From Pixels to Reality: Exploring a New Approach to Making Clothes for Cosplay

Authors: Lina Forsberg and Vilius Ovander

Supervisor: Fatima Jonsson
Södertörn University | Natural Sciences, Technology and Environmental Studies
Bachelor's Thesis 30 hp
Media Technology | VT2025
Game Development Programme

SÖDERTÖRNS HÖGSKOLA | STOCKHOLM
sh.se

Från pixlar till verklighet: utforskande av en ny metod för att skapa kläder till cosplay

Abstract

3D-scanning, 3D virtual simulation software and digital entertainment has the potential to revolutionize how clothing is designed and produced. To explore this, the VSTG-approach (Virtual Simulation to Tangible Garment) was developed and tested to then interview six cosplayers to identify challenges, potential, general opinions and how their motives for cosplay affect their interest in the VSTG-approach, either as a B2C-model (business to consumer) or a personal tool. Interview data was thematically analyzed and showed overall positive feedback from participants, who said the VSTG-approach would both simplify and speed up the process of costume-making, benefiting both beginners and veterans. There was interest in using the approach as both a B2C-model and a personal tool, and while benefits such as reduced waste of resources were recognised, there were concerns regarding data privacy of 3D-scans, associated expenses, and accuracy and difficulty of the VSTG-approach.

Keywords: Cosplay, 3D-scan, Game Character, Handcraft, Marvelous Designer, CLO3D, Auto-fit, Digital Entertainment, Fashion Industry, Data Privacy, VSTG-approach

Abstrakt

3D-skanning, programvara för virtuell 3D-simulation och digital underhållning har potential att revolutionera hur kläder designas och produceras. För att undersöka detta, utvecklades och genomfördes VSTG-metoden (*Virtual Simulation to Tangible Garment*, virtuell simulering till konkret plagg) för att sedan intervjua sex cosplayers för att identifiera utmaningar, potential, allmänna åsikter och hur deras avsikt för cosplay påverkar deras intresse i VSTG-metoden, antingen som en B2C-modell (*business to consumer*, företag till konsument) eller eget verktyg. Intervjudata var tematiskt analyserad och visade överlag positiv återkoppling från deltagare, som sa att VSTG-metoden både skulle förenkla och snabba på processen att skapa utklädnader, vilket vore gynnsamt för både nybörjare och veteraner. Det fanns intresse för att använda metoden både som ett eget verktyg och för B2C, och medan det sågs fördelar som minskat slöseri av resurser, fanns det oro kring datasekretess av 3D-scandata, kostnader, samt VSTG-metodens noggrannhet och svårighetsgrad.

Nyckelord: Cosplay, 3D-scan, Spelkaraktär, Hantverk, Marvelous Designer, CLO3D, Auto-fit, Digital underhållning, Modeindustri, Datasekretess, VSTG-metod

Table of Contents

Introduction

Fictional characters are made real when fans dress up in costumes and perform according to the character's traits, which is a subcultural practice called cosplay (Lamerichs 2014, 113). This paper studies how cosplayers buy and craft their costumes and how that affects their reception to a new method for creating garments that we named the *Virtual Simulation to Tangible Garments*-approach (VSTG), to identify potential, challenges and general opinions on the method. Studying the potential of the VSTG-approach gives an insight into not only how the future of cosplay might look, but how mainstream fashion might operate. Focusing on cosplayers allow for studying a demographic that is not only fashion interested, but also has experience handcrafting their costumes. Furthermore, their interest in media gives a perspective on potential collaborations between the fashion industry and the digital entertainment industries, that becomes possible with the method being studied.

The idea of the VSTG-approach has long been anticipated by industry professionals yet unsuccessfully integrated into the mainstream fashion industry (Paganelli 2019, 2). It involves using 3D scan-data to gather measurements of the wearer. The data can then be used to create a virtual avatar to automatically adjust digitalized sewing patterns to the wearer, which has the potential to democratize the luxury of made-to-measure fashion. Furthermore, technology such as 3D-printing and 3D-weaving could fully automate the process, making personalised fit the new standard. However, such technology is only mentioned as a speculative addition to the method considering the advancements needed for those fields to create full garments.

To experience the method, a part of this study was spent imitating it. A video game character with garments was created, and the softwares Marvelous Designer and CLO3D were used to create and adjust the garments of the digital character to a 3D-scan of one of the authors, and then sewn by hand. The project revealed a few challenges in the concept of translating fiction to reality, but the main focus of the study is on the thematically analyzed interviews of the six participating cosplayers who shared their views on the shown VSTG-approach that was introduced both as a B2C-model (business to consumer) and a tool for cosplayers to utilize themselves.

Related Research

Cosplay

Fictional characters of all genres and media are made real when fans dress up in costumes and perform as the fictional character, which is a subcultural practice called *cosplay* (Lamerichs 2014, 113). Cosplay is commonly performed at fan conventions, but is also commonly engaged through online platforms (Lamerichs 2014, 117). Lamerichs (2014, 114) notes that cosplay has become a global hobby, and has even led to international competitions. It can be seen as a link between the entertainment world, the real world and even the digital fashion world, as the digital garments of fictional characters are made real. While these costumes are often hand-made by fans, many cosplayers purchase them from shops and artisans (Geczy 2016, 13), highlighting an interest in owning real versions of digital garments from video games and other entertainment media. The VSTG-approach could be useful for cosplayers, either as a B2C-model or for cosplayers to use themselves.

[Removed for web publishing.]

Figure 1. b-lu-rry (Reddit 2023, instagram: lu_natic.cos) (left) (permission granted) cosplaying the character Jinx from Arcane (2021) (right).

Video Games and the Fashion Industry

Makryniotis (2018, 10) proposes that digital fashion has the potential to link electronic entertainment such as video games to real life fashion. Digital fashion is a new field of fashion that relies on 3D software to create digital products (Särmäkari and Vänskä 2022, 215). Digital fashion is commonly created using 3D virtual simulation software like Marvelous Designer and CLO3D (Choi 2022, 2), which are both developed by the same company and work the same by having the user create 2D sewing patterns that then simulate on an avatar (CLO Virtual Fashion 2009b; 2009a). The difference between the two softwares is that Marvelous Designer is ideal for the workflow of the video games and vfx industries, while CLO3D helps prepare its garments for manufacturers to actually produce them (CLO support 2024). Duong et

al. (2024, 7) did a study investigating the accuracy of clothing material simulation in CLO3D and concluded that materials in the simulation and reality are relatively similar, and that CLO3D is quite accurate for simulating different clothing materials. Files from Marvelous Designer are compatible with CLO3D and vice versa (as shown in out execution of the VSTG-approach in *Method*), so as these softwares are used both in the production of video games and day-to-day fashion, there is compatiblity between the two industries.

There are already collaborations between the video games and fashion industry. One example is Louis Vuitton's collaboration with the video game *League of Legends* (Riot Games 2009) that featured Louis Vuitton-themed *skins* (graphic downloads that change the appearance of characters in video games) alongside League of Legends-themed garments in the brand's store (Choi 2022, 9). Additionally, Prada dressed characters from the video game *Final Fantasy XIII* (Square Enix 2009) to market their spring/summer 2012 men's collection (figure 2) (Makryniotis 2018, 15). A less obvious collaboration between the fashion and video game industry was when the Emmy awarded costume designer Lyn Paolo was employed by the video game company Rockstar Games to design clothes for characters in the video game *Grand Theft Auto 5* (Rockstar Games 2013) (Makryniotis 2018, 13). This further shows compatibility between the two industries, with collaborations that could further develop in the future.

[Removed for web publishing.]

Figure 2. Prada spring/summer 2012 men's collection worn by a model (left) and the character Lightning (right).

Virtual Simulation to Tangible Garment

One way these collaborations could develop is through the VSTG-approach, that has been put into business in the general fashion industry before. Choi (2022, 21) interviewed fashion industry professionals and a project called WITHIN24+ALLSTUDIOS was briefly discussed. WITHIN24+ALLSTUDIOS was a fashion project that took place in South Korea, where customers were scanned using a 3D body scanner, could participate in the customization of their garments and could try them on in a FX mirror (a mirror where one can try on clothes using augmented reality, without physically trying them on) before the store made the garments real (Choi 2022, 21). While issues with implementing the method were identified, such as being very expensive to turn into an online service and the technology still seeming insufficient, there was still interest from customers (Choi 2022, 21). In the interview, the industry professionals said that there is still a slight gap between a garment rendered in CLO3D and a real garment, and that customers' socio-cultural awareness of digital fashion is too limited for a B2C-model (Choi 2022, 21). In Paganelli's (2019, 6-7) case studies of tailoring businesses that utilize high end 3D-scanners for measurements, it is also reported that their scanners struggle to produce accurate data. However, Baidak, Flaherty and Abdelrazeq (2023, 2-3) used a 3D-scanning app on the phone to scan participants' upper bodies and then sew custom fitted bras, and as it was reported that the bras were of superior fit, 3D-scanning can be used to create garments of accurate fit. One aspect of the VSTG-approach that WITHIN24+ALLSTUDIOS lacked, was automatic fitting. The fitting process does not have to be done by hand, as Wang (2018, 1) among others are developing automatic size adjustment systems for garments in 3D virtual simulation systems. Wang's (2018, 2, 11, 12) system has shown to be convenient and confirmed by professional fashion designers and pattern makers to provide superior fit compared to traditional garment adjustment rules, and while minor fit issues occur, they are believed to be caused by insufficient body measurements, which underlines the importance of accurate 3D-scans.

If fully implemented into the fashion industry, automatic fitting could enable mass production of made-to-measure garments (Wang 2018, 1-2). 3D-scanning has the potential to democratise personalised fit, which today is a luxury. Distributing tailors'

luxurious craftsmanship to a larger audience could enhance the emotional durability of garments, and therefore reduce waste which would further improve sustainability of fashion (Paganelli 2019, 14, 18). The 3D virtual simulation softwares hold a value of sustainability too, as they enable fashion designers to prototype garments digitally, reducing waste, as well as speeding up the production time (Choi 2022, 25 and Duong et al. 2024, 2). Virtual fashion can also make it possible to test and "try on" garments from afar using a 3D-scan as avatar, reducing the need of transporting the clothes to the customer (Duong et al. 2024, 2), decreasing transport emissions and cutting costs for both businesses and consumers.

It is also possible for the production of tangible garments to be automated, as possibilities have been explored in how textile-like compositions can be achieved through 3D-printing, such as arranging micro- or meso structures to achieve textile-like qualities in what looks like plastic chain-mail (Gürcüm et al. 2018, 3). Another alternative for 3D-printing textile-like compositions could be what is called 3D-weaving, where machines interlace threads to create actual fabric (Perera et al. 2021, 25), possibly turning threads directly into finished garments. While these means of automation could further decrease production costs of fashion, and thus lower the cost of garments from the VSTG-approach, they still need more development before implementing into any production line, and are only considered a speculative addition to the VSTG-approach.

Avatars and Privacy

For the VSTG-approach to work, 3D-scans of the user or customer are needed, and while private use of the method would keep data private, a B2C-model would need the trust of the customer to operate. Paganelli's (2019, 6, 13) case studies of businesses that utilize high end 3D-scanners for measurements, reveal that customers are deeply concerned about privacy of 3D-scan data, as they have to undress for accurate data to be gathered. It is further reported that customers concerned about privacy will sometimes be scanned wearing clothes, which distorts the measurements and makes the scan data insufficient, which defeats the purpose of the 3D-scan (Paganelli 2019, 6).

Furthermore, turning 3D-scans into avatars that can be used in 3D virtual simulation software is also dependent on the willingness of the user or customer. Private users would need the expertise to turn 3D-scan data into an avatar, and customers would again need to be comfortable with sharing personal data. Choi (2022, 19) notes that avatars evoke cold and eerie feelings because of the *uncanny valley* effect, which refers to humans' negative response to objects that inadequately resemble humans. It is possible that the uncanny valley effect could disinterest people from having avatars of themselves. The idea of uncanny valley is that when something looks almost real but has noticeable deviations such as dull eyes, stiff movements and an unusual look in general, feelings of repulsion are triggered in humans (Schwind, Wolf and Henze 2018, 46–47). To avoid this repulsion, avatars would have to be made in very high quality to look realistic, healthy and alive in every aspect (Schwind, Wolf and Henze 2018, 46, 49). Park (2018, 1) studied the emotional reaction of people viewing themselves as avatars, and found that levels of self-esteem affected the experience. Positive reactions were found in participants confident in their looks, while the opposite was found in those with low self-esteem (Park 2018, 1). As attractive features are less prone to evoke uncanny valley (Schwind, Wolf and Henze 2018, 46), self-perceived attractiveness might have reduced subjective eeriness in avatars of confident participants. However, Park (2018, 9) found that regardless of reaction, all participants were willing to see their avatar again in the future, which might indicate an openness to using avatars for the VSTG-approach in the future.

Research Question

The purpose of this study is to examine the potential of the VSTG-approach (Virtual Simulation to Tangible Garment) in cosplay and how it might intersect the fashion industry with digital entertainment media. Studying the potential of the approach gives an insight into not only how the future of cosplay might look, but how the fashion industry might operate.

We did a project where the VSTG-approach was designed and tested, as we created a custom-fitted tangible garment from a digital character. Six participating cosplayers were shown the project and interviewed to identify challenges, potential and general opinions on the method. From an essentialist/realist approach, we reported experiences, meanings and the reality of participants. The data was then analysed semantically, meaning that we analyzed the significance of the patterns and their broader meanings and implications. The results could be useful to cosplayers by informing how this method can aid in the craft of cosplay. Additionally, both the digital entertainment industry and the fashion industry could benefit from this study by gaining insight on how to evolve the way fashion is designed and produced, and how they can benefit from collaborating with each other and/or with cosplayers.

The research question of the study is as follows:

What motivates cosplayers to buy or craft their cosplays, and how do they perceive the new VSTG-approach (Virtual Simulation to Tangible Garment) in relation to crafting or buying made-to-measure garments for cosplay?

Methods

The VSTG-approach was tested by carefully executing every step using our own game character, which gave us full control and access to all files, as well as a 3D-scan of one of ourselves to later confirm the fit of the garment. This chapter demonstrates the full process of the executed VSTG-approach, and the collection and analysis of the interview data. A more detailed version of the method is located in the appendix of this study.

Figure 3. Concept art.

Making the Character

The first stage of character creation was gathering references and making concept art (figure 3). A reason to make her stylized instead of realistic is to not make her feel uncanny. Realistic characters have a risk of evoking uncanniness, if not made perfectly (Schwind, Wolf, and Henze 2018).

The character was sculpted in the digital sculpting program Zbrush (Maxon 1999). Accessories such as shoes, goggles and headphones were also made in Zbrush, while the clothes were made using Marvelous Designer (CLO Virtual Fashion 2009b). The material was set to “Cotton_50s_Poplin” for the top. The material settings and sewing patterns were made to fit and look good on the stylized character without real consideration for how this would translate to real life, since this is a game character workflow.

Figure 4. Sewing patterns in Marvelous Designer.

When the character model was done, it was rigged and animated. A stride animation was made to show our participants the character and their clothes in action. The clothing was simulated in Marvelous Designer onto the animated movement of the character. Usually in game development you would not simulate the whole garment, but we decided to simulate it, which is more akin to VFX and movie making, because

achieving similar quality using game development workflows would take too much time for the project.

The last step was rendering in the game engine Unreal Engine (Epic Games 1995). One animation where the camera orbits the character, showcasing the model, and one where the character is animated.

Figure 5. Image from orbit animation.

Figure 6. Image from animated character.

Making the Tangible Garment

The 3D-scan model was prepared and optimized to enable stable performance in CLO3D (CLO Virtual Fashion 2009a). The Marvelous Designer-file of the game character's garments was opened in CLO3D and adjusted using CLO3D's auto fitting feature, giving a result that from a distance looked adequate (figure 7). However, when looking closely at the top, it became clear that there were issues in the fit (figure 8) that were later corrected by hand in CLO3D (figure 9).

The resulting issues may have been caused by the original sewing pattern being designed in non-standard pattern shapes thus/or the auto-fitting in CLO3D performing poorly compared to Wang's (2018) auto-fitting system. It also became apparent that there might be

Figure 7. Auto-fitted garments on 3D-scan and original garments on game character.

issues when translating stylized media to reality, as differing body proportions made the garments look different.

Figure 8. The top (left) and the top with a strain-map showing the fit (middle, right)(red = stretched fabric, blue = relaxed fabric).

The final modified pattern was prepared, printed and placed on the fabric. After cutting out the pieces of fabric, they were sewn together using a sewing machine. A poplin-type fabric was chosen to match the digital garment's settings.

Figure 9. The adjusted sewing pattern (left) and the original sewing pattern (right).

The resulting garment looked identical to the preview in CLO3D, but as the garment became tangible, an unexpected issue in the design was discovered. The poplin-type fabric proved a poor choice for a garment of skin-tight fit. The poplin fabric looked good in the simulation of CLO3D, but in reality, it was far too stiff as the wearer could not pull their head nor shoulders through the top. Instead, the back of the top was cut to be able to wear the top. For this type of top, elastic fabric would be more suitable.

Figure 10. The finished garment.

Data Collection

The data collection was done by using in-depth interviews. We had a sample size of six participants who cosplay, at various skill levels. To easily find participants, we used convenience sampling by contacting first hand contacts that we personally knew as well as second hand contacts. Additionally, snowball sampling was used to find more participants, by asking the participants if they knew more cosplayers that could participate in our study, since we noticed that cosplay is a very social hobby where many cosplayers may know more people that cosplay. The only requirement for the participants to partake in the study was that they identify themselves as cosplayers, which resulted in the participants having different experiences in handcrafting. The participants did not have earlier experience with using the types of programs that this study used. Most interviews were conducted in English, since the snowball sampling resulted in the study having many international participants. We had two first hand contacts, one second hand contact, and three snowballed participants. The participants were informed about what we are researching, and that they will be anonymous and can cease participation at any time. The interviews took place either online or on site. Participants that live far away had the interviews conducted via Discord (Discord Inc 2015), and those who could be on site picked a location and time that best suited them.

We made a consent form that the participants read before the interview started. The participants signed the form either verbally, if the interview was conducted online, or signed 2 copies of the form, if conducted on-site. One to keep for themselves and one for us.

A script was made in preparation for the interviews, which included 15 questions, three of which were warm-up questions. The interview questions can be found in the appendix. Participants were introduced to our topic and presented with what we have done. The goal of the interviews was to get their opinion and view on the VSTG-approach as well to see if they could identify any potential or limitations in the approach. The interviews were then transcribed and coded using thematic analysis (Braun and Clarke 2006) with inductive and deductive coding.

Data Analysis

The interviews were recorded, transcribed, and coded by using thematic analysis as described by Braun and Clarke (2006). Thematic analysis is a method for identifying, analyzing and reporting patterns through themes within data, through a process of six phases.

Phase 1: Familiarizing yourself with your data

We transcribed the audio from each interview, and then read and re-read the transcripts to familiarize ourselves with our data, and search for meaningful patterns and repeated statements.

Phase 2: Generating initial codes

This phase is where we identified and generated the initial codes from the data. The codes were made by labeling relevant or repeating sentences and sections. We had a total of 43 codes once all the transcripts were coded. As per Braun and Clarke's (2006, 88-89) advice, we coded for as many potential patterns as possible, as you never know what might be interesting later on.

Phase 3: Searching for themes

This phase is where relevant codes were grouped into overarching themes and considered how different codes can be combined or removed. We made a thematic map with all the codes to visualize how each code was connected to each theme and how each theme was connected to each other, see figure 11 where themes, sub-themes and codes are represented by colour.

Phase 4: Reviewing themes

We further reviewed the themes, seeing if some can be grouped together or split into subthemes. We also made a more compact and easier to read thematic map that excludes most of the codes, only keeping codes that were extremely frequent or relevant. This was to help us better visualize where each theme connects, see figure 12 where themes, sub-themes and codes are represented by colour.

Phase 5: Defining and naming themes

Themes and codes were given names that we thought represented the theme best, making sure the names are concise and immediately gives a sense of what it is about.

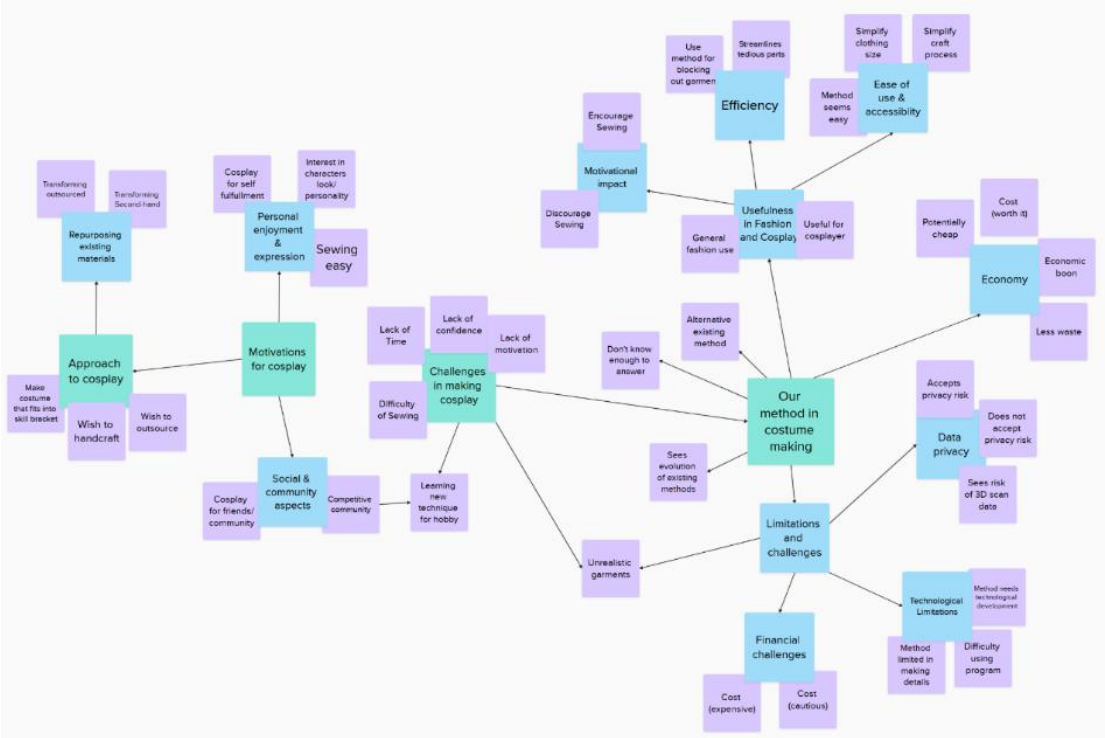

Figure 11. The thematic map with all codes attached. Turquoise notes are themes, blue notes are sub-themes and purple notes are codes.

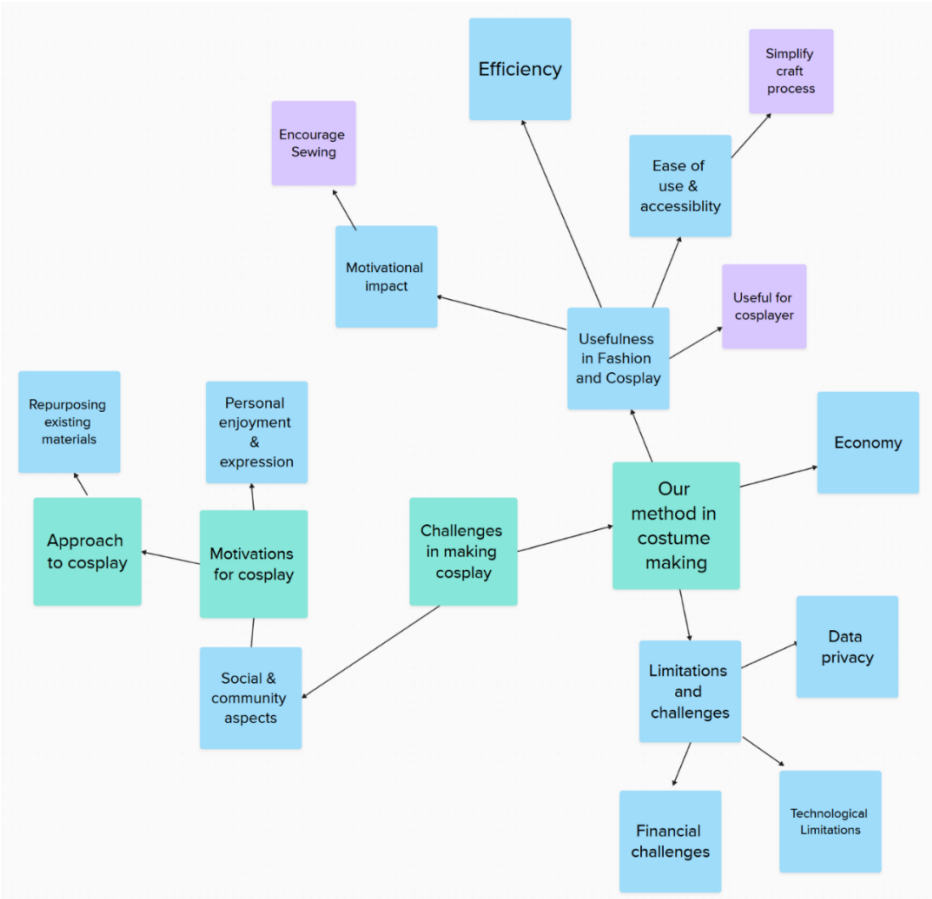

Figure 12. The finished thematic map. Turquoise notes are themes, blue notes are sub-themes and purple notes are codes.

Phase 6: Producing the report

We gave each theme a description and selected extracts from our data that represent and support that theme the best, by using quotes that capture the essence of the point that we are demonstrating. The extracts are embedded within the analytical narrative and interpreted considering similar results from previous studies.

Code Analysis

This part explains what each code means and what theme and sub-theme each code belongs to.

Theme 1: Motivation for cosplay

The sub-theme *Personal Enjoyment & Expression* included three codes. The most occurring code is *interest in characters' look and personality,* where participants are motivated to cosplay a character because of how they look or act. Followed by *cosplay for self-fulfillment,* where they choose to do their cosplay specifically for their own interest. And lastly, *sewing easy*, where the participant expresses that they enjoy the challenge and craft of sewing.

The sub-theme *Social & Community Aspects* included three codes. The most occurring code *cosplay for friends/community*, is about cosplaying to socialize with friends or the cosplay community. The second code being *competitive community*, which is about the competitive aspects of cosplay, that also connects to the code *learning new technique for hobby* which in turn connects to the theme *challenges in cosplay,* as learning new techniques in the competitive community poses new challenges.

Theme 2: Approach to Cosplay

Approach to Cosplay included codes from most to least occurring, *wish to outsource*, being about cosplayers buying cosplays instead of making their own, *wish to handcraft*, which is about crafting their own cosplays, and *make costume that fits into skill bracket,* which is about making cosplays according to their skill level.

The sub-theme *Repurposing Existing Materials* included two codes, from most to least common, being *transforming second-hand*, which is about using pre-owned

clothing to create cosplay, and *transforming outsourced*, which is about transforming newly bought cosplay to fit the cosplayer's proportions.

Theme 3: Challenges in Making Cosplay

Challenges in making Cosplay had six codes. This includes, from most occurring to least, *difficulty of sewing,* which is about the difficulties of sewing. *Learning new technique for hobby*, where the cosplayer learns a new skill to improve their craft. *Unrealistic garments*, which is about fictional characters having unrealistic clothing that may be difficult to replicate. L*ack of confidence*, where the cosplayer lacks confidence in their ability to craft a cosplay garment. *Lack of time*, where the cosplayers may lack time to make their cosplays, and *lack of motivation,* where the cosplayer may not feel motivated enough to start crafting their cosplays. The code *unrealistic garments* is also connected to the *limitations and challenges* sub-theme, and *learning new technique for hobby* is also connected to the *competitive community* code of the sub-theme *social & community aspects.*

Theme 4: Our Method in Costume Making

Our Method in Costume Making includes three codes. Which are, from most to least occurring, s*ees evolution of existing method*, where the participant sees the VSTG-approach as an evolution from already existing method. *Alternative existing method*, where the participant presents an alternative method to the VSTG-approach, and *don't know enough to answer*, meaning that the participant did not feel educated enough on the subject to answer.

The sub-theme *Usefulness in Fashion and Cosplay* include two codes. Being *useful for cosplayer*, which is by far the most occurring code where the participant expresses that the VSTG-approach may be useful for cosplayers, and *general fashion use*, where the VSTG-approach could be used for general fashion purposes.

The sub-theme *Motivational Impact* had two codes. The included codes from most to least occurring are *encourage sewing,* where the participants expresses that they or other cosplayers may be encouraged to sew their own cosplay garments, and *discourage sewing,* showing the opposite.

The sub-theme *Efficiency* had two codes. These are, from most to least occurring, *use method for blocking out garment*, where cosplayers could use the VSTG-approach to see the general shapes of a cosplay before they start making it, and s*treamlines tedious parts*, where the cosplayer may use the VSTG-approach to skip parts of the crafting process that they find tedious or boring.

The sub-theme *Ease of Use & Accessibility* had three codes. Included are, from most to least occurring, *simplify craft process*, where the VSTG-approach can simplify the craft process for the cosplayer. *Simplify clothing size*, where the VSTG-approach can be used to simplify sizing of the garments, and *method seems easy*, where the participants thought that the VSTG-approach seemed easy to grasp and use.

The sub-theme *Economy* had four codes. These were, from most to least common, *less waste*, where the VSTG-approach could help with reducing waste of materials. *Potentially cheap*, where the participants can see the VSTG-approach become cheaper in the future. E*conomic boon*, where participants may see business potential, and *cost (worth it)*, where the participants think the price of the VSTG-approach is already worth it.

The sub-theme *Financial Challenges* had two codes. These are, from most to least occurring, *cost (expensive)*, where the participant thought the VSTG-approach was too expensive, and *cost (cautious)*, where the participant expressed that they were cautious about the cost of the VSTG-approach.

The sub-theme *Technological Limitations* had three codes. The codes that are included in this sub-theme are, from most to least occurring, *method needs technological development*, where the participants though that the VSTG-approach was not ready to be used and needed more development. *Method limited in making details*, where the participants thought the VSTG-approach would have difficulties in finding or interpreting details in a garment, and *difficulty using program*, where the participants thought the programs for the VSTG-approach were too complicated.

The sub-theme *Data Privacy* had three codes. The sub-theme includes the codes, from most to least occurring, s*ees risk of 3D-scan data*, where the participants can see privacy risks in using the VSTG-approach as a service. *Accepts privacy risk*, where

the participant would accept a service using VSTG-approach despite the privacy risks and *does not accept privacy risk*, where the participant would not accept a service using VSTG-approach because of the privacy risks.

Results

In this chapter, we present the results for each theme, supported by direct quotes from the participants. Each section header corresponds to a primary theme or sub-theme, with some sub-themes further divided into more specific aspects that expand upon the parent sub-theme (sub-sub-themes).

Theme 1: Motivations for Cosplay

Motivations for handcrafting or buying cosplay were mentioned in all interviews, and refers to both personal and social aspects that motivate participants to participate in the culture of cosplay. The theme consists of the two sub-themes *personal enjoyment & expression* and *social & community aspects.*

Sub-theme 1.1: Personal Enjoyment & Expression

Almost all participants expressed *personal enjoyment and expression* as a key motivator for their cosplay hobby, with the character's appearance and personality playing a major role in why people decide to create a cosplay, and leading to a sense of self-fulfilment.

Participant two shared: "I find a character that I really sort of, I guess hyperfixate on, and I'm like, I really, really want to cosplay them.", showing a desire to make a cosplay because of their interest in the character.

One participant expressed that sewing was easy for them, and that they enjoyed challenging themselves by creating difficult garments. Participant one said: "[for example] ones that are very interesting and exciting to sew and create are Genshin Impact[1] [cosplays]. There are so many characters with different outfits that sometimes make you wonder how they even designed them, because there is no logic in how they are constructed" (translated to English), meaning that they are excited to see character garments that can challenge them to sew and create, due to their unique and maybe illogical structures.

[1] Genshin Impact, a video game (MiHoYO 2021).

Sub-theme 1.2: Social & Community Aspects

Most participants shared that *social and community aspects* were big motivators for cosplay, as they participate in cosplay together with their friends to dress up as characters from the same universe, but also sometimes do a cosplay on behalf of others, rather than for themselves. In the competitive aspects of the cosplay community, there was also found to be a strong emphasis on making costumes by yourself, with some in the community being stricter than others.

Most participants shared that community was a big motivator for cosplay. Participant one said: “Sometimes it has to do with being part of a friend group where some of us want to cosplay a certain character. If someone wants to join the same group, we can all cosplay characters from that series, school, or universe, and then we gather a group together” (translated to English), showing that cosplayers can join groups to cosplay characters from the same series, school, or universe, and there decide what to cosplay based on the group.

Although rare in the interviews, some participants provided insight into the competitive culture of the community, participant one explained: “Many people think that if you’re going to cosplay, you have to make it yourself and it has to look good. But I think that- and some are so strict with that you should have created your own sewing patterns. You should have, maybe not spun your own thread, but almost” (translated to English), showing that some in the community may be more strict on how a cosplay is made.

Theme 2: Approach to Cosplay

The theme *approach to cosplay* was created to account for how participants make their costumes and why. The theme consists of the sub-theme *repurposing existing materials* and codes. Participants experienced in handcrafting mentioned outsourcing their costumes if they are cosplaying a character for friends/community rather than personal interest. Participants inexperienced in handcrafting reported feeling limited to which cosplays they can craft, as some designs are more difficult to make.

In regard to handcrafting or outsourcing a garment, participant one explained: “For some characters I feel like ‘this is cosplay’, but they’re not a dream character for me, and there are still good quality cosplays available to buy, so then I just buy them instead. And sometimes, I feel like this is a character that I have a vision for, of how I want them to look. So then I sew everything from scratch” (translated to English). Meaning that for some characters, they may buy cosplays if the character isn’t a personal favorite, but for the ones that are, they may create it themselves to bring their vision of the character to life.

Inexperienced participants in handcrafting often choose to make simpler cosplays due to the difficulty of more complex designs. Participant three said: “[I create a cosplay] If I feel that I can manage to create a relatively similar costume with what I have and my very limited skills” (translated to English), meaning they make a costume that they feel are manageable for their skills.

Sub-theme 2.1: Repurposing Existing Materials

All participants mentioned *repurposing existing materials*, transforming second-hand and outsourced items.

Participant four explained: “For certain pieces I will probably like, buy them second hand, or buy them. And then I will alter them myself, with like a sewing machine”, showing that they may adjust different prices to better fit them or remake existing garment for a cosplay.

Theme 3: Challenges in making Cosplay

All participants spoke of *challenges in cosplay,* which refers to the obstacles that cosplayers may face when making a costume. Difficulty of sewing, lack of confidence, lack of time and lack of motivation were expressed as potential difficulties. All participants apart from one, expressed that it is difficult to sew their own cosplays due to their lack of experience with the technique. Some also mentioned the difficulty of recreating garments from fictional characters that may have unrealistic qualities. Additionally, participants had varying levels of enthusiasm about learning new techniques for their hobby.

Regarding difficulties that may occur in the crafting process of cosplay, participant five explained: “people don’t have time or would be too lazy or would just be afraid to start sewing so they will still like go and buy it”, showing that people may buy cosplays instead of sewing them themselves, due to a lack of time, motivation, or fear of starting the process.

Some characters may have garments that have unrealistic qualities, that are difficult to recreate, participant four said, “you have like floating elements (…) that kind of affects how you can probably, create that in real life”, explaining that some characters may have features that are difficult to accurately recreate.

Participants showed varying enthusiasm for learning new techniques for cosplay. Participant three said: “And if I’m going to do it myself, I first need to get scanned, which might not be very easily accessible. Then I have to learn two programs, which is definitely possible—it’s a hobby after all” (translated to English), acknowledging the challenges of learning new skills and tools, but also recognizing that it’s possible to do, as it can be seen as part of the hobby.

Theme 4: Our Method in Costume Making

Our method in costume making refers to the feedback we received after showcasing our method to the participants. This includes several sub-themes and codes. The sub-themes being *usefulness in fashion and cosplay, economy*, and *limitations and challenges*. Some saw elements of existing methods in the VSTG-approach that have been further developed, such as digitalising the adjustment of sewing patterns and estimating them based on the characters’ actual sewing pattern files rather than 2D texture maps. Sometimes the participants expressed that they did not feel experienced enough to give a good answer about certain topics. It also occurred that if someone feels more comfortable with sewing, they might rather opt for using an alternative method that they have developed themselves or heard about.

Some participants saw the VSTG-approach as an evolution of already existing methods, with participant four saying: “I think it's kind of reminiscent of how like, certain cosplayers will already get like, uh, the 3D models from games. (…) I don't know what it's called. I'm not game dev, but um, basically like this flat image, right?

And they will kind of figure out how to make the garment from that. This is like the next step, I think. Like a kind of elevation of like what we already have", where they compare the VSTG-approach to the existing method of estimating characters' sewing patterns based on their 2D texture maps. The VSTG-approach estimates patterns based on the characters' actual sewing patttern files that were used in game development, providing a more accurate result compared to 2D texture maps.

Some participants showed an uncertainty of how they would answer certain topics, such as the technology used in the VSTG-approach. Participant five said: "Uh, I mean, I need to look a bit more into like 3D-scanning because, um, I don't know enough about it", meaning that there is a lack of knowledge of the techniques that are used in the VSTG-approach, like 3D-scanning.

People who may feel more comfortable with sewing might rather opt for using an alternative method that they have used earlier. Participant one said: "I already have a method that I think works for me. So, for me, it's more about feeling if I think that it's worth getting a 3D-scanner for it" (translated to English), saying that they already have a method that works and focuses more on if the 3D-scanner would be a worthwhile addition.

Sub-theme 4.1: Usefulness in Fashion and Cosplay

Usefulness in Fashion and Cosplay is sub-theme that refers to how the method benefits cosplay and fashion. This sub-theme connects to three more sub-sub-themes, *motivational impact, efficiency* and *ease of use & accessibility*. All the participants found that the VSTG-method could be useful for them. There were also some that saw potential for the VSTG-approach to be used in the fashion industry, for regular clothing.

All the participants thought that the VSTG-approach could be useful for them in some way. Participant one said: "So for cosplayers in general, you kind of have the opportunity to do things that are customized at once. Instead of having to go through the process that many cosplayers often do, where you pin and try on, and pin and try on. (…) You don't have to learn how to build patterns in the way that many of us have done" (translated to English), meaning that coplayers are able to create garment

pieces more efficiently, skipping the repetitive process of pinning and trying on, while also eliminating the need to learn traditional pattern-making methods.

The VSTG-approach could not only benefit cosplay, but also general fashion. Participant six explains: “I’d use it for fashion as well (…) I think it just, you know, it kind of revitalizes like fashion in a way.”, stating that they would use it for normal everyday clothing as well.

Sub-sub-theme 4.1.1: Motivational Impact

Motivational impact refers to how the VSTG-approach impacts motivation to make cosplay. Most participants said that the method would encourage them to sew, but it was also speculated that it could discourage beginners from learning how to make sewing patterns without the help of the VSTG-approach.

The VSTG-approach could encourage the cosplayer to sew by making the process seem simpler. Participant two said: “If they can see how it’s processed, I think it could get a lot of people into sort of being like, oh, okay, if that’s how it works, I can sort of go into learning how to make my own patterns.”, presenting how the VSTG-approach could give the cosplayer an idea of how a garment pattern can be created.

However, it could also discourage the cosplayer from learning to sew their own patterns, as the program does it for them anyway. Participant two also said: “why would you go into sewing a cosplay and learning how to make patterns when you can get a 3D-scan to do it for you, if you know what I mean?”, implying that the technology can replace traditional methods.

Sub-sub-theme 4.1.2: Efficiency

Efficiency refers to how the method can be used to make the crafting process of cosplay more efficient. Some participants said that they could use the method for blocking out garments to see a rough prototype of how it will look and therefore how it can be made. Many said that the method could streamline tedious parts of garment creation.

The VSTG-approach could help the cosplayer block out the garment in the simulation program to get a rough idea of how it can be made. Participant six explained: “I think

visual representations work really well. It's like if you can see the outfit that you wanted to wear on like a character model, then you get a better idea of it.", saying that visual representations are effective for seeing garments on a model, which gives the cosplayer a clearer and a better understanding of how it will look.

The VSTG-approach could streamline processes that the cosplayer may find boring or tedious. Participant four said: "I think. Because, I mean, you can focus more on the fun parts, like, actually, like, decorating the cosplays or something.", highlighting that the VSTG-approach would make it easier and faster to get to the stage they most enjoy during the crafting process.

Sub-sub-theme 4.1.3: Ease of Use & Accessibility

Ease of use & accessibility refers to how this method can make cosplay easier or more accessible. Some of the participants thought that the VSTG-approach looked easy to use and could easily be adopted by the community. Many said that the VSTG-approach could specifically simplify the sizing of garments, and everyone said that it could simplify the craft process in garment creation.

Some of the participants thought the VSTG-approach looked easy to use. Participant five said: "I kind of see the process as a fairly straightforward one. Like, you know, like you scan your body, then you just kind of like model the clothes around your own body and then just have them like made by someone else based off those, like, based on those scans.", saying that the process seems simple and straight forward, especially if the creation of the garment is outsourced.

Many said that the VSTG-approach could help with the sizing of the garment. Participant four said: "if you 3D-scan yourself, and then you have like your measurements, it's easier to like, you know, like alter the clothes", saying that 3D-scanning could provide accurate measurements and make it easier to alter clothing.

Everyone thought that the VSTG-approach could simplify processes and eliminate guesswork when making a garment. Participant three said: "I think it feels like a very easy way to be able to make quite complicated clothes, which is great for cosplay.

Because if you want to cosplay a Genshin Impact[2] character – not that I play those games – but they have like 15 layers for each shirt. So, it might be easy or a better way to visualize it in a program where you don't have to put real materials into trying things out, so that's good" (translated to English), meaning that the VSTG-approach can be an easy way to visualize and create complex, multi-layered outfits without needing to work with real materials.

Sub-theme 4.2: Economy

All participants took economical viewpoints on the method. Every participant expressed that the VSTG-approach could help make less waste of fabric for cosplay. A few participants saw ways in which this method would benefit businesses. A few participants decided the price of the VSTG-approach was worth it, and many participants also expressed different ways in which they think this method could become cheaper.

The VSTG approach could be a way to waste less materials while creating a garment. Participant four said: "[This would] save resources, because then, you know, you do it once, you measure once, you cut it out once, you don't, like, waste fabric because you cut it the wrong size.", saying that the VSTG-approach can help cosplayers save resources by having accurate measurements, reducing fabric waste from incorrect sizing.

There may be business potential for video game companies in using the VSTG-approach. Participant four said: "I think a lot of companies would start to see cosplayers as a potential market to increase their revenue streams. Uh, for example, by selling, like, I don't know, their [game] models.", suggesting that companies might see cosplayers as a potential market to boost revenue, possibly by selling their garment patterns from the game models.

A few participants said that the VSTG-approach would be worth the current price. Participant five said: "I think like when you hear about like $200 the first time, it sounds like a little bit expensive, but at the same time it would be like, this would be so convenient and so helpful later, that it would be like a price that I think is worth

[2] Genshin Impact, a video game (MiHoYO 2021).

paying.", saying that initially the VSTG-approach seemed too expensive, but that the convenience and long-term benefits would make the price worth paying.

Most of the participants thought of how the VSTG-approach could become cheaper, with participant five, who was concerned about the price of a 3D-scan, saying: "If it became more popular, I think way more companies would invest into just like making 3D-scanning way more accessible. Like just an app on your phone or something.", suggesting that companies would likely invest in making it more accessible, if it became more popular.

Sub-theme 4.3: Limitations and Challenges

Limitations and challenges collects participants' concerns of the method. This sub-theme connects to three more sub-sub-themes, *financial considerations, technological limitations* and *data privacy*. The code *unrealistic garments* that is connected to the theme *challenges in cosplay*, is also connected to this sub-theme, as the unrealistic properties of fictional garments also affect this method.

Sub-sub-theme 4.3.1: Financial Challenges

Financial challenges refer to the participants' concerns on the cost of the method. Many participants were concerned over the perceived expenses of the method. Some were cautious about the price of the VSTG-approach, but could still consider using the approach if the benefits justify the price.

To be effectively adopted into the community, the VSTG-approach might need to become cheaper. Participant two said: "I think with the current sort of price range it's at right now, I don't think it would do much. It would be sort of an exclusive thing to have, I think", saying that at the current price, the VSTG-approach might not get adopted easily and would be an exclusive method to use.

Some stayed cautious about the price, but could still consider using it if it would help them. Participant one stating: "[I'd use the method] If it saves me enough time for it to be worth the money" (translated to English), justifying the VSTG-approach if it is beneficial enough to saving time.

Sub-sub-theme 4.3.2: Technological Limitations

Technological limitations refer to how this method lacks in being user friendly or optimized for garment creation. Many thought that this method is limited in making details, and a few participants said that the method needs technological development. A few had concerns about the difficulty of learning and using the programs.

One limitation that many pointed out was that the VSTG-approach may not be able to interpret details found in garments. Participant one said: “Limitations, as I said, depends a little on how the program places the seams. That is probably the biggest limitation. Because often when you cosplay, you want to be as close to the source material as possible. And then it may be that there is a seam in this pattern that you feel that, yeah but, there is no seam on the actual [garment]. But then, as I said, you have to find your own way to solve it in that case” (translated to English), saying that placements of seams may be a limitation of the VSTG-approach, as it is important for cosplayers to stay true to the source material.

Another limitation may be that the programs are not user friendly enough to be used by beginners. Participant three said: ”It may take a long time to learn two programs. Not everyone is great with technology either. But that can also be fixed if you make it more user-friendly” (translated to English), meaning that it might be difficult for a beginner of these types of programs to learn and use them, but could be addressed by making them more user friendly.

Sub-sub-theme 4.3.3: Data Privacy

Data privacy refers to if the participants see any risk with sharing their 3D-scanned data to a company or service, and whether they accept sharing their data or not. Every participant had privacy concerns with the VSTG-approach. Most of the participants accepted the privacy risks of sharing 3D-scan data, but a few participants said that they did not accept the risks.

Every participant saw privacy risks in using the VSTG-approach by a company or service. Participant four said: “I think some people might be concerned like, oh, there’s a 3D-scan of my body, you know, like, they might be like, uncomfortable with that idea or something like that. (…) famous cosplayers who often get like, creeps on

them. Like, they might try to like, somebody might try to like, steal that like, scan for whatever god knows what purpose", meaning that some may be uncomfortable with their 3D-scan data being stored on a service where it may potentially be used or stolen for purposes unknown to the user.

Most of the participants said that they may use it despite the privacy risks. Participant two said: "I wouldn't be too fussed about like the data side of it. I'm not going to lie, but, but yeah, I mean, that's just me. I mean, I've sold my data to everyone on the internet at this point", stating that because they have already shared a lot of data to other companies, the risk of 3D-scan data does not concern them too much.

A few participants did not accept the privacy risks. Participant one said: "If they say we will save your data or say we will not delete it when you are done. Then I might feel that no, you know what, I'll make my own pattern instead" (translated to English), saying that if the 3D-scan data is stored after use, they'd rather not use the VSTG-approach, and instead opt for other methods.

Discussion

Participants shared multiple aspects of cosplay and the VSTG-approach. The following chapter is separated into multiple headers to better present the findings relevant to the discussion. We start with discussing *Motivation*, which affected participants' approach to cosplay and the VSTG-approach. Next, in *Acknowledging Hard Work*, we address how a cosplayer's skill-level of handcrafting may shape their opinion on the VSTG-approach, especially regarding recognition of skill. We then examine *Perceived Challenges*, where participants suspect certain limitation of the method, followed by *Data Privacy*, where we discuss concerns about personal data. Lastly, in *Economical and Environmental Benefits*, we discuss associated economic benefits. The chapter ends with reflections on the study's limits and suggestions for future research.

Motivation

Motivation proved to be a big factor for participants' approach to handcrafting and outsourcing. A costume is chosen and recreated as the cosplayer finds appreciation in the character (Lamerichs 2014, 8), but our participants also reported sometimes engaging in cosplay to be part of the community rather than to express themselves personally. This results in outsourcing of costumes even when the cosplayer has the skills to make the costume themselves, as the motivation for the cosplay is for the community rather than for personal interest in the character. Geczy (2016) connects cosplay to carnivals and finds similarities that explain motivations for modern cosplay. As the people of the Renaissance yearned to escape from conservative social norms, masquerades would allow participants to interact with each other as their authentic selves as their true identities were hidden behind masks (Geczy 2016, 26-27). The masquerades required a masked identity to participate, similar to how one today must wear a cosplay to participate in cosplay events. While cosplayers do not seek to hide their true identities, wearing a costume and being part of the community may allow them to express their true selves, as Lamerichs (2014, 117) says that cosplay events strip social hierarchies and gather people of the same interests. Additionally, cosplay events allow playful behaviour which ceases social norms, allowing freer interactions between people, similar to the Renaissance masquerades

(Geczy 2016, 28). It becomes clear that the social factor of cosplay is very important, and that it sometimes can be more important than the costume itself.

Motivation also proved relevant in whether participants would use the VSTG-approach. Participants less experienced in sewing expressed feeling limited by their inexperience. Afterall, cosplay involves many different skills in addition to sewing and pattern creation, such as prop building and wig styling (Lamerichs 2014, 114, 118), meaning that not all cosplayers are skilled in sewing. All participants said our method would make it easier to create garments that fit them correctly, and multiple participants said that having a correct pattern from the start would make the process of sewing costumes less intimidating and motivate them to learn sewing, indicating a wish to skip the pattern creation stage of making costumes. It was suggested that the VSTG-method could help beginners sew without needing to learn pattern-making like today's cosplay veterans did. However, it was also suggested that the method might discourage people from ever learning how to make sewing patterns, as the motivation to learn a skill diminishes when it can be made automatically by a computer. In addition to encouraging people to learn sewing, our method would also speed up the craft process, which is important as many participants reported that they wish to handcraft their costumes but have a lack of time. Furthermore, participants expressed willingness to completely outsource the creation of their costume to a business if it used our method, like WITHIN24-ALLSTUDIOS that was referenced by Choi (2022, 21). Some participants were concerned that the method might be difficult to use as a personal tool, but everyone expressed willingness to try, as the method simplifies the craft process.

The VSTG-approach might also increase motivation in cosplay through enhanced connection to characters. In the VSTG-approach, the user is brought closer to the source material, linking their 3D-scan to the character they want to portray, to the character's actual files and arguably to the character's real body. As highlighted by Lamerichs (2014, 120), fans may decide to do a cosplay to express their personal connection to a character. Furthermore, a character may be chosen because their traits resonate with the cosplayer's true self, thus allowing them to feel more authentic in their costume (Geczy 2016, 10-11). Therefore, the VSTG-approach could be very interesting for those who cosplay for personal interest, as it deepens a cosplayer's

connection to the character. In this way, the VSTG-approach may evolve how identities are expressed in cosplay.

Acknowledging Hard Work

As the cosplay community has grown, so has the desire to compete with the quality of their costumes. A few participants said that they perceive the cosplay community as becoming more competitive, and that the VSTG-approach could be adopted by cosplayers to get the results they want. While non-competitive cosplay can still be enjoyed in the hallways of conventions, competitions are an important element of cosplay (Lamerichs 2014, 114, 123). Competitive cosplayers might alter their bodies and perform in very uncomfortable costumes for the sake of their cosplay (Lamerichs 2014, 122), and it is possible that the pressure and high standards of the competitive community affect non-competitive participants too, as one naturally wants their costume to look good. The VSTG-approach could become adopted by the whole community to achieve higher quality cosplays. However, it depends on the community's attitude to the method. Handcrafting is important in cosplay culture (Lamerichs 2014, 114, 116, 123), and it was shared in interviews that some people in the community are very strict about whether the cosplayer made the costume themselves, including the sewing pattern. There was full agreement about the VSTG-approach being a tool rather than a cheat, but one participant that is highly skilled in sewing shared that a cosplayer should not take credit for a garment if they have not sewn or made the pattern themselves, showing a desire to uphold appreciation of today's handcrafting techniques. We believe it is possible that the competitive community of cosplay might accept the VSTG-approach, thus altering the balance between convenience and "traditional values", further digitalizing the community. However, transparency of the process might be necessary to acknowledge the hard work of those who have worked hard to learn skills that seem to become diminished.

Perceived Challenges

The main challenge seen in the VSTG-approach was that it could have difficulties picking up on details. Some participants said that the program may not be able to pick up small details that a lot of cosplays may have, which we think is unlikely as Wang

(2018, 10) noted in his study that programs like CLO3D will interpret even small unintended artifacts as features, indicating that they do not leave out details.

Additionally, there were concerns that the program might not create garments with correct seam placements, as game developers might place seams incorrectly on digital garments, and might fake the appearance of some seams by putting them in the texture of the garment instead of in the sewing pattern. This is something that we experienced since we placed the seams on the game model garment incorrectly which did not translate well to the real garment, meaning that our digital garment was unrealistic. The garment also proved unrealistic in proportions as the game character's body was cartoonish, making the garment difficult to look identical on a body of realistic proportions. As some game characters are even more cartoonish than the one we designed, there was concern regarding performance of the VSTG-method on such characters. A more complicated and unrealistic garment, perhaps with even more incorrectly placed seams and stylized proportions, would be highly difficult to translate to real life, and could be even more difficult for the program to automatically adjust to a 3D-scan. Afterall, Wang notes that his automatic size adjustment system may need to be complimented with modifications if the body differences are large (Wang 2018, 12), meaning that cosplayers might need more technical knowledge than expected to use the VSTG-approach as a personal tool.

Correspondingly, some participants expressed concern about the difficulty of the programs required to do the VSTG-approach, but also said that they think cosplayers would be willing to learn, especially if it became more user-friendly. Crafting is an important aspect of the cosplay community, that also acts as a learning space where members share knowledge and learn from each other (Lamerichs 2014, 114). Here, the VSTG-approach could be shared, but as socio-cultural awareness of digital fashion is low (Choi 2022, 21), cosplayers would probably need to learn technical aspects online, shifting the learning space to the internet. This is likely true for many digital tools, meaning that while digitalizing the craft could evolve cosplay, it could also have an isolating effect on members of the community.

Most participants had something to say about the cost of 3D-scanning, with many believing that if this method became more adopted by businesses, it could potentially

be cheaper. They believed that if it becomes more popular, companies may invest in it to make it more accessible. For example, Baidak, Flaherty and Abdelrazeq (2023, 2) used a 3D-scanning app called EM3D in their study about custom fit bras from 3D body scans, showing that apps might be a sufficient cheap alternative, and that the technology is being developed and getting more accessible.

Data Privacy

Paganelli's (2019, 6, 13) case study of businesses that offer 3D-scanning for tailoring, found that customers have privacy concerns regarding the 3D-scan data of their body, as they must undress for the scanner to get accurate data for the avatar. In our study, all participants understood the risk of storing 3D-scan data on a service, but the majority of them stated that they would be willing to do so. One common reasoning for this was that they have already shared their data to big companies, and that this would not make a big difference. The participants that disagreed, said they did not want to risk such private data. However, considering the cosplay community's strong group identity based on costumes as well as their tendency to evaluate each others' costumes (Geczy 2016, 29-30), it is possible that increased popularity of the VSTG-approach might pressure cosplayers into risking their privacy in order to achieve higher quality costumes.

It was found that more experience in sewing could influence the willingness to take privacy risks for the VSTG-approach, as one could instead opt for a familiar alternative method. This shows that the VSTG-approach may be less attractive to people highly experienced in sewing and pattern creation, as they can choose to use an alternative existing method without compromising quality. It was shared that cosplayers experienced in sewing and pattern creation will make mannequins that are customized to their proportions to use as reference, or measure themselves and freestyle their patterns until they get the fit they want.

It was shared that seeing oneself as an avatar would be frightening, but the interest remained. This might be related to self-esteem and the *uncanny valley* effect. Park (2018, 1) studied peoples' reaction to seeing themselves as avatars, and found that people with low self-esteem had negative reactions to their avatars, while the opposite was found in people with high self-esteem. One reason for this may be that attractive

features are less prone to evoke a feeling of uncanny valley (Schwind et al., 46), with self-perceived attractiveness causing reduced subjective eeriness in avatars of confident participants. However, as reflected in Park's (2018, 9) study, participants were still willing to see themselves as avatars in the future, indicating an openness to use 3D-scans for the VSTG-approach.

Economical and Environmental Benefits

There were some economic and environmental benefits perceived in using the VSTG-approach. Many participants said that they could spend less fabric using this approach and therefore save resources. They also shared that the VSTG-approach could help them know how much of a material that they need to create a garment, and reduce the risk of cutting a sewing pattern incorrectly.

There was also business potential for game companies identified in the VSTG-approach. There was an emerging idea that the VSTG-approach could become a new revenue stream for game companies by selling Marvelous Designer-files for cosplay use. This could benefit cosplayers, particularly those who cannot find motivation or time to handcraft a certain costume. However, it may be possible that involving businesses in cosplay could put a financial barrier to quality costumes, especially if the service discourages people from learning how to make their costumes by themselves.

Multiple participants also said that the VSTG-approach could be used for general fashion. By using the VSTG-approach, made-to-measure fashion could become cheaper for the average customer and therefore democratized. Instead of being measured by a tailor, the customer could use a 3D-scan of themselves to have a program automatically fit the garment to the 3D-scan. Duong et al. (2024, 2) also says that 3D-fashion makes it possible to test and try on different products before buying them, reducing the need for long distance transportation of clothes that the customer may not be happy with and then return.

Limits of the Study and Future Research

There were several limits of the study, such as the sewing pattern of the garment not being constructed according to standards. While this gained insight into unrealistic

aspects of digital garments, it could have affected the auto-fitting performance negatively. Future research can study how different garment constructions might affect automatic fitting, not only based on how well the garment is constructed, but also comparing between garments of stylized and realistic game models as it is possible different proportions might affect the performance of auto fitting as well. To make such a project less time consuming and perhaps more accurate, it might be of interest to gain access to Marvelous Designer-files of game characters from real published games.

Additionally, the sample size of six participants was small, and as the participants were of different skill-levels in handcrafting, the samples for each skill-level was even smaller, where more of the participants described being less experienced in sewing. One possible reason for this imbalance is that snowball sampling was used to recruit participants. It is likely that participants pointed us to participants of similar skill-level, as people tend to know like-minded people. Thus we did not get in touch with many competitive cosplayers. Having more participants of a broader skill-range could have given a wider range of feedback, and a better understanding of which opinions are common in the community. Future research should keep the different skill-levels of cosplayers in mind.

It could also have been beneficial to make more garments, and actually present the garments to the participants in person to give them a more complete view of the VSTG-approach. In future research, it might therefore be interesting to finish a whole costume using the method, and present it to all participants in person.

Furthermore, even though the VSTG-approach was explained and shown to participants, it became clear that they still lacked knowledge on the topic, as it includes many different aspects such as 3D-scanning and computer programs that people are likely unfamiliar with. Multiple participants said in the interviews that they did not know enough to answer, which reflects what the industry professional in Choi's (2022, 21) study said about socio-cultural awareness of digital garments being too low to implement any model like the VSTG-approach. In future research about the topic, it might be important to explain the method to participants on a deeper level to gain better information from interviews.

Lastly, to immerse the participants in the VSTG-approach, it could be interesting to give them an opportunity to actually experience the method from 3D-scan to tangible garment by treating them as customers in a B2C-setting. It could also be studied as a personal tool, in which it would be interesting to see if they manage to use the VSTG-approach themselves.

Conclusion

This study examines what motivates cosplayers to buy or craft their cosplays, and what challenges and potential they perceive in the new VSTG-approach (Virtual Simulation to Tangible Garment) to make or buy made-to-measure garments for the craft of cosplay. The authors created a garment using the VSTG-approach and showed the participating cosplayers the process and result.

The results of this study indicate that while cosplay is practiced for personal expression, there is also a very important social factor. The hobby has become a large community, where social pressure influences cosplayers to either buy or handcraft their costumes. Therefore, it was found that cosplayers would like to use the VSTG-approach both as a B2C-model to outsource, and as a personal tool to handcraft. The method can be used to simplify and speed up the process of costume-making, by automating adjusted sewing patterns which also can encourage beginners to learn sewing. Additionally, there can be economic and environmental benefits for both cosplayers and for businesses, as the VSTG-approach may reduce waste of resources and provide a new stream of revenue for companies through collaborations.

The results also showed concerns about the VSTG-approach, as accuracy in detail and seams were questioned, as well as difficulty of learning how to use the method as a personal tool. There was concern of expenses required for the VSTG-approach, but optimism that costs may decrease in the future. Furthermore, there were concerns of the privacy of data, but interest in having a 3D-scan of oneself was still strong.

References

Adobe. 1990. ‘Photoshop’. Windows, macOS, Ipad OS.

———. 2014. ‘Substance 3D Painter’. Windows, macOS.

Artell. 2017. ‘Auto Rig Pro’. Blender addon.

Autodesk. 1998. ‘Autodesk Maya’. RHEL/Rocky Linux, Windows, MacOS.

Baidak, Bella, Kristen Flaherty, and Zain Abdelrazeq. 2023. ‘Custom Fit Bras From 3D Body Scans’. In *Proceedings of the 8th ACM Symposium on Computational Fabrication*, 1–2. SCF ‘23. New York, NY, USA: Association for Computing Machinery. https://doi.org/10.1145/3623263.3629151.

Blender Foundation. 1994. ‘Blender’. Linux, MacOS, Windows, IRIX, BSD, Haiku.

b-lu-rry. 2023. ‘[No Spoilers] My Jinx Cosplay vs. Character (Yeah i Was Missing the Tattoos for This Costest Xd)’. Reddit Post. *R/Arcane*. www.reddit.com/r/arcane/comments/10tdqqo/no_spoilers_my_jinx_cosplay_vs_character_yeah_i/.

Braun, Virginia, and Victoria Clarke. 2006. ‘Using Thematic Analysis in Psychology’. *Qualitative Research in Psychology* 3 (2): 77–101. https://doi.org/10.1191/1478088706qp063oa.

Charrue, Pascal, Arnaud Delord, and Bart Maunoury, dirs. 2021. *Arcane*. Streaming. Animated Series. Netflix.

Choi, Kyung-Hee. 2022. ‘3D Dynamic Fashion Design Development Using Digital Technology and Its Potential in Online Platforms’. *Fashion and Textiles* 9 (1): 1–28. https://doi.org/10.1186/s40691-021-00286-1.

CLO support. 2024. ‘What Is the Difference between CLO and Marvelous Designer?’ How Can We Help You? 29 May 2024. https://support.clo3d.com/hc/en-us/articles/115012666547-What-is-the-difference-between-CLO-and-Marvelous-Designer.

CLO Virtual Fashion. 2009a. ‘CLO3D’.

———. 2009b. ‘Marvelous Designer’. Windows, MacOS.

Discord Inc. 2015. ‘Discord’. PC.

Epic Games. 1995. ‘Unreal Engine’. Windows, Linux, macOS.

Geczy, Adam. 2016. ‘The Psychology of Cosplay’. *Journal of Asia-Pacific Pop Culture* 1 (1): 18–36. https://doi.org/10.5325/jasiapacipopcult.1.1.0018.

Gürcüm, Banu Hatice, Huseyin Riza Börklü, Kursad Sezer, and Ogulcan Eren. 2018. 'Implementing 3D Printed Structures as the Newest Textile Form'. *Journal of Fashion Technology & Textile Engineering* s4. https://doi.org/10.4172/2329-9568.S4-019.

Lamerichs, Nicolle. 2014. 'Costuming as Subculture: The Multiple Bodies of Cosplay'. Text. Intellect. 1 October 2014. https://doi.org/10.1386/scene.2.1-2.113_1.

Makryniotis, Thomas. 2018. 'Fashion and Costume Design in Electronic Entertainment—Bridging the Gap between Character and Fashion Design'. *Fashion Practice* 10 (1): 99–118. https://doi.org/10.1080/17569370.2017.1412595.

Maxon. 1999. 'Zbrush'. Windows, MacOS.

MiHoYO. 2021. 'Genshin Impact'. Andriod, iOS, PS4, Windows, PS5, Xbox Series X/S. MiHoYo.

Orgaz, Santiago. n.d. 'xNormal'. Windows.

Paganelli, Nicholas. 2019. 'Custom Clothing Technology: Diffusion of Luxury Practices in Fashion'. *Fashion Studies*. https://doi.org/10.38055/fs020104.

Park, Juyeon. 2018. 'Emotional Reactions to the 3D Virtual Body and Future Willingness: The Effects of Self-Esteem and Social Physique Anxiety'. *Virtual Reality* 22 (1): 1–11. https://doi.org/10.1007/s10055-017-0314-3.

Perera, Yasith Sanura, Rajapaksha Mudiyanselage Himal Widooshaka Muwanwella, Philip Roshan Fernando, Sandun Keerthichandra Fernando, and Thantirige Sanath Siroshana Jayawardana. 2021. 'Evolution of 3D Weaving and 3D Woven Fabric Structures'. *Fashion and Textiles* 8 (1): 11. https://doi.org/10.1186/s40691-020-00240-7.

Riot Games. 2009. 'League of Legends'. Windows, macOS.

Rockstar Games. 2013. 'Grand Theft Auto V'. Playstation 3, Xbox 360, PLaystation 4, Xbox One, Windows, Playstation 5, Xbox Series X/S.

Schwind, Valentin, Katrin Wolf, and Niels Henze. 2018. 'Avoiding the Uncanny Valley in Virtual Character Design'. *Interactions* 25 (5): 45–49. https://doi.org/10.1145/3236673.

Sega. 2000. 'Jet Set Radio'. Dreamcast, Java ME, Playstation 3, Windows, Xbox 360, Playstation Vita, iOS, Andriod. Jet Set Radio.

shteeve3d. 2023. ‘Wiggle 2’. Blender addon.

Square Enix. 2009. ‘Final Fantasy XIII’. Playstation 3, Xbox 360, Windows.

Wang, Huamin. 2018. ‘Rule-Free Sewing Pattern Adjustment with Precision and Efficiency’. *ACM Transactions on Graphics* 37 (4): 1–13. https://doi.org/10.1145/3197517.3201320.

Appendix

Interview Questions

- How long have you been Cosplaying? When did you start? Why?
- Are there any particular games or movies that you think have interesting outfits?
- What makes you want to cosplay someone?
- How do you do your cosplay, do you transform clothes from second hand, do you buy something ready-made, do you sew them yourself?

Show what we have done and explain scenarios where this may exist.

Scenario 1:

The Korean store

Scan and upload 3D-scan to company database. Ordered online or offline. Decide on design – Material, fit, preview.

Scenario 2:

You yourself use the tools (3D-scan, Marvelous Designer, CLO3D, sewing machine) to help in the process of creating garments.

- Do you think this method would be useful for you as a cosplayer?
- Would you consider using this method for cosplay?
- How do you see the process of doing cosplay in this way? why? (using 3d scans to adjust the clothing)
- What limitations/challenges can you see with the method and why?
- How would this method support cosplayers?
- What is your attitude towards this method?
- Would you imagine making your costumes with a 3D scan?
- What are your thoughts on this use of 3D scanners and would you have liked to have your own for this purpose?
- How do you view storing 3D scan data on a service?
- How do you think this method can affect cosplay?
- Do you have anything to add?

Detailed Method

The VSTG-approach was tested by carefully executing every step using our own game character, which gave us full control and access to all files, as well as a 3D-scan of one of ourselves to later confirm the fit of the garment. This chapter demonstrates the full process of the executed VSTG-approach, and the collection and analysis of the interview data.

Figure 13. Concept art

Making the Character

The first stage of character creation was gathering references and making concept art (figure 13). The character is inspired by the Jet Set Radio game series (Sega 2000). The focus was to give her a unique silhouette with her big cargo pants and spikey hair, to match the character designs of Jet set Radio. A reason to make her stylized instead of realistic is to not make her feel uncanny, realistic characters have a risk of evoking uncanniness, if not made perfectly (Schwind, Wolf, and Henze 2018)

Figure 14. Highpoly mesh in Zbrush

The second stage was sculpting of the character. Starting out with a rough blockout and refining until you have a good enough highpoly mesh (a model with high and dense topology) in the digital sculpting program Zbrush (Maxon 1999). The character deviated from the concept art during this phase to have a little less cartoony proportions and getting fingerless

Figure 15. Sewing patterns in Marvelous Designer

leather gloves. Accessories such as shoes, goggles and headphones were also made in Zbrush, while the clothes weren't, as they were being made using Marvelous Designer (CLO Virtual Fashion 2009b). The hair was made in Blender (Blender Foundation 1994) (another 3D modeling software) to make it have a little more stylized look using curves.

The body mesh was decimated (an unoptimized version of the highpoly mesh with less polygons while having roughly the same shape) to keep program performance in Marvelous Designer, where the clothing was made and the fabric setting "Cotton_50s_Poplin" was assigned to the top. The fabric settings and sewing patterns were made to fit and look good on the stylized character without real consideration for how this would translate to real life, since this is a game character workflow.

The highpoly mesh was optimized in Maya (Autodesk 1998). Remeshing (making a mesh with reduced number of polygons by building geometry with more uniform topology on top of the highpoly mesh) it in order to be able to be animated and not tank the performance inside the game engine, where it will later be rendered. The model was UV-mapped (projecting a 3D-models surface to a 2D-image) in order to be able to apply textures to the model. The character was made with UDIMs, which allows you to have multiple lower resolution texture maps instead of one high resolution texture map, in a tile system where each UV tile is different, to not compromise performance on the memory usage of the rendering software.

Next step was rigging and animating in Blender. The rigging (creating a skeleton that makes it possible to animate the movements and deformation of a mesh) was made semi automatically using the addon Auto Rig Pro (Artell 2017). The hair was added to the rig with wiggle bones using the Wiggle 2 (shteeve3d 2023) addon, to be able to simulate the movement of the hair, rather than animating it manually. Once the rig was done, a stride animation was made to show our participants the character and their clothes in action. The clothing were simulated in Marvelous Designer onto the animated movement of the character. Usually in game development you would skin (attaching the 3D models surface to the rig) the clothes to the character directly during the rigging phase, but here it is simulated in order to have a more realistic movement of the clothes. This is more akin to VFX (visual effects) and movie making.

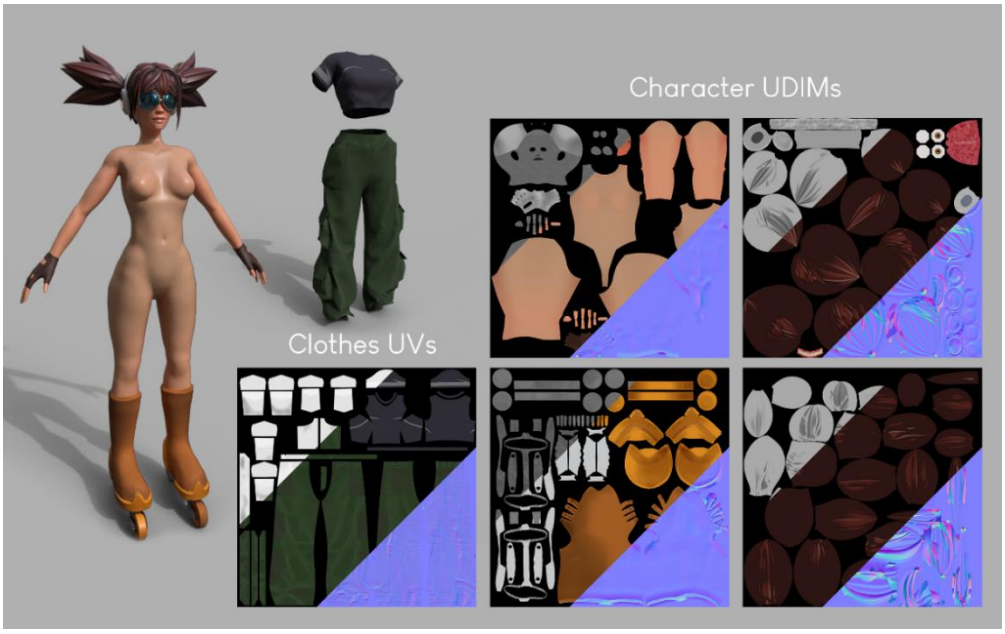

Figure 16. Textures, UV and UDIMs

The baking and texturing was made in Substance 3D Painter (Adobe 2014). Baking is when you project the geometry of the highpoly mesh onto the lowpoly mesh, using a texture file. This gives the illusion of more dense and detailed geometry than there actually is on the lowpoly mesh. Texturing is the process of adding textures to the 3D model. The colors were changed from the concept art to better match the materials of the shirt from real life.


Figure 17. Image from Orbit animation


Figure 18. Image from animated character

The last step was rendering in a game engine. The rendering (creating 2D images or video from a scene with lights and 3D models) was made in Unreal Engine (Epic

Games 1995). One animation where the camera orbits the character, showcasing the model, and one where the character is animated.

Making the Tangible Garment

To use the 3D-scan for digital fitting of the game character's top, topology count was reduced to enable stable performance in CLO3D (CLO Virtual Fashion 2009a). The raw file of the 3D-scan featured a highly detailed model (figure 19) with a very dense topology (figure 20) of 12,5 million triangles in total. The raw model was cleaned up in Zbrush (Maxon 1999), removing the hair and separating fingers and toes to prepare it for retopology (recreating a model's polygonal mesh to obtain better topology). The model was retopologized in Maya (Autodesk 1998), creating a lowpoly mesh of 10 000 triangles that was then subdivided five times in Zbrush to project the raw model onto, creating the highpoly model while also keeping the lowpoly mesh for baking the highpoly onto (figure 21).

Figure 19. Raw 3D-scan model with raw texture.

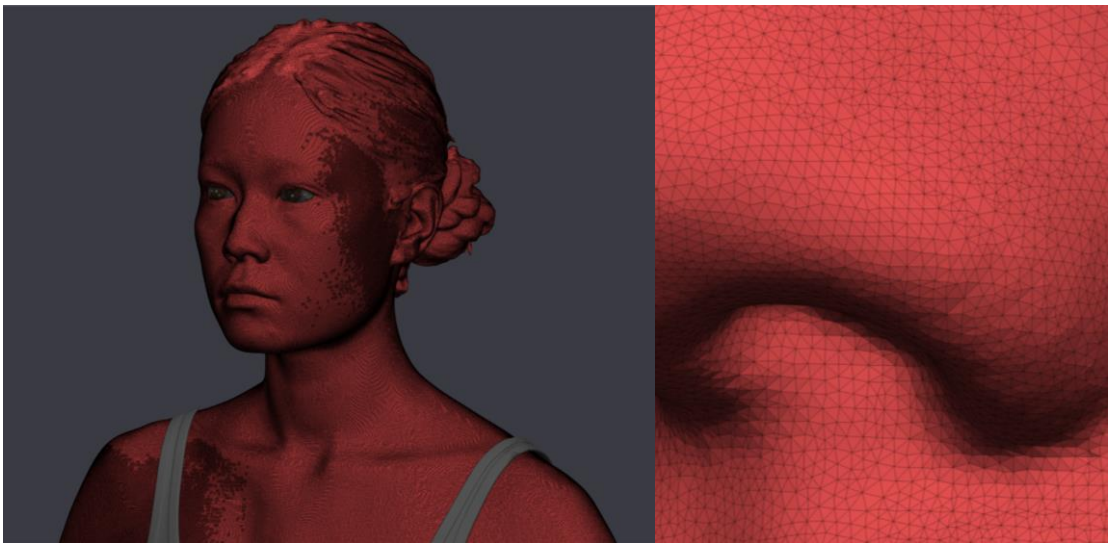

Figure 20. Topology of the raw 3D-scan model, zoomed in on the nose.

Figure 21. Highpoly mesh (left) and lowpoly mesh (right).

The texture of the raw model was projected to the new lowpoly model using xNormal (Orgaz, n.d.) and texture artifacts from the scanning process were painted over in Substance 3D painter (Adobe 2014). The lowpoly mesh was imported into CLO3D (CLO Virtual Fashion 2009a) and textures were applied. The top of the game character was adjusted using CLO3D's auto fitting feature, giving a result that from a distance looked adequate (figure 22). However, when looking closely at the top, it became clear that there were issues in the fit (figure 23) that were later corrected by hand in CLO3D (figure 24, 25).

Figure 22. Auto-fitted garments on 3D-scan and original garments on game character.

Figure 23. The top (left) and the top with a strain-map showing the fit (middle, right)(red = stretched fabric, blue = relaxed fabric).

The resulting issues may have been caused by the original sewing pattern being designed in non-standard pattern shapes (figure 25) thus/or the auto-fitting in CLO3D performs poorly compared to Wang's (2018) auto-fitting system. It also became apparent that there might be issues when translating stylized media to reality, as the differing body proportions made the garments look different.

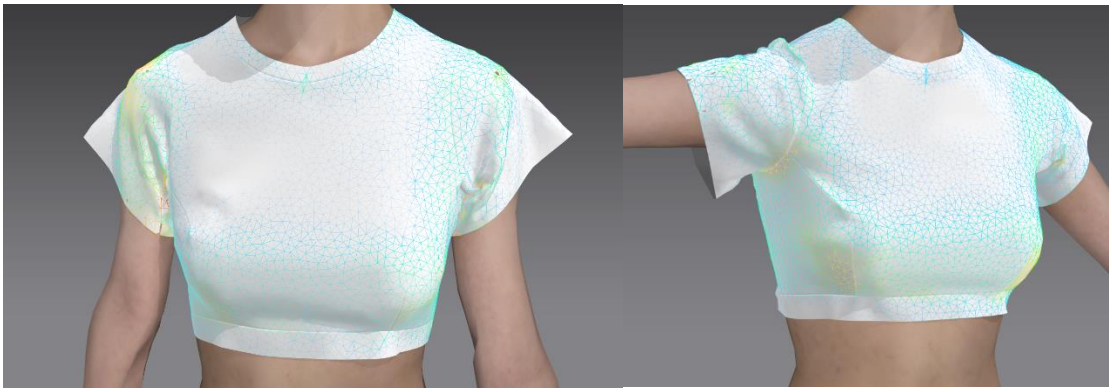

Figure 24. The top after adjustments to fit, showing strain-map.

Figure 25. The adjusted sewing pattern (left) and the original sewing pattern (right).

After finishing the modifications of the pattern, the print layout was assembled in Photoshop (Adobe 1990), and cutting lines were put around the pattern pieces 1 cm from the edge. The pattern was printed on 10 A4 sheets of paper (figure 26). The sheets were taped together and cut out to use as reference when cutting the fabric. A poplin-type fabric was chosen to match the digital garment's settings. The pattern pieces were placed on the fabric and lines were drawn along the edges to mark the cutting lines (figure 27). After cutting out the pieces of fabric, they were put together using pin needles and sewn together 1 cm from the edge using a sewing machine.

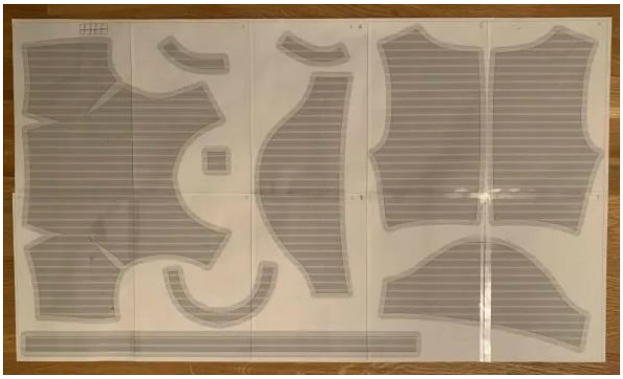

Figure 26. Printed sewing pattern taped together.

The resulting garment looked identical to the preview in CLO3D, but as the garment became tangible, an unexpected issue in the design was discovered. The poplin-type fabric proved a poor choice for a garment of skin-tight fit. The poplin fabric looked good in the simulation of CLO3D, but in reality, it was far too stiff as the wearer could not pull their head nor shoulders through the top. Instead, the back of the top was cut to be able to wear the top. For this type of top, elastic fabric would be more suitable.

Figure 27. Marking on the fabric where to cut.

Figure 28. The finished garment.