Tracking data is being transmitted wirelessly to a computer or a smart device using a router or a bundle.

For the artistic component of this research, I decided to stick to inertial X-sens MoCap suit for several reasons. The precision of markerless MoCap system was not sufficient for the purposes of our

performance, namely tracking quite complicated and diverse motion data in real-time. Optical MoCap system is usually location-based and would require technical assistance with setting up the equipment for each and every rehearsal, which also did not seem practical. Inertial motion capture system, therefore, proved to be the best possible solution for the needs of our performance, as it is precise enough to convey the exact movement of the performer, it is mobile and accessible to use for someone without a specific technical background.

### 3.2.2 PERSONAL PERSPECTIVE ON MOTION CAPTURE & CASE STUDIES

Motion capture technology has fascinated me ever since I started my studies in Aalto Media Lab, but it was my first encounter with inertial MoCap system that really drew my interest to the medium. I was attending the workshop called Motion Capture vs. Animation organized by our faculty, where we were introduced to X-sens inertial Motion Capture system. During the workshop, there was a chance to wear a suit and animate either one's own or the default 3D character in real-time in Maya 3D animation software. The experience was transformative: watching yourself animating a 3D creature with mirror precision, but at the same time seeing an intricate extraterrestrial 3D avatar that has nothing to do with your normal mirror reflection, was truly mind-altering. I had a feeling as if part of my consciousness moved into that other creature on the screen, as if I was less present in my own body and less concerned about it, which resulted in a bigger freedom in bodily expression. At that moment I was associating myself with the avatar, I was the avatar, and my movement and acting was not my own but rather it was inspired by the shape and character of the avatar. These reflections go hand in hand with "the research on embodiment that suggests that if the physical body does not match with the virtual body, we adjust our behaviour to match the input" (Akbas et al., 2022, p. 3)

After that first encounter with the inertial motion capture system, I started to think about its potential uses in performing arts. I instantly drew the line between dance and motion capture: it made total sense to integrate MoCap into the movement since I found the visual output or effect with a one-to-one mapping of the movement to be the most noticeable and prominent. I was not the first nor the only one who drew that connection, as already in the late 90s first iconic works using motion capture in contemporary dance were born.

OpenEndedGroup, with artists Paul Kaiser, Shelly Eshkar, and computer-scientist Marc Downie were the first ones to engage in MoCap and integrate it into contemporary dance. In 1998 OpenEndedGroup started several long-term collaborations with choreographer Merce Cunningham and as a result, such pieces as Hand-Drawn Spaces (1998) and Biped (1999) were born. Both works were utilizing the same technique of animating the hand-drawn sketch-like figures in a digital landscape with Cunnigham's dancers' motion captured movement. While Hand-Drawn Spaces was rather a virtual choreography installation, in Biped the hand-drawn figurines "shared a stage with live dancers, being projected onto a huge, transparent scrim that covered the entire width and length of the proscenium." (Salter, 2010, p. 267) For Biped, Kaiser and Eshkar were working with around 20 of

Cunnigham's motion captured sequences, which order, how they will appear on stage, was determined by Cunnigham not long before the premiere, based on a chance principle. According to Dixon, neither OpenEndedGroup members saw the Cunnigham's dancers performing the piece, nor Cunnigham himself saw Eshkar's and Kaiser's virtual dancer's animations before the first show, which brought a lot of ephemeral beauty, and elements of chance into the interactions between virtual and real performers in the piece. The successful New York premiere of Biped in July 1999 marked a turning point in the history of dance and technology, as the wider Western world's arts media scene became aware of the unique possibilities digital performance could offer (Dixon, 2007).

In 1999 OpenEndedGroup collaborated with choreographer Bill T. Jones on an installation Ghostcatching, where they applied similar techniques and aesthetics as with Merce Cunningham. In this piece movement data captured during the rehearsal with Jones was reconfigured and used to animate multiple hand-drawn 3D characters creating an astonishing chronophotographic dance (Salter, 2010).

OpenEndedGroup's collaboration with Trisha Brown, how long does the subject linger on the edge of the volume…(2005) was quite significant for the history of MoCap in contemporary dance as it was one of the first instances of using MoCap to track dancer's movement on stage in real-time. Aesthetically the piece reminds of the previous works by the group, but this time pencil strokes are depicting abstract shapes, points, and lines, essentially motion paths, driven by the dancer's motion captured and "computed through probabilistically augmented agents" (Salter, 2010, p. 268). Visuals were projected on stage the same way as in Biped, creating a living environment, sensitive to the dancers' movements, "a choreography of bodies without human figures" (Salter, 2010, p. 268).

## 3.3 GAME ENGINE TECHNOLOGIES

### 3.3.1 GAME ENGINES: DEFINITION, APPLICATIONS

In recent years with the advancement of hardware and software, game engines evolved into versatile tools that are being used far beyond game development. Unreal Engine community defines the following applications of game engines outside of computer games context: training simulations, VR and AR experiences, Architectural visualizations, Data visualizations, TV and Broadcast, Filmmaking and animation and other (Unreal Engine, n.d). This "other" section includes numerous practices that do not fall into predetermined categories. It is essentially how a single practitioner defines their workflow with the game engine and its application.

According to Celine Tricart, a game engine is a software that displays a 3D environment where one can place various 3D assets, sounds, and special effects as well as animate them and create interactive sequences of events using different coding languages. Code scripts or visual scripting algorithms define how each asset in the game environment "moves/reacts/interacts depending on various stimuli." Different elements and functionalities can then be tested in the "play mode", modified, and tested again until finished. The complete experience can then be exported as a file called

“build” that is compatible with a specific platform like mobile, desktop, console, or VR platform (Tricart, 2018).

Functionalities that game engines typically include are a rendering engine (“renderer”) for 2D and 3D graphics, a physics engine, collision detection, sound, scripting, and animation as well as modeling and video support for cinematics (Tricart, 2018). Cinematic tools and real-time renderer are one of those functionalities that are so captivating for artists and designers outside of the game development world, as they make it possible to render high-quality animation sequences in minutes, as well as render content in real-time. Scripting along with physics engine and collision detection is another truly powerful group of tools that could be used as a means for telling a story, by creating different behaviors for objects or processes in the scene.

There are plenty of game engines and some of the developers and creative coders even program their own engines to suit their artistic needs, but the most commonly used engines both in traditional game design context and for more experimental purposes are Unreal Engine and Unity engine.

Unity is a C# (C-sharp) based 2D and 3D game engine, developed by Unity technologies first for Mac OS X and launched in June 2005 (Ciesla, 2005). With the Unity engine, Unity technologies strived to democratize game development and provide access to the tools to more developers around the globe. Over the course of two decades, Unity has improved and expanded dramatically, managing to keep up with the latest technologies and demands from the industry. Currently, the engine’s main priority is to provide the most robust set of tools for the game development industry as well as to make the engine accessible even for developers with entry-level skills (Schardon, 2023). Unity engine has expanded its reach into other industries such as film, automotive, architecture, engineering, construction, and military (Unity, n.d)

According to Unreal Engine's official website, Unreal Engine is the world’s most open and powerful visual scripting 3D tool, that “enables game developers and creators across industries to realize next-generation real-time 3D content and experiences with greater freedom, fidelity, and flexibility” (Unreal Engine, n.d, 01 Overview, para. 1). The engine was developed by Epic Games Inc. and was first showcased in the 1998 first-person shooter game Unreal. The latest edition of the engine, Unreal Engine 5, launched in April 2022, and included such new functionalities as the Nanite engine, which makes importing highly detailed film quality assets and rendering possible, Lumen, a “fully dynamic global illumination solution, that immediately reacts to scene and light changes” as well as advancements in Niagara particle system, Physics engine, animation and procedural modelling tools (Unreal Engine, n.d, 02 Key Features, para. 2).

Both engines provide a great number of tools for creating stunning and truly unique virtual experiences. Applications of these tools expand far beyond the computer games industry including numerous artistic practices. Although, when it comes to making art, bigger and more powerful tools do not equal better art. Therefore it is relevant to ask how artists should approach this medium to create art that resonates, and more specifically how artists could benefit from game engines in the segment of dance and technology. In the next subsection, I will try to answer this question by analysing several examples of using game engines in the context of contemporary dance.

### 3.3.2 GAME ENGINES IN CONTEMPORARY DANCE: CASE STUDIES

One of the first instances of using game engines and game mechanics in the context of contemporary dance is the piece by Krisztina de Chatel, Lara (1998). The piece showcases the choreography performed by multiple dancers that are mimicking the primitive movement of the protagonist Lara Croft in Tomb Raider video game being projected behind the performers. The game was played in real-time by the whiz-kid on the stage (Lara, n.d). Whereas in this iteration of the project, choreography was informed by the protagonist's movements without real technological mapping, in the second iteration of the project Lara and Friends (1999) projected video game environment backdrop was driven by the dancers (Salter, 2010). This piece is extremely innovative and even visionary since it was employing game mechanics and using game development as an artistic medium already back in the 1990s, the trend gaining more and more popularity only now, 25 years after.

Another relevant example that involves using both game engine and motion capture in contemporary dance is the performance Morbid Angel by House of Kenzo, Rabit, and Sam Rolfes showcased at Day for Night festival in 2017. According to Fact Magazine, Morbid Angel was a performance "which saw Rolfes corralling a glistening stripper angel and a colossal moth outside a 3D-rendered model of Screwed Up Tapes And Records, the legendary record shop of Houston rap originator DJ Screw" (Bruce-Jones, 2020, Stage one). The performance's virtual environment included different 3D assets, and particle systems such as rain, fire, and flashes. Lighting played quite an important role: it was dramatic and made all of the assets in the scene look whimsical and otherworldly. At times light intensity was reactive to the sound input, thus creating a stronger connection between the visuals and the sound.

The main tools that Sam Rolfes was using in Morbid Angel to control different elements in the scene were motion capture, motion controllers as well as keyboard buttons and joysticks (180 Fact, 2020). Motion controllers were used to control the puppetry and lighting as well as to navigate across the environment, and show it from different perspectives. This particular element plays a huge role in Sam's practice as many of the stories that Sam and his collaborators are telling are unfolding spatially, and, similarly to computer games, out of spectator's or 3D character's interaction with different areas of a virtual environment. The keyboard buttons were used to trigger different events in the scene, such as a moth's flapping of wings. Motion capture is integrated into the performance in a very intriguing way: apart from a one-to-one mapping of the main avatar, Sam is mapping other creatures or objects in the scene to the same MoCap input, which creates a network of interconnected geometries and special effects. In his Fact Magazine residency documentation video Sam is saying that this approach: "allows everything to breathe together at once"(180 Fact, 2020).

According to Sam, the process of formation of choreography both in Morbid Angel specifically and in his performance practice in general is semi-improvisational. It arises from the design of the avatar and how a dancer is responding and changing the performance in dialogue with what they see on the screen or in VR. Sam affirms that "you find yourself moving in completely different ways than you would otherwise because movements are emphasized by the design of the character" (180 Fact, 2020).

Another intriguing example of using motion capture and game engines in contemporary dance is the practice of Keijiro Takahashi. Keijiro Takahashi's day job is currently a developer at Unity Technologies, but during the periods when he was self-employed, he collaborated with musicians and motion graphics artists. In those projects, he attempted to implement all of the knowledge and skills he got from the gaming industry in a more creative context (Fargo, 2019). In 2019 Takahashi collaborated with the dancer GENDAI to produce a series of visual experiments on the intersection of dance and technology. The outcome of these experiments was a video showcasing the dancer and the choreography abstracted into different geometrical shapes and particles. Keijiro Takahashi was using Kinect Camera and Depthkit software to record the motion capture and produce volumetric video and Unity VFX graph to manipulate the data into the stunning moving particles distantly resembling a human (Fargo, 2019).

Further relevant dance and tech project to analyse is the project Presence & Absence done by a team of Immersive Arts Space of the Zurich University of the Arts. The project is an "artistic research that focuses on an interplay between presence and absence of real dancers and virtual characters" that was realized in the form of a dance performance with augmented projection mapping as a scenography (Presence & Absence, n.d). In the course of the performance, the dancers disappeared behind the stage elements replaced by the avatars that appeared as projections on those elements. When the performers appeared back on the stage, the virtual avatars vanished at the same moment. Perhaps the most intriguing parts of the performance were the ones when the performer was partially hidden by the wall: in that case, the audience could see a digital age centaur, half avatar, half human being. The technical setup of Presence & Absence included MoCap, a projection mapping system with multiple projections, performative 3D mapping software, and a game engine, that made it possible to track up to 8 virtual characters in real-time (Presence & Absence, n.d).

### 3.4 MODERN HYBRID CLUB MUSIC

This section will shed light on contemporary hybrid club music, whose nature is everchanging, elusive, and hardly gives in to be described. I am using this combination of words because I think that it serves as the best placeholder for those musical phenomena that I am going to discuss in this section: Deconstructed Club and Hyperpop. This division is also very conditional and unfortunately leaves out a lot of little subgenres and musical influences that I would love to include in this section. Nevertheless, the very context of the academic research leaves no other option than to stick to these widely accepted denominations, that were made to make rational sense of something very fluid eclectic, and ambiguous. Deconstructed Club and Hyperpop even though sonically quite different, have a lot in common and above all the genre fluidity and genrelessness: they are essentially represented by the people who do not care about the genre and are "more experimental about what they put in the DJ set" (Ravens, 2020).

Whereas the first two subsections will talk about each of these movements the last one will introduce my personal perspective on this music: what influence it had on my relationship with the digital medium as well as why it is of such importance for this research. The chapter will conclude with the two case studies from the intersection of technology, hybrid electronic club music, and contemporary dance.

### 3.4.1 DECONSTRUCTED CLUB

The appearance of the genre Deconstructed Club is strongly associated with the New York party series called GHE20G0TH1K. The event series was founded by Venus X and Shayne Oliver to "channel their feelings of confusion and dispossession in the face of a predominantly white, hetero, and highly formulaic nightlife" (Nikolay, 2020). The event series became popular within the circles of voguers, punks, and fashion kids who according to Bandcamp journalist, Andra Nikolay came to the parties to show their anger and frustration with the prevailing nightclub scene and social norms.

Nikolay affirms that within GHE20G0TH1K parties the new style of DJing was born. It was influenced by the rebellious spirit and "radical political attitude that empowered" black, LatinX, queer, and LGBTQ people as well as by the latest technological advancements in djing equipment. The appearance of CDJ:s, with sync, loop, and cue buttons, as well as playlist creation and editing possibilities in Recordbox software, unlocked a whole new approach to DJ: ing and encouraged DJs to play with greater freedom (Ravens, 2020). The possibility of playing music from USB connectors also affected the sound of GHE20G0TH1K affiliates: they were mainly playing MP3 files, which broadcast on a bigger sound system produced crunchy cruddy texture. Each of the members of the collective came from a different background, which put together resulted in a mix "galvanizing a mélange of Jersey club, Baltimore, footwork, and punk, alongside elements of house and techno" (Nikolay, 2020). In her Bandcamp article, Andra Nikolay compares Deconstructed club or Post club to postmodernism in music:

> The genre breaks away from dance music tropes like four-on-the-floor beats, stable tempo, and constant mix with gleeful anarchy, proposing a sonic locus where ballroom breaks, field recordings, rap a cappellas and heavy metal are reconfigured into dancefloor fodder. Post-club feeds off of shocking transitions. The disruptive element of the mix and its wide dynamic range, alternating between atmospheric breathers and high-BPM paroxysms, keeps listeners (and dancers) on their toes. The genre's vision is dissonant, dystopian, and dissident, using a mix of high- and low-brow cultural signifiers to reclaim the club floor co-opted by mainstream electro-pop and EDM. (Nikolay, 2020)

GHE20GOTH1K showed how things could be done differently in the club scene, which brought a sense of freedom and inclusivity and largely affected like-minded labels and collectives around the globe. Such labels as NAAFI in Mexico, Staycore in Stockholm, and No Shade and PAN in Berlin were the pioneers of the genre: they have expanded the sound, creating a network of like-minded artists and their fan base around the globe.

### 3.4.2 HYPERPOP

Another important movement that is intertwining with Deconstructed Club is called Hyperpop, a fluid music genre, and internet movement that originated in the United Kingdom in the early 2010s and is strongly associated with such artists as A.G.Cook, Charli XCX, SOPHIE, 100 gecs, and others. A huge "number of Hyperpop artists identify as transgender, non-binary, or otherwise part of the LGBTQIA+ community" (O'Regan-Reidy, 2020, para. 6).

One of the most accurate definitions of Hyperpop is the one by Joe Vitagliano, which states that "Hyperpop draws on everyday symbolism and the cliches of 'popular music' to craft something which is maximalist, impressionistic and,..., incredibly entertaining. With saw synths, auto-tuned vocals, glitch-inspired percussion and a distinctive late-capitalism-dystopia vibe, the sound captures the sense of catharsis and anxiety which seems to have become so prevalent in our modern world", but adding Joe, it manages to convey all of that while still remaining genuinely fun and entertaining (Vitagliano, 2020).

According to Emma O'Regan-Reidy, Hyperpop's advent is widely seen as connected to the cultural activity of Goldsmiths' alumni A.G. Cook within a label PC music. PC music was founded by Cook in 2013 in response to a lack of connection and understanding of relationships between humans and computers (O'Regan-Reidy, 2020). In his interview with Guardian Cook was showing his frustration with how the music that was made or referencing computers has essentially nothing to do with people and their time spent online (Aroesti, 2020). Trying to undermine this popular mindset, PC music embraces the everyday experience of using the internet; memes, messaging, posting, scrolling, and glitching (O'Regan-Reidy, 2020). Similarly to PC music, Hyperpop is deeply rooted in computer and internet culture with its meme-y inspired lyrics, visual aesthetics behind the genre, and even with the name itself, which arose from the title of a Spotify playlist.

### 3.4.3 PERSONAL PERSPECTIVE ON MODERN HYBRID CLUB MUSIC & CASE STUDIES

Music plays a huge role both in this research and more broadly in my artistic pursuit in general. I started to listen to Deconstructed Club music and the subgenres associated with it in 2013. For a long while I was just a mere listener until in the summer of 2018 I borrowed a DJ controller from a friend and started mixing my first tracks together. Music introduced me to a whole new community in Helsinki and together with some people with similar interests we started to organize music events, book foreign artists as well as release music records. Running a label and event series together with organizational matters required production of graphics and live visuals. I found these very aspects of collective work especially exciting as it required interpretation of sonic and cultural elements into the visuals. The visual aesthetics that was formed around Deconstructed Club music usually included displaced and distorted imagery, 3D computer graphics, particles and physics simulations, unhinged color combinations, and juxtapositions of different visual elements into an eclectic collage, which really appealed to my taste.

August 2019 became another important landmark in growing my interest in new medium, as then I visited the FLOW x OPERA event, where I witnessed an Audiovisual MoCap performance by one of my all-time favorite collectives FRACTAL FANTASY, as well as a contemporary dance performance Autobiography edits with choreography by Wayne McGregor and music by Jlin. Here again, music came first, as I was familiar with both Jlin's and Sinjin Hawke's and Zora Jones's (FRACTAL FANTASY members) sonic output, for a couple of years at that point and came primarily for that. During the show, I was very impressed by seeing how my favorite music was augmented and visualized in FRACTAL FANTASY's performance by real-time video imagery and in Autobiography edits by contemporary dance and lighting. Deeply inspired by the show, I started to work on my first interactive media project, and already a year after I found myself studying in Aalto Media Lab. Thus, music has always been quintessential for my artistic practice and for my interest in new media.

Let's take a closer look at these two examples that were so significant for shaping my identity as a new media artist. FRACTAL FANTASY is an audiovisual production unit founded by Montreal-based artists Sinjin Hawke and Zora Jones to experiment with audiovisual interactive art. The platform was founded in 2014 and by 2017 it was considered one of the most innovative audiovisual projects according to Resident Advisor (Sinjin Hawke, Zora Jones, n.d).

The show I was attending in August 2019 was one iteration of the bigger, constantly evolving FRACTAL FANTASY AV project, that the duo has shown around the globe including such festivals as Barcelona's Sonar and Unsound Festival in Poland. In its essence, the AV is based both on the sound that is being interpreted in the form of the dance and sound-reactive visuals as well as on the motion-captured movement translated into the sound and visuals. These two domains are constantly intertwining and providing impulses to one another creating an otherworldly, pulsating, living audio-visual organism moving as a whole. The visuals could be characterized as abstract, uncanny, glossy computer-generated environments in the centre of which is a fluid avatar of either one of the artists. The iconic FRACTAL FANTASY sound lies on the intersection of hip-hop, grime, footwork, and Jersey club, channelling the influences of both major music movements mentioned in this study (Sinjin Hawke & Zora Jones, n.d).

In the FRACTAL FANTASY AV, the visual and the audio domains are constantly inspiring and enriching each other, essentially conveying the same information while speaking their own languages. The movement of artists captured by Kinect camera elevates both the sound and the visual in a way that makes the audience empathize and strongly engage in the performance. I found it difficult sitting down and occupying my seat in the Opera house during the show not only because the music was more suitable for the club environment, but also because the way the avatars on the screen were moving was infectious. I think that FRACTAL FANTASY AV is a great example of using technology to augment audiovisual dance performances in a way that all three mediums are constantly elevating and enhancing one another on stage in real-time.

Autobiography is a collaboration between renowned choreographer Wayne McGregor and electronic music composer Jlin facilitated by Unsound Festival. At the core of Autobiography was an idea of a body as an archive, a dance portrait inspired by the sequencing of McGregor's own genetic code. The choreography for the piece was created in 2017 based on McGregor's "writings, personal

memories, pieces of art and music that have been important in his life" (Company Wayne McGregor, n.d, Winner, para.3). All of that material was alchemized into 23 choreographic sections - the metaphors of 23 pairs of chromosomes of the human genome and then fed into the algorithm, based on McGregor's genetic code. For each performance the algorithm was randomly selecting the choreographic sections, and in which order the dancers were performing it, "book-ended by a fixed beginning and end". According to McGregor himself, "Autobiography was an experiment that spoke directly to the idea of life-writing" (Company Wayne McGregor, n.d, Winner, para.3).

The full version of the piece was performed with set design by visual artist Ben Cullen Williams and interactive lighting installation by Lucy Carter, McGregor's long-time collaborator. The stripped-down version of the Autobiography edits, exactly the one that I saw during the Flow x Opera event, included just choreography and the sound performed live by Jlin. I got interested in the show initially through the music of Jlin, which according to Planet Mu label "builds on a Chicago footwork style, expanded and warped into a complex percussion-driven work a sophisticated poly-rhythmic sound all its own" (Jlin, n.d). In my opinion, Jlin's music is multilayered, maximalist, and truly deconstructed, which makes it at times a bit demanding to listen to. Keeping that in mind I was really curious to see what type of choreography this music can encourage. And the answer was truly unique and ground-breaking. Sometimes the movement was abrupt and fragmented whereas other times it was more subtle and nuanced. At times the dancers were moving synchronically and then out of the blue, the synchronism was broken, as if in an attempt to visualize different instruments, layers, and unexpected arrangement in Jlin's music. Even the softest moments in the choreography looked very sharp and well-rehearsed, which perfectly suited Jlin's music, which usually keeps a recipient in constant intellectual tension. All in all, I think that contemporary dance with its numerous influences from across different genres in dance and a great number of tools works perfectly with modern hybrid electronic music. And as there are not many instances of similar serious professional collaborations as the one between Jlin and McGregor, there is a great unexplored territory of what the juxtaposition of these two mediums can give rise to.

# 4 INTERVIEW WITH SAM ROLFES

For this research, I had a chance to interview a pioneering virtual performer, 3D animator, and co-director of the real-time digital performance and image studio Team Rolfes, Sam Rolfes. According to Sam's own words, he is a "digital performance artist, whose work largely emerges from real-time 3D improvisation", which "can take the form of VR puppeted music videos, motion capture festival-stage performances with musicians, album covers, fashion print collaborations, games, and others." The core element of this performance practice "is playing around in 3D until a narrative takes form" (Rolfes, n.d). Along with the work of FRACTAL FANTASY, introduction to Sam's work has become another important landmark for shaping my artistic practice and relationship with the new medium.

At that point, I was already doing my master studies in Media Lab and got to work with simple MoCap techniques and different creative coding platforms, like Processing and TouchDesigner. When I stumbled upon Sam Rolfes's work I first of all empathized with the visual aesthetics around it: very maximalist, painterly, deformed, fragmented, very bold when it comes to the colours, but what was even more compelling, was that I could not understand, despite my knowledge and skills in 3D and creative coding, how exactly this was done. The way Sam is approaching the new medium is very experimental, innovative, borderline crashing, which comes from his desire to stretch the medium and use it in a way that it was not optimally designed for to fulfill his artistic needs. During the interview, I got a chance to ask both more fundamental questions about Sam's relationship with MoCap, game engines, and creative tech in general as well as technical questions on how exactly he is using these techniques in his artistic practice. This chapter is largely based on this interview and other interviews that Sam gave to different internet publications.

Sam Rolfes is originally coming from a painting and illustration background, working with such mediums as oil painting and watercolour. The semi-impressionist approach that he acquired during the years of his studies at Chicago University, "responding to the image developing on the surface and letting the narrative take shape organically" is still very much present in his practice with a digital medium (Rolfes, n.d). Sam's first experiments with 3D began around 2013-2014 when he started to work with ZBrush. What interested Sam in ZBrush was the possibility to model and see the results of the work in real-time, a feature at that point not available in the other 3D modelling softwares like Blender and Maya. Around the same time, Sam started to do live visuals for the music shows in Chicago and participate in the festivals. His VJing technique at that point included outputting the ZBrush scene with the green background to Resolume Vjing software: "I would have…a library of characters or tools…that I…planned for the show and then I would just manipulate them…bounce them around, contort them, build up a canvas and then delete it and then build up another one…"(S.Rolfes, personal communication, June 9, 2023).

This kind of process allowed Sam to be improvisational and expressive in a way that felt related to the painting background that he had: "for me…painting or any kind of physical media still has a level where you are doing an act and then you are looking at it and then responding to that...stimuli". According to Sam, this process is guiding how the piece is unfolding and this whole approach

could be extrapolated to all of his real-time work. Therefore, introduction to real-time designing tools like ZBrush set the ground for what Sam finds interesting up until the present day.

In 2015 Sam collaborated with Amnesia Scanner as well as Danny L Harle and Caroline Polachek on music videos and in conjunction with those projects Sam started to use Unreal Engine and Kinect cameras for the first time. Based on Sam's words, he started to work with game engines, since he wanted to use traditional key-framing as little as possible - he was much more interested in recording and performing in real-time. Unreal Engine offered necessary functionality to be able to do that, and furthermore to control the lighting and other VFX with a keyboard/joystick input real-time, build a scene for VR and bring the human-camera perspective and reactivity, as well as manipulate real-time MoCap data coming from Kinect. When Sam was recording the AS Chingy video he made approximately 30 takes and throughout the process of iterating, responding, and improvising he learned where in the scene he needed to be for a certain moment in the music. Thus, according to Sam, choreography and dramaturgy of the music video were born through this "improvisational iteration", which is still pretty much what their performance practice is about (Personal communication, June 9, 2023). Around 2016 Sam and his brother Andy acquired their first MoCap suit and already in 2017 they started to integrate it into their performance practice. In the previous chapter, I am analysing one of their first shows using MoCap suit Morbid Angel, which they did together with House of Kenzo and Rabit for Day and Night Festival in Houston in 2017.

Working with MoCap and game engines along with other technology that Sam is using in his performance practice allows him to "respond to an environment, respond to a story, to a character, it allows him to be expressive immediately" and understand the piece much more. Sam is saying that he can write a storyboard and have an idea of how this needs to be done, but once he actually gets the character rigged up and tries it out with VR puppetry or motion capture, once he sees the character in real-time, it completely changes the tone: "You're not working theoretically anymore, you are working responsively, and you can make much more critical decisions"(Personal communication, June 9, 2023). When we were discussing the general positive sides of creative tech Sam elaborated on this particular feature even more: "You can have an idea of the story in your head..but when you are neck deep in the performance in the story, the things will come out of it that are unexpected and that you need to respond to". "Oftentimes", Sam adding, "this is much more interesting than whatever… you had in your head initially", and working in real-time allows to make this very process much faster in comparison to other artistic mediums, like key-frame animation or claymation to name a few. According to Sam, working in real-time lets this process happen in a way that there is less time between the impulse being sent into your eyes and you responding to it, which allows him to live and create more in the moment. In Sam's opinion, this very impressionistic in its essence way to make art is one of the biggest positive sides that MoCap, game engines, and other creative tech with real-time features could offer (Personal communication, June 9, 2023).

Besides the positive sides, we also discussed the negative sides of working with creative tech and along with other things Sam marked out that usually, it is quite expensive and at times unreliable. As an example, he was talking about the need to confirm the license of the Rokoko MoCap suit every 24 hours, which could happen right in the middle of the performance and create major problems.

When it comes to the price range of different MoCap suits, the current best solution on the market, the Xsens suit costs over 50000 euros (including the license and good quality router), which is far out of reach for many individual creators. Furthermore, according to Sam, tech is breaking all the time, it can be quite hard and time-consuming to learn and what is probably one of the most crucial and least obvious points is that "it is completely reliant on this broader gigantic industry that" does not care "about your art at all". From the past 5-6 years of Team Rolfes's practice with creative tech they learned how to build a project with the safeguards in mind, they established a specific order of operations to set things up for performance, which eventually made performing on stage safer and more sustainable. Also, Sam adds "leaning into the chaos, understanding that it is a slapstick" and perhaps even embracing this quality during the shows is a good tactic to overcome the downsides of the creative tech (Personal communication, June 9, 2023). Integrating the motifs of crashes, fatal errors, and emergency mode into the performance narrative is quite characteristic of Team Rolfes's style and one of their latest bigger projects DISKOKINA: 50 Invisible Bullets in my Hair is no exception.

DISKOKINA is event series founded by Sam and his friend Jake from Club Cringe to platform and showcase experimental real-time audiovisual motion-captured mixed reality multidisciplinary performances. The event concept was born in response to lack of the events or festivals, where this type of culture could be represented in the US. The first event DISKOKINA: Fifty Invisible Bullets in my Hair a "spectacle of cybercore 'club theatre'"(Goldberg, 2023), took place on January 28th in ZeroSpace, next-generation production & creative studio, that Team Rolfes is partnering with. "With DISKOKINA Team Rolfes wanted to create a scripted saga where technology itself — specifically live motion capture, interactive game design, and VR puppetry — headlined alongside human talent". One of the show's main characters Kina, an animated flying sprite "the world's first AI superfan" was playing a role of evening's mascot and host (Goldberg, 2023).

Along with performances by FRACTAL FANTASY, Torus, Club Cringe, and Von's "Bloody Mary" during Diskokina Team Rolfes was showing their 321Rule performance, the first "fully original, VR-puppeted, motion capture avatar-ed mixed reality narrative project", starring Lil Mariko or GFOTY as an Eris Wonderful, a memory hunter gig worker in the near-future metaverse (Rolfes, 2023).

DISKOKINA offered a platform, a context for Team Rolfes to expand and experiment with the performative dramaturgical aspects of their practice, that they have been previously working into their music videos and into their performances, as well as for other digital creators, to showcase and expand their performance practice. The 321Rule performance demonstrated the most recent interests of Sam and his brother Andy in relation to real-time tech tools as well as dramaturgically moving from a music-centered approach to more narrative-based theatre performances with a bigger cast.

DISKOKINA event and a part of its program 321Rule performance are great examples to illustrate the dialogue between different elements of the show that real-time technology like MoCap and game engines can facilitate. According to Sam real-time tech tools allow performers to respond both to one another and also to the audience, they allow you to consider the moment and the mood where everyone and you yourself are and act accordingly, thus making it possible to embrace and

crystallize the originality and specificity of a current moment in time. This particular quality is really powerful and this is where a lot of real-time stuff really shines, adds Sam, and it gives the reason for these shows to be executed live (S.Rolfes, personal communication, June 9, 2023).

# 5 ARTISTIC COMPONENT: ROCK/STAR Vol.1

ROCK/STAR Vol.1 is a mixed reality audiovisual dance performance, where a virtual avatar, animated real-time by a dancer is exploring and interacting with the virtual cave environment through choreography and in response to the music. The project is a collaboration between me (world building, character design, MoCap, VFX, virtual performing), dance artist and choreographer Johan Högsten (choreography, dancing), and sound artist Henia Nikkilä (sound design, SFX). The performance premiered at Odeion Cinema in Otaniemi, Espoo on the 20th of May 2023.

## 5.1 PRODUCTION AND PRACTICAL ARRANGEMENTS

December 2022 marked as the starting point of the ROCK/STAR Vol.1 the mixed reality audiovisual dance performance, the artistic component of this master thesis. Back then I reached out to my friend and sound designer Henia Hikkilä, whose music and sound design I really liked. Despite the busy schedule Henia agreed to take part in the project and together we started to search for a dancer to complete our team. Henia recommended me Johan Högsten, at that point a student of the dance department at Uniarts Helsinki and a dance practitioner that was already trying to integrate tech into his practice. Johan got excited when we invited him to the project, as augmentation of dance with MoCap was something he himself really wanted to try but did not have sufficient technological skills. After our first meeting and initial exchange of ideas, I got the feeling that this collaboration will probably work well, as we shared a lot of common interests in music, art, and culture and this feeling grew stronger the more we got to know each other and proceed with the project.

The process of our collaborative work was quite intuitive and fluid. We started off by exchanging ideas about our interests within the framework of this project. Based on that exchange, we made a sticky note Miro board and among the words that popped in that board were: Hyperpop rockstar, spirals, slow motion, weird winter, Lil Uzi Vert. Interestingly enough, these ideas eventually found their way into the final piece, even though we haven't developed them purposefully. Another important input that we got in the very first stages of the project was music. As Henia, the sound designer, had a tight schedule for the upcoming spring, we decided to create the performance's soundscape based on the songs from Henia's new record that they were about to release called Back Life. We got the first version of the soundscape already in the beginning of February 2023 and as it was one of the first elements that was more or less ready it largely defined the dramaturgy of the performance.

In parallel with that, we started to rehearse with simple Unreal Engine scenes, Default 3D character, X-sens MoCap suit, sound, and large projection. We tried out different functionalities in Unreal Engine, such as animating different 3D characters, occupying various 3D environments freely available online, as well as putting the MoCap character into the first-person shooter and third-person shooter presets. The results of those rehearsals were truly precious and inspiring as I discovered the artistic potential of using MoCap in conjunction with Unreal Engine, something I was not expecting

and could not foresee. These revelations had a direct practical effect on how the performance structure unfolded and made us deviate from some of the initial thoughts and ideas that we had.

At the same time, I started to work on my part of the project, trying to create the fundamentals of the visual story: the virtual environment where the performance took place and the protagonist, the 3D character that Johan would animate. The designs were heavily based on my interpretation of the music, our discussions with the team, and some random activity of my subconscious mind. As soon as I started to get first prototypes of a virtual space and 3D character, we instantly tested them out with the soundscape and the movement, paying attention to how the actor would respond to them. The more I got done the more we were able to progress with the creation of the dramaturgy of the performance, which was more or less complete by the middle of March.

The original timeline for the project was dependent on my graduation time, which was first planned at the end of May 2023. Based on that we were aiming at having a show at the end of March after which I would have approximately two months to work on the manuscript and finalize it. In total, we reserved two and a half months to work on the production part, which afterwards appeared to be completely unrealistic to be able to fulfill all of our ambitions. Fortunately, we were able to adjust the timeline for the project and schedule the concert for the 20th of May. Thus, the production of the project took approximately four months, in comparison to the two and a half months originally planned. The biggest reasons for this one-and-a-half-month delay were the exploratory nature of this project and the fact that I did many of the technical procedures for the very first time in my life, and therefore was not capable of realistic evaluation of the time required to accomplish them.

When it came to the collaborative studio work having a spacious room (around 70-80 square meters) with a projector that is capable of producing large and bright image was an absolute must. There was only one suitable room in the Väre campus of Aalto University (room G203) that fit these requirements. The room was usually booked during the weekdays for different courses, which technically made us schedule our rehearsals for weekends. Our set-up consisted of a powerful gaming laptop (MSI 16W2), Xsens full-body MoCap suit, and Unreal Engine 5.0. The real-time motion capture data was analysed in Xsens native MVN software and sent to Unreal Engine 5 via Live Link plug-in.

The process of getting ready for a rehearsal was quite tedious and sometimes took up to 2 hours. It included bringing the suit from the Aalto tech library into the rehearsal space, resetting the suit's battery pack, putting motion trackers into the suit as well as calibrating it, and setting up the Unreal Engine integration. Even though I was happy to have access to the X-Sens suit as well as rehearsal space for free, the conditions we were working with were not optimal. I think that us having constant access to the suit and well-equipped workspace, which we would not need to share with other people, could have minimized the time spent on those technical preparations and optimized the time spent on creative work, as quite often we found ourselves exhausted even before we started to rehearse. I must admit that this quality was quite characteristic of the whole process of working with creative tech: we were so focused on trying to make things work technically, that unfortunately there was too little time left to test things out creatively. Through all of the technical difficulties, we managed to get creative freedom with the chosen medium only during the general rehearsal, a day before the premiere, which resulted in a great deal of improvisation in real-time during the first

show and less rehearsed preplanned elements. This is not necessarily a negative thing, but rather something we were not entirely ready for.

Now that I explained the process of our collaborative creative work from ideation to realization in detail, I will proceed into describing each separate unit of it: Dramaturgy of the performance; 3D environment, VFX, Game Mechanics; Character design and motion capture; Sound Design, SFX and Audio reactivity; Choreography.

## 5.2 DRAMATURGY OF THE PERFORMANCE

The process of formation of dramaturgy for the performance was unconventional and unpredictable. The nature of this performance with so many mediums of artistic expression and people involved (none of which was a director) made us invent the way we approached the creation of the dramaturgy ourselves. At times this process felt unreliable and unsustainable, but now after finalizing the production work and looking back to what we have done and how we did it: seeing all of the initial ideas and thoughts materializing in different aspects of the final work and creating coherent artistic sense altogether, I know that we were on a right track.

As it was mentioned in the previous chapter the soundscape was at the core of the formation of the dramaturgy. It gave a lot of initial impulses for both visual storytelling and choreography. These impulses resulted in concrete artistic choices in those domains that in turn when being tested during the rehearsals together with other elements of the performance triggered more creative impulses up until the point when we devised the following performance structure.

The performance starts with the spectator camera entering the cave environment and showcasing the space and its different areas for about 90 seconds, after which it approaches the stage and shows the protagonist, performing an “exploratory” dance. Next, the protagonist engages in interaction with different stones on the virtual stage, he moves and kicks them around trying to find the glowing gem. He spots the gem and approaches it but at that point, something stops him from picking it up: something bigger is about to start. Noise coming from the stones bouncing off each other and the surfaces awakens the guardian of the cave and to prevent the kid from stealing the stone the guardian initiates the storm. The storm constitutes a climax event of the performance and lasts up to 5 minutes. During the storm both the protagonist and spectator camera perform a spiralling movement, that highlights the spiralling nature of a tornado storm. The protagonist is trying to survive. After an intense 5 minutes of duel, the storm backs down and leaves the protagonist on its own. For a moment the protagonist forgets about the glowing gem and becomes aware of an audience around him and of an avatar on the screen. The spectator camera is trying to establish the connection between the 3D character and the audience by showing the close-ups of him. Towards the end of the performance, the protagonist spots the glowing gem and remembers his original intention: he approaches the stone, picks it up, and performs a gentle and adorable dance with it, holding it like a baby. The performance ends with the spectator camera leaving the space and showing it from further away.

With such performance dramaturgy we wanted to introduce just a short fragment of a bigger story, not giving any clear answers on how the protagonist ended up in the cave, the reason he was searching for the glowing gem, and in what way the possession of the gem will affect his life, why the gem was so important to find? Keeping up with that line we did not want the dramaturgy to be very clear for the audience and I hope that no one really perceived it exactly the way I explained it above. The dramaturgy mostly served as a tool for us to put together all of the numerous layers, mutual interests, and influences into a harmonious whole that would resonate with an audience on a sensual level rather than on rational one.

### 5.3 SOUND DESIGN, SFX, AUDIO REACTIVITY

During our very first meeting with the team, we were listening to the songs from Henia's upcoming EP Back Life to get a taste of their latest production. I empathized with the EP instantly, especially with the track Trance 369, which afterwards became a climax part of our performance. Not long after we decided to recycle the songs from the EP for the soundscape of the performance, which helped to kickstart the ideation process. Thus, the soundscape was the first of the different components of our performance to be more or less ready and consequently, it was at the core of the design process, providing a lot of impulses for the development of visual storytelling and choreography. For example, there was a moment in Trance 369 track with just a bass and rain sounds, that inspired us to include the storm episode. The intensity of the track and its spiralling motifs worked really well with the tornado storm, therefore we decided to devote the whole track to that episode.

As it comes from the name of the song Trance 369, Henia’s music is essentially trance music: it has all of the distinctive features of the genre such as euphoria, epicness, melodiousness, and hypnotism, and all of these features are strongly present in the performance's soundscape as well as in the performance in general. Together with Trance 369, I proposed to include another track, one of Henia’s earlier works referred to above, the Double Helix. Before I heard their new songs for Back Life EP, I thought that Double Helix encapsulates the very essence of Henia's music, this is why I wanted to include it as well. Later on, we realized that Double Helix and Trance 369 started to compete for the recipient's attention, especially when put one after another, as they both are pretty epic, maximalist, and multilayered. To ease the level of drama Henia ended up remixing the Double Helix into a more subtle ambient version of a track. The Double Helix ambient remix was accompanying the episode, where the performer was establishing a connection with his virtual self and with the audience after the storm. It was really suitable for conveying a certain level of tension, uncertainty, and awe.

We ended up using the same remixing approach with other tracks from Back Life EP to make them more suitable for the dramaturgy of the performance and how it was unfolding. The main mechanism behind it was to give the EP tracks more air to breathe, by stretching and decreasing the original tempo of some moments in songs, as Henia's music according to their own words "tends to be overly compressed and full of 'in your face' type of moments” (Personal communication, June 13, 2023). The performance soundscape is mostly instrumental except for the lyrics fragment we took

from one Lil Uzi Vert song and the very last episode, the Dilemma remix. The fragment from Lil Uzi Vert's collaborative song with Snow Strippers is quite important for the whole performance as it includes the name of the performance and some of the cultural references behind the project. The Dilemma remix was accompanying the moment when the protagonist finally lifted the glowing gem and performed a very gentle and intimate dance with it.

Another important audio component besides the soundscape was sound effects. Game engine functionality makes it possible to manipulate sounds in ways that can really augment artistic expression and elevate storytelling. One of the functionalities that we were using in our projects was spatial sound. We placed the sounds of wind and falling water into the specific areas in the environment and the closer the camera was approaching those areas during the performance the louder the sound was playing, thus creating a great level of immersion for the audience. Another algorithm was triggering different rock sounds when rocks were colliding with different objects: when the protagonist was touching the stones, or if the stones were touching one another or the floor, the rock sample was playing. The sounds were randomized creating variety and adding a level of realism to the performance. Rock sound effects were designed by Henia Nikkilä.

When it comes to the audio reactivity of the visuals, there was no automated audio-reactive functionality involved in the project. I did it mostly manually by activating and deactivating some layers of the storm at specific moments in the soundscape. Another way how sound was amplified by the visuals was through the beautiful cinematic movement of the spectator camera. The effect was achieved by programming a SpaceMouse device to pilot a camera in Play Mode in Unreal Engine. The camera had physics properties of a ball which made it possible to have a different speed depending on the mouse input, as well as achieve a pretty natural rolling effect. Camera movement thus had the necessary functionality to create a harmonious connection with different moods of a soundscape, both with the dynamic as well as with the stretched-out, slow moments in it.

### 5.4 VISUAL DESIGN: 3D ENVIRONMENT, VFX, PHYSICS, GAME MECHANICS

Virtual 3D environment was one of the first fundamentals of the visual world that I started to develop. I wanted it to both be functional and meet the needs of our performance as well as reflect the mood of the soundscape. As I mentioned in the previous sub-section, the music was one of the first units in the performance that was more or less defined, therefore it was at the core of the design process. When I was thinking about Henia’s music and how to visualize it in the form of virtual scenography, the pictures of wintery landscapes with cold colours and reflective, glossy materials came to my mind. I was browsing through different ready-made 3D environments in the Unreal Engine marketplace and a couple of cave environments with beautiful rocks and gems caught my attention. I found the idea of having a closed cave environment as a mise en scène for the performance quite compelling and ended up loading one of the free assets into my Unreal Engine project. I reworked the environment quite a lot by changing/removing/adding the geometry, replacing the built-in textures with the textures I designed myself, and drastically changing the lighting.

I find this workflow of recycling the 3D environments built by someone else quite interesting, as besides it being timesaving in the context of performance art it distantly resembles a site-specific approach. What I mean by this is that the ready-made 3D environment was providing impulses for us to respond to creatively and largely contributed to formation of the dramaturgy of the performance. After reworking the environment, I designed an otherworldly cave, which had an improvisational performance stage in the middle and was constructed out of gemstones, that were either blue, turquoise, purple, or red in colour. The ground level of the cave was mostly covered with snow and had some transparent liquid surfaces here and there. (See Figure 3,4)

When it comes to functionality of the virtual space there was one important factor that I had to take into consideration while designing the floor surface: the area where the 3D character driven by MoCap was moving must be flat. This requirement is imposed by the limitations of the X-sens motion capture system, which is not good at tracking the actor whose legs are not on the floor. Therefore, I ended up modelling a designated area in a 3D environment with a flat surface, for the 3D character to occupy. This area was situated in the middle of the environment and served as a stage. (See Figure 2) We scaled and calibrated the character in a way that it would always stay within the boundaries of this stage, even though at times because of the problems with drifting the character ended up outside of the stage, levitating in the air. I found the solution of having different floor levels in the environment visually more interesting than having only one level of flat floor, as it created more space for piloting the camera during the performance.

My palette of Visual effects for the project included the Niagara particle system and experimenting with the lighting. The performance's climax, the tornado storm, was made entirely out of different particles in the Niagara system of Unreal Engine and included the following layers: 2 tornado storm particle systems (low and high), 2 layers of snow particle systems with different parameters, and a layer of leaf particles. All of the particle systems except for the snow were using the Vortex force, which helped to achieve the circular movement of particles so important to get a feeling of a tornado storm. (See figures 10,11) The duration of the storm was mapped to the specific moment in the soundscape, and the separate layers of the storm were triggered by different keys on a laptop keyboard.

When it comes to the lighting there were two different directions I worked with: the rotation of the directional light (the natural lighting), and adjustments of colours and intensities of artificial light sources. I programmed the directional light to rotate at a certain speed so that the natural light was present at the very beginning of the show and at the very end, creating a metaphor of a sped-up day and night cycle. In the middle of the performance, the directional light was in its night position creating a space for artificial lights to take over. The role of artificial lights was to contrast and highlight some certain areas in the environment and events happening in the performance. At times it was needed to show only a glowing gem that the protagonist was searching for, therefore the majority of artificial lights were off. At other times it was important to show the environment on a bigger scale, which required a lot of lightning in the scene. Along with adjusting the intensity of the lighting in some specific moments I also adjusted the colour. I consider both lighting manipulations to be powerful instrument for transforming a space and changing the mood and atmosphere of the performance.

One of the most exciting and thrilling functionalities that I discovered while working with Game Engines was physics simulation. During our first rehearsals, we were exploring different UE blueprints: we put a 3D character animated by an actor wearing a MoCap suit in real-time into a first-person shooter blueprint in Unreal Engine. I was controlling the first person and instantly when I took the gun, I started to shoot the actor: the projectiles flew right into him and bounced off him. I was literally trying to kill my actor, it felt surreal, disorienting, and ecstatic at the same time. Another similar experiment that we tried was activating the physics properties of different objects in a scene (cubes, spheres, rocks) and seeing how the 3D character will interact with them. Soon enough we realized that our actor could trigger changes in a virtual environment by his actions in the real world, which was therefore blending the border between the virtual space and reality even more. That was more than I could comprehend at that point, as it opened a whole new palette of instruments that we wanted to explore.

For the actual performance, in the middle of the virtual stage, I collected a pile of stones that had physics properties turned on. The protagonist was constantly interacting with them, either purposefully while searching for the glowing gem, or accidentally out of his uncontrolled movement throughout the stage, which triggered truly beautiful, unexpected moments in the performance. Rising from simple experiments with physics, the motif of interacting with the stones became quintessential for the dramaturgy of the whole performance.

The denouement of the performance, when the protagonist finally managed to lift the glowing gem and perform an intimate dance with it did not involve physics directly but was made possible using another similar game mechanic: attaching the object to the bone of a skeletal mesh. This process involved creating a script that would measure the proximity of a 3D character to the glowing object, and when it was less than a specific number the glowing object would attach to the arm of the character.

## 5.5 VISUAL DESIGN: 3D CHARACTER DESIGN & MOTION CAPTURE

The character design was largely inspired by our initial discussions with my collaborators, by pop culture, as well as by some chance factors that were influencing me during that period of my life. It was the least logical and the most intuitive out of all of the design stages: when I got the idea, I had a feeling as if it came to me in a dream. Nevertheless, when I try to decompose the design, I could see quite clearly where all of the different influences come from.

The motif of Hyperpop rockstar mentioned in the previous chapter was quite integral for the character design. This combination of words initially came to my mind when I was trying to interpret one of Henia's most iconic tracks Double Helix. I think that subconsciously I was trying to design a character that would somehow fit that description, and I think that after all I succeeded, especially after the word rockstar gave a new meaning with a slash symbol put in between the words rock and star in the name of our performance. Another factor that influenced the design was my intention to create an androgynous character: not clearly a female, nor male, but something that would embrace both femininity and masculinity. Yet another set of influences came from such cultural layers as

anime, drain gang, and punk rock. Similarly, with the 3D environment design, there were a couple of technical requirements imposed by the nature of our performance, involving dance. Namely, we aimed to design a simple humanoid character that will have distinct limbs in order to showcase the movement as clearly as possible.

As a result of these different artistic and technical requirements, I created a kid character, (distantly resembling Lain from Serial Experiments Lain), whose outfit included a hoodie with devilish horns and a skeleton print, reflective pants, and boots with glowing platforms. (See Figure 5, 6) Unlike the modelling that was done completely in Blender, I created different materials and textures for the character's outfit in Unreal Engine. This helped to create a uniform visual style and blend the cartoonish character into the highly detailed 3D environment. Another important element that was added during the UE phase of character design was cloth simulation. (See Figure 7) The areas of the clothing where the simulation was applied were responsive to the wind and movement of the character in real-time, therefore adding a beautiful level of realism. Unlike the design of the environment with the design of the character it was important for me to create it myself from scratch, to make sure that I will implement my vision the way I want without making any compromises.

Creating a character from scratch meant that I also had to make it functional for real-time MoCap-driven animation myself, which was probably one of the most demanding and time-consuming parts of the whole project. In order to use a 3D character as a vessel for motion-captured movement one needs to create an armature with a specific number of bones to match the retargeting procedure in UE, as well as do the rigging and weight painting. The biggest challenge of rigging a humanoid character like the one I designed is that the movement should be realistic and human-like. The challenge became even more difficult by adding the real-time MoCap layer to it, since with the traditional key-frame animation one can more or less control the movement of the character and how the geometry deforms, whereas with MoCap animation the movement can be so unpredictable and different that one technically needs to rig a character ready for any kind of movement, in other words perfectly.

When rigging of the character was done the last step towards animating it in real-time with MoCap input in my workflow was Unreal Engine integration. This procedure involved a couple of steps that altogether would require less than 30 minutes, providing the character is rigged and exported correctly. Thus, I could say that Unreal Engine is very well optimized to work with real-time MoCap data and is one of the best options currently available.

## 5.6 CHOREOGRAPHY

According to Johan, the soundscape together with the visual storyline gave a lot of impulses for the development of the choreography. The movement dramaturgy in the performance was divided into 6 main parts. During the first part, Johan was performing a "travelling and exploring" dance, tuning into the mood of being a little kid in the cave, surrounded and mesmerized by the beautiful rocks. The second part was mainly devoted to the performer's interaction with the stones: Johan was moving them around, pushing and kicking them as if they would be physically present on the stage in an

attempt to clear up the space and find a glowing gem. The movement of the second phase included some simple acrobatics, break-dance elements, and was generally pretty low.

Next phase marked the protagonist's first attempt to approach the stone: the performer was trying to affect the stone without actually touching it but was lacking something to execute that. With his movements, Johan was trying to communicate the tension that arose from that process. The next part marked the beginning of the storm and was movement-wise based on improvising in response to the storm. The more the storm was roaring the dizzier and more disoriented the performer became and the more lost he got into the spiraling dance. (See Figure 8) During this part Johan was trying to show the presence of the storm through his movement: he was dragged by the storm at times from one end of a stage to another and at times down to the floor, the movement being ragged and fragmented. With his dance, the performer was trying to fight against the storm up until the moment when he surrendered and let go of control. In the second last part after surviving the storm, the performer is going through a process of symbolic rebirth, re-evaluating his relationship with the virtual doppelganger and his surroundings: for the first time during the show, Johan felt like himself and not as a virtual avatar, for the first time he became aware of the audience, for the first time the stone was not significant anymore. (See Figure 1) The movement during that part was quite minimalistic: the performer was mainly standing still or frozen staring either at the avatar or towards the audience, trying to communicate feelings of anxiety, confusion; and uncertainty of that moment, giving a moment for the audience to feel the same confusion, “like what is actually happening here” (J. Högsten, personal communication, June 7, 2023)?

After that short moment of contemplation, the protagonist remembered that he was looking for a glowing gem, and with this new knowledge about different aspects and layers of reality, he got finally empowered to lift the gem. (See Figure 9) Holding it in his arms gently, Johan performed a very intimate and sensual dance with it: "I was thinking of a stone and treating it as if it was my baby" Högsten commented. He was performing a minimalistic 2-step dance with a stone, holding it very closely and swinging it at times. Even though it was not clear what value the gem would bring to the one who will find it, the gem was very precious and significant for the protagonist in the moment: he was truly connecting with the stone and empathizing with it. The performance ends with spectator camera departing from the cave and leaving the performer one on one with the glowing gem (J. Högsten, personal communication, June 7, 2023).

According to Högsten, interactive real-time visuals gave a lot of input to embody the character and the storyline. Having the image of the whole world, the cave built out of precious rocks and a glowing gem in front of his eyes gave Johan a much stronger feeling of him being a protagonist and the dull grey rock on the stage being an actual precious glowing gem (J. Högsten, personal communication, June 7, 2023). The fusion of Johan with the fictional character would not have been as strong without the visual augmentation, which brings us to the very essence of this study: how to augment contemporary dance with MoCap and Game Engine technologies? The next chapter will bring us closer to answering this question.

# DISCUSSION

The following chapter is summarizing all of the important theoretical and practical knowledge that I have obtained from devising and analyzing my first mixed-reality audiovisual dance performance. The chapter will mirror the structure of the previous chapter in a way that it will bring the important insights from each subsection in chronological order.

As far as the overall **production** part is concerned, the main lesson that I learned is that projects of this type where multiple people, artistic mediums, and technological layers are involved are very time-consuming and labour heavy. Working in the given circumstances required a lot of synchronizing of schedules of multiple people together with the availability of the rehearsal spaces and technology, which at times could slow down the progression of the project and decrease motivation. Planning the working process in as much detail as possible together with reserving the equipment and rehearsal spaces well in advance usually helped a lot. When it came to **planning** different parts of my own work, such as designing different 3D elements, doing visual scripting, or testing out some new functionality together with an actor, I came to understand that it is better to double the time that I originally reserved, especially if doing something I never did before. One of the important things to keep in mind while working with technology creatively is that you can never really anticipate and plan ahead for everything that can go wrong, as every single project is unique, and with the new project and new requirements come new unforeseen challenges. Oftentimes dealing with these challenges and making things work can be really frustrating and, which is more important, take away the time reserved for creative work with this technology.

As Sam Rolfes in his interview to myself was saying: "...the amount of hours per day that I am just mad is really so much higher because these things are so frustrating and annoying" (personal communication, June 9, 2023), proving the fact that technical issues, regardless of how well equipped of a studio you have will always be a part of the process of working with the tech creatively. And the sooner one accepts it or even embraces it the better it is for both one's mental health and the creative output.

Nevertheless, when you overcome technical difficulties and things do get to work, the feeling one experiences is of little comparison to anything else. Seeing the actual results of your artistic work with motion capture and game engine technologies in real time is truly rewarding, stimulating, and encouraging for the creator. Based on the audience feedback and my own experiences perceiving multidisciplinary performances involving creative tech, I could confirm that for the audience this same quality translates into a feeling of deep immersion and engagement with the piece.

When it comes to **dramaturgy** of the performance, it was crucial for us to get as many creative impulses as possible to get things going in the very early stages of working on the piece, because we were not relying on any ready-made text or scenario. Therefore, it was important to have at least one of the artistic domains more or less ready in the early stage so that it could influence and give inspiration to others. In our project music became such a domain, placing our performance on the same grounds as audiovisual performances. This choice was intentional as music plays a huge role in my practice with new media. The process of devising a performance dramaturgy based on a

soundscape was really interesting, as it added a good level of abstraction and left a lot of room for the interpretation of a final piece.

The **soundscape** was largely based on Henia's older sonic works that were then remixed and made more suitable to the needs of a performance. As Henia's music is quite dense and maximalist, with remixing they were mainly aiming to add more air for the soundscape to breathe. By using the possibilities that game engines offer to manipulate the sound such as spatial sound and sound that would be triggered on collision, we added an extra level of realism and immersion to the performance. When it comes to audio reactivity, a game engine is a great instrument to create a connection between visuals and audio. Even though we have not used any direct audio-reactive algorithms in our project, by triggering different layers of particle systems at specific times and programming the joystick for smooth navigation in space we managed to create a more subtle, indirect layer of audio reactivity for our performance. In our discussion with Sam Rolfes, he pointed out, that they in Team Rolfes are usually also doing audio reactivity just manually, as this approach lets you "choose when is it dramatically important to be hitting that light button…" (personal communication, June 9, 2023).

As far as **world-building** is concerned game engine is truly one of the most powerful tools for executing that. Using such game engine functionality (in my case Unreal Engine) as modelling, landscape and foliage instruments, particle systems, lighting, material panel, etc it is possible to create and animate impressive, highly detailed, imaginary worlds to serve the needs of different artistic projects. At the core of our performance was a visual world for the choreographic and sonic narrative to take place and to create that world I recycled one of the ready-made 3D environments from the Unreal Engine marketplace. For building an environment I was mainly using modelling tools, scaling, moving, rotating tools as well as material panel. As a result, I created quite spacious, otherworldly cave terrain made out of different precious gems, with a pretty complicated architecture.

In order to **animate the environment** across time I was using such visual effects as lighting and particle systems. **Lighting** appeared to be one of the most powerful dramaturgy instruments game engine can offer. By manipulating different lighting parameters such as colour and intensity across time I managed to drastically transform the virtual space when it was needed and create visual diversity throughout the whole course of a performance. The possibility to map the lighting to time or to the sound input or the lighting to be triggered by some event creates a spectrum of great opportunities for artistic expression. Another important group of visual effects that I was actively using was **particle systems**. With particle systems, it is possible to recreate various atmospheric conditions such as fog, rain, snow, and wind, and different chemical reactions such as fire, explosions, fireworks, and special lighting effects. Yet again being able to create all of these effects and trigger them either with a keyboard input or as a result of a collision with an object or just automatically at a specific moment in time opens up a huge potential for using these functionalities creatively in the context of performance art.

Further Unreal Engine functionality that I found very effective in the context of my research is **physics engine and visual scripting**. I was using these functionalities mainly to animate the movement of different stones: whenever the 3D character animated in real-time with MoCap data was touching or kicking the stones in the virtual world the stones were moving away according to the

law of physics. Besides that, I coded a blueprint for attaching a glowing gem to the hand of the 3D character, so when it approached the stone close enough, the gem got attached to the arm of the 3D character. Using physics engine and visual scripting in conjunction with real-time data coming from a MoCap suit facilitated deeper integration of the 3D character into the virtual world as well as created a strong augmentation of performance, that was revealing the hidden layers not visible in the actual physical space.

As far as **manipulating motion capture data** is concerned, the game engine has all of the necessary functionality: in the case of Unreal Engine, it requires only a few simple steps to connect the Xsens MVN software to UE virtual production unit in order to send the data and animate your custom character. Within game engine, it is possible to create complex and versatile materials, that can mimic cloth, plastic, leather, metal, and other surfaces and apply them to different areas of your skeletal mesh. On top of that, it is possible to activate cloth simulation for different parts of character's outfit as well as animate hair and facial features. Thus, Unreal Engine provides a **great palette of instruments** to use motion capture data to animate a 3D character as well as to build extra layers of animations and simulations on top of MoCap animation. These instruments applied together in different combinations can result in really impressive creative solutions for real-time character animation.

In their study on Choreomorphy Raheb Katerina and other authors deduced, that design of the 3D avatar not only inspired dancers in their project to move in a particular form or quality but also affected dancer's overall mood (Raheb et al., 2018). Throughout my research I came to the same conclusions: thanks to creating a **unique 3D character**, that performer could animate with his movement in real-time, as well as a whole world, with dynamic lighting, a great number of objects, and atmospheric sensations that performer was an active part of, the performer got a much stronger feeling of him being a little kid in the cave looking for a glowing gem. Thanks to dynamic, responsive live visuals the performer was able to truly embody his role and convey a story on a deeper level, which would not be the same without the visual augmentation.

Chosen digital mediums real-time motion capture and game engines, facilitated a **dialogue and greater connection** between choreography, interactive live visuals, and soundscape so that these domains were constantly affecting and blending into one another, resulting in a coherent, harmonious whole, the Gesamtkunstwerk (Wagner, 1849) of a digital era.

# CONCLUSIONS

As referred to in the introduction section this study sheds light on the question "How can real-time motion capture and game engine technologies augment contemporary dance, both in the visual and audio domains, in a way in which sound and visuals can influence each other?" To respond to this question, I undertook these actions in order as follows: I conducted artistic research according to PBR methodology, I examined related work and case studies on the topic of Dance and Technology starting from the late 1980s, and finally, I conducted an interview with pioneering virtual performer Sam Rolfes. The order in which I approached these methods was intentional, as I preferred my artistic production and the knowledge, I extracted from it to be influenced neither by the work of the older generations nor by the contemporary. I wanted to obtain the knowledge following my own original process which I am going to share in the next paragraph.

Out of the three major artistic domains involved in the performance, the sound part became a starting point for the formation of dramaturgy and largely influenced the creative decisions made in the two remaining domains, live visuals and choreography. With the help of the various modeling and texturing tools that game engines offer, I designed an otherworldly cave environment that was corresponding with the music as well as provided functional background for the virtual choreography. Such game engine functionalities as spatial sound, sound on collision, and various audio reactivity tools helped to create a more profound connection between the soundscape and the visuals as well as largely contributed to the immersiveness of the piece. The usage of the MoCap suit in conjunction with the physics engine, and scripting made it possible to integrate a real performer much deeper into the fabric of the virtual environment: by making some actions in the physical world the performer could directly affect the virtual environment, which created much stronger connection between the choreography and the live visuals.

Further game engine functionalities such as simulations (cloth, hair) and animation added on top of real-time motion-captured movement could heighten the 3D character's expression and add a level of realism. By experimenting with the lighting as well as with different particle systems I managed to animate an otherwise static and permanent environment and create a visual interest and diversity throughout the whole course of a performance. An opportunity to map or trigger these visual effects at specific moments in the music or choreography opened up a whole new palette of creative instruments and helped to establish more connections between different aspects of the performance. The chosen technological mediums motion capture and game engine, therefore, helped to create a much stronger bond between choreography, interactive live visuals, and soundscape making them influence and permeate one another throughout the whole process of formation of dramaturgy as well as during the performance itself on stage real-time. I discovered that having a highly detailed interactive virtual world with the figure of a protagonist that human performer could animate in real-time had a huge impact on the choreography: the amalgamation of the human performer and protagonist as well as the feeling of the character and the story that human performer embodied was much stronger with the responsive live visualization rather than if the performer would just try to visualize the narrative inside his head.

My findings resonate quite a lot with the ideas that I came across while conducting the related work review and interview with Sam Rolfes. Various hardware and software that were used throughout the dance and tech movement starting from EyeCon software and different sensing devices and ending with MoCap suits and contemporary game engines helped to establish a greater connection between different aspects of the performance, be it choreography and sound or choreography and lighting, or choreography and visuals or all of these mediums used together. The level of this connection is profound: powered by certain tech tools different artistic domains of the performance are constantly shaping and flowing into one another so that you can start "seeing" the music or "listening" to choreography or watching it being abstracted into tiny particles that are still dancing along the music. As a result of this process, one essentially gets to see the art that is alive (Victor, 2012), an ecosystem, a living breathing creature, whose different elements are behaving and responding in relation to one another.

In the early years of dance and tech the "common criticism was made that real-time interactive sonic and media manipulations" triggered by specific moments in dance "could have been preset and pre-rehearsed to equal or greater effect "(Dixon, 2007). The technology has exponentially improved ever since and currently, it is neither easy to imagine nor makes any rational sense to attempt aligning certain interactive sonic and media manipulations to dance by pre-rehearsing. Furthermore, this type of rigid pre-rehearsed approach kills the very essence and beauty that many real-time tech tools like MoCap and game engines can offer. According to Sam Rolfes, the real-time tech tools during the design phase allow you to respond to an environment, respond to a character, and eventually to the whole story, which makes one understand the story they are creating much better and therefore make much more critical decisions. Then, when it comes to the performance phase real-time tech tools allow the performers to respond to one another, to the audience, and to the current moment in time where everyone is, thus making the performance more genuine and impressionist (Rolfes, 2023).

Based on the conducted research it is relatively hard to exhaust the potential answers to the stated research question because in my opinion every single dance performance executed using MoCap and game engine technologies can be a unique answer to this question on its own. Therefore, for future research, I would, first of all, consider studying more examples of using MoCap and game engine technologies in the context of contemporary dance and applying qualitative research methods to the analysis of those examples. Secondly, for the lack of previous substantial research made on the topic, I would consider conducting more interviews with the artists working on the intersection of the mediums in question, as this method proved to bring a lot of valuable knowledge and insights. Thirdly and finally, I would devise another audiovisual mixed reality dance performance according to PBR methodology, with a bigger focus on playability and game mechanics, as due to the constraints of the current research I could not integrate these aspects of working with game engines as much as I wanted.

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# APPENDIX A: INTERVIEW QUESTIONS

1. When did you start to experiment with real time motion capture and game engine technologies, what drew your attention to these mediums and what have they brought into your artistic practice?
2. Which motion capture technique/game engine have you worked with, and which one is your most preferable and why?
3. What are the problems, critiques, negative sides of motion capture and game engines (and even using tech in general in dance/performing arts) and how do you overcome them?
4. What are the positive sides?
5. What is your attitude towards Extended/Mixed Reality?
6. What roles does music play in your mixed reality performances and how do you do audio-reactivity?
7. How can motion capture and game engine technologies augment contemporary dance and performing arts?

# APPENDIX B: VIDEO DOCUMENTATION OF PERFORMANCE

The fragment of video of the “ROCK/STAR Vol.1” has been uploaded to aaltodoc.aalto.fi together with the pdf file of the manuscript.

**Figure 1:**

*Performance still picture 1*

# APPENDIX C: PICTURES RELATED TO ARTISTIC COMPONENT

**Figure 2:**

*Virtual landscape with a glowing gem in the middle of the stage*

**Figure 3:**

*Virtual landscape angle 2*

**Figure 4:**

*Virtual landscape angle 3*

**Figure 5:**

*Character in the landscape*

**Figure 6:**

*Character portrait, close-up*

**Figure 7:**

*Character, T-pose*

**Figure 8:**

*Performance still picture 2*

**Figure 9:**

*Performance still picture 3*

**Figure 10:**

*Landscape with snow and leaf particles*

**Figure 11:**

*Landscape with tornado storm*