Ubiquitous Augmented Fashion: A Design Fiction on the Future of Digital Fashion in the Augmented Metaverse

S. (Simone) Cooijmans
Industrial Design
Eindhoven, The Netherlands
s.cooijmans@student.tue.nl

J.A. (Arjo) Nagelhout
Industrial Design
Eindhoven, The Netherlands
j.a.nagelhout@student.tue.nl

L.A. (Lara) Potma
Industrial Design
Nijmegen, The Netherlands
l.a.potma@student.tue.nl

T.S. (Thomas) Wezel
Industrial Design
'S Hertogenbosch, The Netherlands
t.s.wezel@student.tue.nl

ABSTRACT

Ubiquitous Augmented Fashion explores the potential societal implications of integrating Augmented Reality into society, in order to determine desirable and less desirable future outcomes.

We investigate the experience of designing and wearing augmented fashion through autoethnographic research, while creating a design fiction to speculate about a scenario in which AR has become ubiquitous and a fully functional metaverse has become part of the everyday scene. Our experiences from this exploration allowed us to further develop our fictional future, with designed outfits functioning as diegetic prototypes. We used this scenario to organize several discussion sessions with people from all walks of life in order to gain a wide range of insights. The data collected from these sessions were analysed to gain insights into the creation of this new metaverse. Based on our findings, a framework was created as a foundation for further research addressing augmented fashion in the future.

Author Keywords

Augmented Reality; Digital Fashion; Augmented Fashion; Speculative Design; Design Fiction; Auto-ethnographic Research.

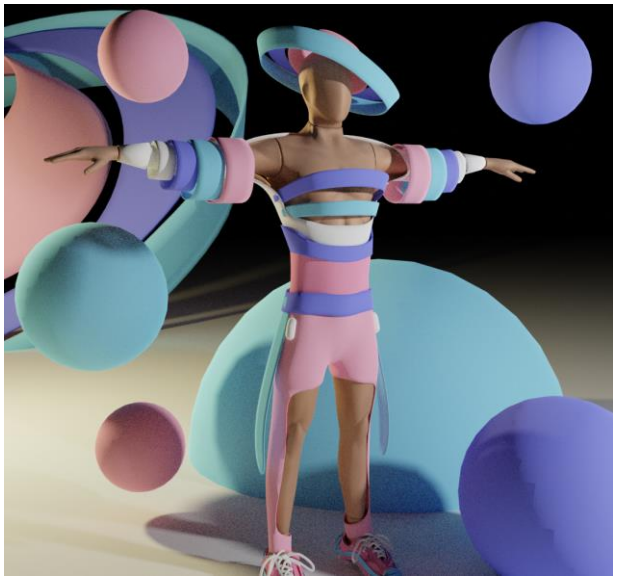
1. INTRODUCTION

Current technological developments in the field of Augmented Reality (AR) have transformed technology into being used in social environments, but what impact do these developments have on the fashion industry? What will fashion look like if people are able to wear items that have AR features implemented? Will they become more eccentric with their styles or will they stay undifferentiated? Is it possible that this new technology will be used for undesirable or even offensive intentions? These are all questions that arise when one imagines a future context in which AR-Head-Mounted Displays (HMD) have become ubiquitous and a fully functional metaverse has been created.

Fashion has always been one of the most innovative and fastest-growing industries. The Ellen McArthur Foundation even stated that clothing production has nearly doubled in the last 15 years, mainly due to the "fast fashion" phenomenon [11]. The idea behind "fast fashion" is to get new styles and fits on the market as rapidly as possible. This way, people can buy them while they're still hot and trendy. The downside is that as a result of this process of continuously releasing new trends, people keep buying new outfits only to discard them after a few wears, solely because a new collection has been released. A lot more clothing is being produced and almost all new outfits are

just being thrown away [16]. This phenomenon has led to the fashion industry creating a lot of waste, and thus being very unsustainable. But what if the rise and development of a new technology could not only change this but also create a whole new fashion field?

Augmented Reality, also known as AR, is a technology that allows digital information to be displayed on objects or places in the real world for the purpose of enhancing the user experience [5]. Since AR overlays this digital information in the real world, it, therefore, separates itself from VR, virtual reality, which creates a completely digital environment. Applying AR technology to the fashion industry allows for the continuation of fast fashion, yet this time without the massive amounts of waste. Augmented fashion will allow the customer to simply buy and replace clothing only when absolutely necessary, but still, keep up with the latest trends by replacing the digital overlay.



Fashion also plays a big role as a communication tool. How we dress and express ourselves influences how others see us, yet also reflects how we see ourselves. AR would allow us to express ourselves in ways not possible in the physical world since physical limitations don't apply that much in the augmented world. Especially because of the social role of fashion, it is important to speculate about the impact that this technology can have in the future, both positive and negative [21].

The main goal was to explore and start discussions about the impact that augmented fashion can have on our society, on how we dress and express ourselves when suddenly a whole world of possibilities opens up to you. We used design fiction, a design research approach based mainly on exploring potential future scenarios, in order to create a scenario that functions as a basis for auto-ethnographic research. This research technique enabled us to experience what it is like to design and wear augmented fashion. With the insights from autoethnographic research, we further developed our scenario and used it as a starting point for several discussion sessions.

In this paper, we discuss related work, with a focus on history and relevant topics in terms of research. We describe our experiences from auto-ethnographic research and discuss our design fiction process and discussion sessions based on our scenario, reflect on our methods and the limitations they have brought with them, and conclude by summarizing our findings.

2. RELATED WORKS

This paper engages into the world of Augmented Fashion, a new frontier in the field of digital clothing. This concept of wearing clothes that people can't see in the physical world dates all the way back to Hans Christian Anderson's story of two weavers pretending to make a new suit for the emperor, convincing him that only those who were fit for their role could see it [2]. Not only did "The Emperor's New Clothes" initiate a whole new perspective to the field of clothing, but the short story also explains how this type of non-physical clothing can result in self-deception. Starting from the '80s, people like Harry Wainwright began designing basic controllable fashion, for example by integrating fibre-optics and microprocessors into a sweatshirt to display and control visuals [15].

In the next two decades, the fashion industry's technological explorations expanded significantly; conductive fabrics, LEDs, and special forms of ink were all added to the field of soft materials [29]. A good example of this development is Valerie Lamontagne's clothing line of glowing, interactive, colour-changing dresses, responding to real-time weather conditions[39]. Another example of a similar project, is a chemically treated dress designed by The Unseen's designers. They used chemistry to create a dress that changes colour with the climate [1]. Other experiments, such as Angela Mackey's experiment, are more concerned with investigating potential scenarios by putting them into practice in today's world. Angela Mackey's experiment, which has been a great inspiration for us, focuses on wearing dynamic fabric with digital display capabilities. She observed this through an autoethnographic approach by wearing green every day for a longer period of time by using chroma-key technology to apply a digital overlay to the clothing, and keeping track of her experiences [21]. This experiment also inspired us to focus on an autoethnographic approach for our initial research. A few small start-ups took it a step further and attempted digitally controlled designing of visuals on physical soft materials through e-ink; however, this was never a huge success, and most of the projects were abandoned. [36].

Within the last decade, in tandem with the rapidly growing technological possibilities, the fashion industry has begun to place a greater emphasis on digital fashion. Applying Augmented reality into the world of fashion is a fairly new and currently ongoing process, and while the current technology only allows us to go so far, the possibilities for the future are endless [13]. To imagine what an augmented reality inspired future would look like, and to be able to look at it from a design perspective [10], a couple of speculative design short films have been made. "HYPER-REALITY" [23] is a great example of a concept film that depicts a perplexing and kaleidoscopic vision of a future in which the physical and virtual worlds have

unified. These short films, just like the Black Mirror television series, were a great inspiration for our own design fiction.

This design research approach is mainly based around exploring an (often in the future) story world, a scenario in which a concept is prototyped within that story world. This scenario's main purpose is to give people a stepping stone to start speculating about a possible future with the realized concept and the implications that would bring along. Diegetic prototypes are used to make the scenario more tangible. They are designed in such a way that they allow your scenario to be clearly explained, while at the same time leaving enough space for other people's creativity to fill in the blanks. They are also known as "artefacts from someplace else, telling stories about other worlds" [19][20]. Design fiction is a part of the speculative design discipline and aims to generate and foster discussions. Using this method allows us to start debating the topic of augmented fashion and all of its implications before the actual technology gets available.

Fashion brands and shops are implementing AR "Magic mirror" technology to give customers instant access to the complete catalogue and allow them to virtually try on all kinds of styles from an assortment of retailers. While this is still a long way from everyday digital fashion, it gives a good impression of how the outfit will look on the customer [12][18][35]. Providing an accurate representation of an outfit on the body before a purchase reduces consumer uncertainty, resulting in lower return rates, as well as strengthening the effectiveness of online retailing. That said, returns continue to account for about half of all online purchases, as online platforms struggle to resolve inherent challenges such as a lack of tactility in clothing selection [36]. Even without modifying their product offerings, brands can profit from digital fashion. A large company like Puma can form a relationship with a specialist firm like The Fabricant. In this example, Puma created digital evidence of a concept that significantly reduced the need for sampling, handling, travel, and other logistics. PUMA decreased their water consumption by up to 17.4 percent for their new collection, simply by adapting their product innovation process based on their collaboration with The Fabricant. In addition, PUMA cut their time to market and costs by 30% [4]. Not just stores and brands, events such as fashion shows and catwalks are also switching interests towards digital events. This is partly due to the whole COVID situation, but other factors such as rising financial and environmental costs also play a significant role. In comparison to traditional fashion events, virtual shows and augmented reality experiences are evolving as an innovative and more open alternative.

The topic of sustainability has become a major focus field in recent years, and the pressure to become more ecologically responsible is rapidly increasing. and this also applies to design and the points of focus during a design process. Aspects as material selection and durability have taken on a whole new meaning and recyclability is now a factor [22]. At the same time, the fashion industry is undergoing a physical-to-digital transition. The continuously deteriorating climate is, next to COVID, one of the key reasons for this, since the fashion industry accounts for 8-10% of global greenhouse gas emissions, with the potential to reach responsibility for 25% of total allowable emission levels, as reported by the climate goals [4]. Therefore, fashion brands are attempting to implement digital prototyping in order to reduce the amount of waste they generate. The development of digital clothing to replace physical fast fashion is also high on that list since people are buying more outfits than ever before while wearing only a couple of times before replacing it. The negative consequences of this never-ending buying sequence are clear, but if people replace their digital fashion for the looks and only replace their physical clothing when absolutely necessary, this will no longer be an issue [30].

While the Fashion industry is focusing its digitalization mainly on the more advanced technologies such as Clo3d, which allows for advanced fashion designing, companies such as Instagram and Snapchat on the other hand just want to make the AR technology available to the general public. Everybody with an account can use basic AR functionalities for their pictures & stories, simply through precreated lenses and overlays. Snapchat even offers a programming application where people can create their own lenses. This application allows having a sneak peek at the possibilities for AR fashion in the future, by using the technology of today.

Next to the positive impact, it can make, augmented reality also raises some new security concerns. AR HMD'S (Head-mounted displays) are currently already collecting all kinds of personal data, while your personal computer or phone data collecting is often limiting this to browsing behaviour and interactions with content. Eye- and head movement tracking, gesture- and motion detection and location tracking is all part of the data used while working with AR. This introduces a big privacy challenge, companies have to be clear about how they store, manage, and obtain personal data, as well as how and when they share it with third parties and how they secure it on their own servers, much like every other organization that collects personal information [9].

We can only speculate about the endless possibilities of AR in the future. Scenarios, as visualized in the "HYPERREALITY" short movie [23], are promising, yet also include safety threats. The AR world will be filled with visuals overlaid on the real world, and people will rely on what they are shown by the AR applications. If hackers gain access to the application, they can show whatever fake information or visuals they want the user to see. Imagine the consequences of a traffic light displaying the wrong colour, a windshield turning solid black or a doctor receiving inaccurate information about a patient's status [6]. Situations like that can potentially cause massive harm. Next to general adjustments, it also becomes possible for hackers to change what someone is wearing or even change a person's identity. For many people, the internet has already become a toxic world as a result of cyberbullying, and with the possibilities AR provides, this might take a turn for the worse with aspects such as digital abuse and visual bullying now playing a part (Rocks,

2018). There are also certain risks associated with digital fashion. As Angela Mackey describes in her paper, "One colleague intermittently photographed me when he felt inspired and placed what I perceived as unfavourable digital content on my garments." [21] Without a solid security protocol, people can simply display anything of their choice to you, which is something to keep in mind for our project, since this can be a really unpleasant experience.

3. METHODOLOGY

In this section, we describe the study setup, which is divided into two main parts: 1) Autoethnographic exploration of designing and wearing augmented fashion, and 2) Developing and deploying a design fiction on augmented fashion.

3.1 Autoethnographic exploration of designing and wearing augmented fashion

First, we establish a future scenario by extrapolating from current technological developments in the relevant fields. This future is then used as a basis for autoethnographic exploration. For this, we take inspiration from the work and autoethnographic approach of Mackey et al. in "Can I Wear This?" [21]. Writing about our personal experiences, such as also described in "Autoethnography: An Overview" by Ellis et al. [7], is key to gaining an understanding of the multiple aspects and perspectives of augmented fashion. The process itself is therefore part of the product of our study.

We differ from the approach in "Can I Wear This?" by focussing on gaining an initial understanding of the topic and the process thereof, instead of focussing on the long term impact of integrating this technology in our daily lives.

Over the course of ten weeks, different approaches to designing and wearing augmented fashion are explored. Results are shared on social media via an Instagram page, in which the descriptions function as a brief journal entry on the thoughts or concerns that come up and experiences gained by creating the visuals. When writing down detailed accounts on the current understanding of the subject and the description of an Instagram post does not suffice, additional writing is done elsewhere.

For approaching the experience of wearing augmented fashion, multiple methods are used and experimented with. These include using real-time 3d body tracking filters in Snapchat, using virtual reality to visualize augmented fashion outfits around a wearer and superimposing augmented clothing onto captured video using visual effects. Each of these methods has their own levels of fidelity and immersion, allowing us to approach different aspects of wearing augmented fashion. Visual effects for example allow great fidelity, but virtual reality allows for great immersion. Real-time filters in Snapchat also offer a different form of immersion than an outfit in virtual reality.

3.2 Developing and deploying a design fiction on augmented fashion

The second part of our study is developing and deploying a design fiction, using the approach described in the book "Speculative everything: Design, Fiction, and Social Dreaming" by Dunne and Raby [10]. The designs that are created as part of the autoethnographic exploration are used as diegetic prototypes.

First, we conduct thematic analysis on the collected data from our autoethnographic exploration in order to establish broad themes. For this, we use the methodology developed by Braun and Clarke [6]. These overarching themes are then used as topics for the different scenarios. The contents, worldbuilding, detailing and intricacies of these scenarios are drafted from the findings, journal entries and gained an understanding of augmented fashion.

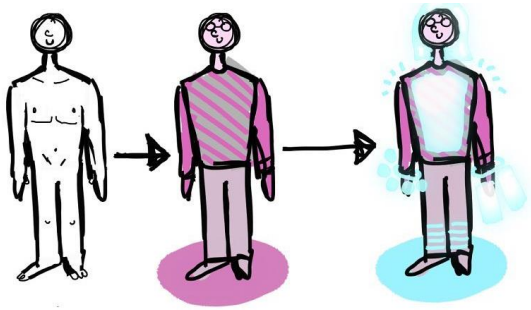
The design fiction is comprised of multiple scenarios in written text, with additional supporting visuals and the aforementioned prototypes. It is then integrated into a digital, easily digestible format — a slide show and later a website — for use in discussions.

Deployment of the design fiction is done in the form of hosting discussion sessions. We show the participant our design fiction scenarios and ask them a set of accompanying, thought-provoking questions. These are then analysed and from this process, in combination with the data collected from the autoethnographic exploration, we compose a list of likely or desirable scenarios, possibilities, concerns and ethical considerations.

4. EXECUTION

The following text is written in the first-person perspective by the authors. The team describes the process of the execution of the research project Ubiquitous Augmented Fashion. To see more visuals of this, see appendix 10.1.

We started our study by exploring the field of digital fashion, digging into what this technology really is, what it can do and how it currently is implemented in daily life. We visualized the physical body, the body wearing physical clothing and finally wearing digital clothing in order to get the first vision on digital fashion (Figure below). This was our first step towards thoroughly understanding AR and establishing what the possible courses of action were.



4.1 Establishing a future for first-person exploration

By creating visualised speculative scenarios, in which, for example, everybody in the room is wearing AR glasses and digital clothing, we developed a good vision of how it would look and what it could be. We sketched on top of existing pictures of crowded areas.

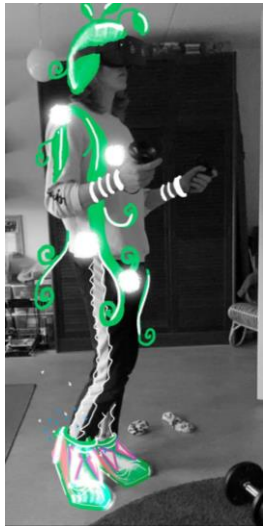
By sketching on top of existing real-life scenarios, we acquired a good impression of what it would be like if AR and digital fashion would become ubiquitous. This made us realize that we came upon a very interesting point of view to research: What would our world look like if AR would become ubiquitous? How would people behave if they wear digital clothing over their physical clothes? What positive or negative contributions would this development bring into society, and what benefits or downsides are linked with this technology?

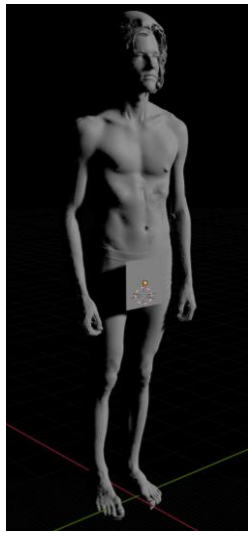
We went ahead and designed many different outfits and scenarios within the framework of AR. We did this by working with a variety of sketching and modelling applications, such as Blendr, Sketchbook and Tilt-Brush (See Figures below and to the right).

It was a very important activity to gain experience for first-person accounts in designing digital clothes, since it gave us new valuable insights and allowed us to experience a designers perspective. At this point, we also decided to make an Instagram to share our progress with the squad and other interested parties. This approach allowed us to experience what it is like to design augmented clothing and collect input from others, without being limited by physics, materials and standards.

4.2 Autoethnographic study / First-person exploration

The next phase was applying the auto-ethnographic approach in our next study. We projected AR on images of ourselves (Fig. below) and experienced what it was like to actually wear augmented clothing. After that, we underwent the experience of creating 3D scans of our bodies (Fig. left). This experience was extraordinary, it even made us feel insecure. This feeling was the result of us standing still for 10 minutes, while wearing very little





clothing and felt eyes staring. It was also very confrontational to see the results of this scan, which resulted in a considerable mental barrier that led to us not wanting to design on our own body scans.

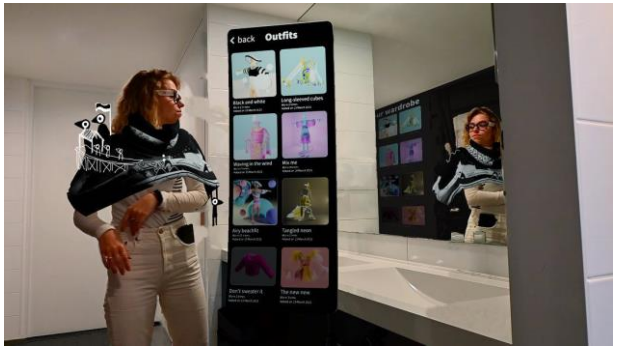
We experimented with connecting physical clothing with digital clothing and brainstormed about approaches that would allow us to integrate physical work into our process. A part of our group wanted to work on physical products, so we switched some attention to that area. We did this by sewing a corset from scratch and creating various designs in Sketchbook. An interesting angle that resulted from this, is to consider making specific clothing lines and only being able to project on top of them, or only being able to design and adjust certain details. However, this would be very restrictive, so we decided to move our focus back to digital fashion with all of its unlimited possibilities.

4.3 Design fiction development

Diegetic prototypes were a very important aspect of our design fiction. These prototypes allowed outsiders to get a good image of the narrated world, yet left enough space for people to create their own vision, propose possibilities and draw conclusions. In our case, this world consists of a fully functional metaverse that became part of the everyday scene and AR glasses that have become ubiquitous. We have created moving visual effects shots to resemble this digital fashion as realistic as possible. However, this was a very long and intensive process, and for that reason, we created three final VFX shots (Fig X.) that we could show experts, students, coaches and others. This was the right solution, as the frames were very short and realistic design fiction was clearly presented in them. In this way, experts and coaches, as well as students and outsiders, could speculate about what this technology might bring and how our society would look like when this technology was to be implemented in our daily lives.

4.4 Discussions

The development of a design fiction was very important for the discussions we held, because people could use it as a foundation to form an opinion on what consequences this technology might have on our society and daily lives, which we could discuss with them during discussion sessions. We had these discussion sessions with people from all levels of knowledge and involvement on the subject and had a variety of discussions. The sessions have been held in such a way that the people are in no way being directed to opinions or answers (see Findings). In this way, the conversations were interesting, long and spontaneous, which really helped to gain different and unexpected insights (see Findings).



5. FINDINGS

The aim of this study was to gather insights into wearing and designing augmented fashion and the potential social implications it could have on our daily lives, in order to determine desirable and less desirable future outcomes. In this section, we present a list of findings that have come out of our autoethnographic exploration, the creation of the design fictions, and the held discussions. We identify likely and plausible scenarios, as well as a range of ethical issues and considerations that could be of interest for further research and for implementing these future systems.

5.1 Defining and designing desirable augmented fashion

As part of our autoethnographic exploration, we experienced what it was like to go from no experience in designing augmented fashion, to having an understanding of the creative and technical processes, required tools and possibilities augmented fashion could bring. Our findings are both in the outcomes of this process, and the process itself.

Throughout our entire process, we shared all experiments and created visuals on our Instagram page. We found that this was a highly effective method for getting direct feedback — in the form of reach, likes and comments — on whether we were on the right track or not with regard to appealing to the imagination and creating attractive outfits. Since we are then stacked against the world's top digital fashion designers, we also get a better sense of what is considered state-of-the-art. Thus, we see Instagram as an effective tool for driving projects that have the creation of visuals at their core.

During our exploration, we experimented with using Virtual Reality (VR) for embodied design. Tilt Brush [citation] and Gravity Sketch [citation] were used for this purpose. Both applications allow the user to create three-dimensional drawings and designs, and compose scenes with imported objects.

We also developed an efficient workflow for creating an augmented fashion outfit; From sketch to an augmented fashion video. We define the following steps: 1) Ideation and concept development, setting requirements. 2) Capturing video footage or images from multiple angles. 3) Sketching the outfit on top of a still frame. 4) Designing the high fidelity outfit in Gravity Sketch, Marvelous Designer and Blender. 5) Perform 3D body tracking using OpenPose and triangulation. 6) Couple a 3d scanned, rigged mesh of the person to the tracking results. 7) Perform cloth simulation. 8) Render in Blender and composite, either in Blender or After Effects.

Through our exploration we discovered the following possibilities of augmented fashion, some of these are also visible in our designed outfits:

- The ability to alter your facial or bodily appearance
- Animate parts of the augmented outfit
- Integration of realistic cloth physics, with potentially non-realistic material properties.
- Augmented fashion items that interact with each other. These items can create emergent behaviour and potentially create modifiers.
- Fashion items that change the appearance of nearby surroundings, such as shoes that change the ground.
- The inclusion of floating elements that are not directly connected to the body.
- The use of interactive elements. Someone could make a t-shirt that has a small game on it.
- The ability to share information. Things like your name, relationship status, age.
- The ability to gather information. An outfit that changes based on the environment.
- An outfit that changes based on health information.

5.2 First-person accounts on approximating wearing augmented fashion

Next to designing augmented clothing pieces, wearing them has been approached in various ways, each giving a unique insight into what it will be like to wear augmented fashion.

Wearing minimal to no clothing and AR glasses in a public space.

This is not frowned upon. People give a couple of looks, but are not weirded out by it.

Wearing clothing pieces in Virtual Reality

An interesting insight from this was that, if aligned correctly, you could place yourself in the virtual outfit. Even without a physical body visible, this was the most immersive way to experience what it was like to wear augmented fashion items. Further experiments could be done with this method, composing entire scenes of what a future with augmented fashion could look like.

Wearing fashion using mobile AR, Snapchat.

This is the closest we got to what it would look like in real-time if someone were to wear augmented fashion. However, the immersion was lacking. It did not feel like *you* were

wearing the outfit, but rather just a visual representation of you. The tracking also wasn't working properly.

Superimposing clothing onto captured video and images, either onto strangers or ourselves.

This was the highest fidelity visualisation we could get to, and allowed us the largest amount of freedom in terms of what we could design.

Suggestions for experiences for approximating wearing augmented fashion that have not been tried yet:

- A screen with one or multiple cameras pointed towards the participant, making it function as a mirror, and then projecting augmented fashion onto them in real-time using 3d human pose estimation and cloth physics.
- A 3d interactive narrative experience that shows people wearing augmented fashion, going through different scenarios.

Contexts in which we envision wearing augmented fashion could be adopted:

- Festivals, events, large and organised
- Nightclubs, social hubs, bars
- Workspaces, open workspaces, collaborative workspaces
- Social meet-ups, parties, small scale

Our experiences have been that wearing augmented fashion in the context of everyday situations could be considered "overdressed". Similar to how one might wear a gala dress only for special occasions. Even with our prediction of AR glasses becoming ubiquitous, the glasses will likely not be worn at all times. Because of this, wearing an outfit in a context where everyone is expected to be wearing AR glasses, and be in the same digital space would be the most likely.

5.3 On developing a future for the augmented reality metaverse

From our experiences and findings from first-person exploration, we went on to construct a future scenario in which our outfits could live as diegetic prototypes. Engaging in this process of worldbuilding forced us to critically look into the foundational technology that is required for augmented fashion to emerge. We share our insights into developing this future and our insights into how this future might work.

We found that the identified possibilities of augmented fashion previously discussed are not easily implemented in a single platform. Current platforms tend towards basic customisation and simple outfits, leaving out user-generated content. Platforms that allow users to create custom avatars, such as VRChat, only allow full avatars to be uploaded. We have created a realistic future scenario of how AR glasses and the AR Metaverse might be implemented so that the creative ideas will be implementable. This takes inspiration from the open standards of the internet and current developments in that area regarding WebXR.

- How AR glasses might work
- How the AR Metaverse might work
    - How AR spaces might work

5.4 Behind the scenes: Creating an augmented reality design fiction

Building on the preceding first-person experiences and worldbuilding, we aimed to create multiple narratives and scenarios that would allow us to provoke meaningful discussions about this future. Accompanying visuals were also created to make these scenarios more tangible. We share our insights about the creation process of these narratives and the accompanying artifacts.

Artifacts that are part of the created design fiction:

- A set of discussion-provoking questions about the future of digital fashion
- A set of diegetic prototypes in the form of augmented outfits, AR glasses, promotional graphics and social media-advertisements
- A website that contains multiple future scenarios, with each of these consisting of a textual narrative and the aforementioned diegetic prototypes.

Methods:

- Writing a narrative, taking inspiration from science-fiction works such as Black Mirror
- World-building through the use of thought experiments

5.5 Social impact and ethical considerations of augmented fashion

Increased social segregation, the formation of certain subcultures and subgroups will occur, and existing social groups will be more easily separated from each other. One can simply create their own version of reality, filtering out a group of people they do not want to see. Making sure inclusive public spaces are created and maintained is important. Moderation and censorship are also topics of interest in what people are allowed to and are going to wear.

Furthermore, exclusion of poor and less financially equipped demographics or individuals is an important factor to consider when creating AR spaces. People without the financial needs to buy AR glasses will be left out from certain social interactions, events and important information.

The impact on body image. With people being able to alter their appearance in the context of a real-world setting, instead of just online through the use of photo manipulation, dissatisfaction with one's own body could increase. Similar to how Snapchat filters currently allow people to subtly change their face structure in real-time, which in certain cases can result in someone wanting to undergo plastic surgery to match their digital appearance [citation]. This phenomenon could become even more prevalent by introducing the possibility to alter one's body and face in AR spaces. One could make themselves a bit thinner, add a little bit of muscle or make their face more symmetrical. Subtle changes like these could result in someone getting used to their new look and becoming dissatisfied with their natural appearance.

Impact on social interaction when mixing "teleported" people and physically present people, in which "teleported" refers to people who are digitally present in the AR space, but are physically at a different location.

Another scenario that could result in unwanted usage is the introduction of more sophisticated AR filters. These AR filters could be used to accurately superimpose visuals onto environments and individuals. These could then potentially be used to spread political messages without the consent or knowledge of the subjected people. Individually targeted "attacks" could also occur. This relates to current concerns being brought up by the introduction of deep fakes. Being able to trust what is presented in videos is not straightforward as before, and training people or machine learning models to recognise fabricated footage will become increasingly important.

Following up on that, we found that trust plays a major role in the AR Metaverse. How does one user know that what they see is the same as what the other sees?

Impact on social interactions with multiple overlapping AR spaces.

Impact on buying physical clothing, fast fashion, the interaction between digital and physical outfits, and the position of brands in this potential transition.

Customer spending patterns.

Mental health impact of spending extensive amounts of time.

6. DISCUSSION

During this study, we experienced what it is like to design and wear augmented fashion and we used design fiction to gather insights about possible implications regarding augmented fashion in the future. This design research approach is mainly based on extrapolating from current trends and speculating about the possibilities through the development and discussion of a future scenario. By using this approach, we were able to collect some really valuable but also diverse thoughts and opinions. These opinions provided us with new insights, for us to analyse and draw conclusions from. At the same time, they function as a foundation for further research, since the new insights also introduced new perspectives, questions and debatable topics.

At first thought, one would say that augmented fashion can play a big part in solving the massive amounts of waste generated by the fast fashion trend. When people no longer have to replace their clothing collection every other week and still can keep up with the latest trends, physical outfits can be worn for as long as they last instead of only till the next collection gets released. Given our scenario where AR glasses have become ubiquitous and a fully functional metaverse is in place, it would very well be possible to only have as little as 5 shirts and 5 pairs of trousers in their closet. A decrease in demand for physical clothing leads to less physical production, therefore resulting in less waste and pollution being generated by the fashion industry. However, this decrease in physical clothing production also has its downsides. A big percentage of people living in developing countries live in poverty and although the circumstances in the production centres are way below standard, many of those people rely on the fashion industry for an income [27]. This development would on the other hand create a lot of jobs for digital fashion designers, yet that is a whole different target group. This once again explains how important it is to use multiple perspectives. From a sustainability focussed perspective, it would be ideal to reduce the physical fashion production as much as possible, while from an ethical perspective would it be disastrous to simply let so many people become the victim of this development. This is a dilemma that needs additional research and debate before conclusions can be drawn about whether reducing physical clothing production as much as possible is actually a positive development.

A discussion topic that might influence the previous dilemma, is whether augmented fashion should be implemented in daily life and fully replace the concept of physical style or act as an addition to create a combination between physical and digital. A complete switch towards augmented fashion would result in the situation as described above, while there are way more possibilities in which augmented reality can be implemented into our society. Using augmented fashion on special occasions as events and parties are generally seen as a valid option, and since fashion is also a way of expressing yourself, it could very well function as an unintended conversation starter. This would especially be an interesting option if people could fully design their own outfit, yet it is to be expected that not everybody has the skill to do so. The option mentioned to use a basic style outfit with the option to adjust details would be a great way of allowing everybody to adjust their outfit as they want, yet keep it available for everybody. It would be ideal to give people the option to do the designing, but also have enough pre-designed options which they can choose from. Creating this connection between the physical and digital world needs to be done in a way that both realities lay very close to each other because only then it can grab the attention of the market. People actually love to buy physical items, so that they can really feel the product. This is an important detail considering the marketing aspect, a part that got little attention in our current study, yet is definitely worth taking into account for future studies. Especially since our current society is really focused on profit orientation, which could potentially be a hijack for augmented fashion. This makes a study focusing on a transition period a really interesting possibility, which can also produce more insights in questions such as "What (de)motivates people to try and use this?", "What role will the big fashion brands such as Prada, Gucci or Chanel play in this process?" and "(How) can we make this hype last, instead of just falling back on plain physical clothing over time?"

Augmented fashion, just like a lot of other things, has some desirable aspects and some less desirable aspects. When we talk about cyberbullying in its current form, people think about using text or photos to humiliate or even hurt someone. When augmented fashion comes into play, we have a whole different scenario. AR is hackable, just like any other type of technology, which means people with who knows what intentions might get the chance to mess with your virtual outfit. Cyberbullying in an augmented society adds a whole new dimension to the harm that can arise. People are no longer limited to words, they

can just display anything of their choice onto you, and you might not even know it. This can be something innocent as a bad joke, yet when this happens to a public figure, it can have serious consequences. Someone's career can be ruined, simply by changing how the outside world sees their augmented outfit. Bullying does not even necessarily have to be about what someone is wearing, augmented reality has a price, and some people will be able to afford it, and some people will not. Yet because they cannot afford access to the AR world, they get afraid that they will miss out on all of the fun and excitement, and that people will laugh at them. These societal problems are part of the unplanned possibilities that come along with the development and release of new technology, and despite the fact that people generally assess these as inevitable, it is still important to keep those societal aspects in mind, as they are not always positive and could potentially be detrimental.

There are many ways digital or augmented fashion can be implemented in our society, as explained earlier. These all individually require more in-depth exploration and research, since every one of those scenarios brings along different consequences and makes a different impact on our daily lives and people as a society. Our current study was limited to exploring the general implications of a future involving augmented fashion, which, on one hand, was a good thing, because it allowed us to gain insights about a wide variety of topics, on the other hand, it limited us to go in-depth with our study, because the topic was just too broad to do detailed research on all aspects and scenarios.

The main research goal was to explore potential implications for an augmented fashion implemented future, and since this goal directed us towards doing a speculative design research approach, we decided to do this through the medium of design fiction. This choice was made to allow us to speculate on the future, while leaving enough space for outsiders to create their own vision. This choice turned out to be a good one, since this approach allowed people to focus on any aspect they envisioned, which, when combined, created a well-rounded foundation filled with insights from a variety of areas. This approach has been of real use during our study, yet for further studies that go more in-depth on one specific aspect or scenario, a more focused speculative design research approach might be more convenient.

Autoethnographic research was mainly done to give us the experience of designing and wearing augmented fashion ourselves, while the insights gained from this research also contributed to the development of our design fiction. Where design fiction focuses on speculating, this technique really allows the research to experience a perspective, which can give completely different insights than solely speculating. For us, it really did that and created some eye-openers on aspects we did not consider before. It turned out to be a decent choice for both our current study, as well as future studies.

The only real downside of our research approach turned out to be that our study subject, digital/augmented fashion, is currently still under development, which resulted in some missing aspects that kept us from fully finishing our design fiction. The main reason was the lack of existing ready-to-use software, such as proper 3d human pose estimation, which resulted in us losing quite some time by developing and setting up a workflow to achieve this without having predefined software to use. This is something we should have considered earlier on in the process, and is definitely important for further research to take into account.

7. CONCLUSION

In this paper, we explored the impact Augmented Fashion has on society in the future and what kind of implications it could cause. We approached this query by applying different types of research methods. With the help of Design Fiction, we have created a scenario in which a fully functioning metaverse is part of the everyday scene and AR glasses have become ubiquitous. This scenario consisted of a variety of visuals that were created with the help of a wide range of applications. In addition to design fiction, auto-ethnographic research has been carried out to experience first-hand what it is like to design and wear augmented fashion. We created visuals and noted down our experiences, which we then shared via the social media app Instagram to keep track of our progress, as well as to gain insights from outsiders. Discussions with experts were also conducted to gain more insights and queries on this future. This paper presents the results of our exploratory process of creating visual images, but also examines the questions that arise in creating this augmented future.

8. ACKNOWLEDGMENTS

Throughout the whole process, we have received a great deal of coaching, support & assistance.

First and foremost, we would like to express our sincere gratitude to our project- and teacher coach Stephan Wensveen, whose guidance and support has been invaluable throughout the entire process. Your sincere feedback and advice was a decisive factor, especially during periods when all the possible follow-up stages overwhelmed us.

In addition, we would like to thank Marina Toeters, Kristina Andersen, Svetlana Mironcika, and all those who have used some of their valuable time to have a discussion session with us.

We would also like to thank Chet Bangaru, for helping us with making the body scans and providing the necessary hardware to make the scans.

9. REFERENCES

[1] Alleyne, A. C. (2017, November 7). *When chemistry meets couture: Clothes that change color with the climate*. CNN. https://edition.cnn.com/style/article/when-chemistry-meets-couture/index.html

[2] Anderson, H. C. (1837). *Kejserens Nye Klæder*. C.A. Reitzel.

[3] Anthony Dunne and Fiona Raby. 2013. Speculative Everything: Design, Fiction, and Social Dreaming. (1st. ed.). The MIT Press

[4] Ball, T. (2021, January 4). *Why Digital Clothing is 2021's Most Exciting Tech Trend*. Medium.

https://uxplanet.org/why-digital-clothing-is-2021s-most-exciting-tech-trend-64717db6856b

[5] Berryman, D. R. (2012). Augmented Reality: A Review. *Medical Reference Services Quarterly*, *31*(2), 212–218. https://doi.org/10.1080/02763869.2012.670604

[6] Braun, A. (2021, February 25). *Security, Privacy, Virtual Reality: How Hacking Might Affect VR and AR*. IoT Tech Trends. https://www.iottechtrends.com/how-hacking-affect-vr-ar/

[7] Carolyn Ellis, Tony E. Adams and Arthur P. Bochner. 2010. Autoethnography: An Overview. *The KWALON Experiment: Discussions on Qualitative Data Analysis Software by Developers and Users* 12, 1 (2011). DOI: https://doi.org/10.17169/fqs-12.1.1589

[8] Cosco, A. (2020, September 8). *Are virtual fashion shows the future of fashion week?* Electric Runway. https://electricrunway.com/virtual-fashion-shows/

[9] Dickson, B. (2018, February 4). *Will AR and VR create new cybersecurity threats?* TechTalks. https://bdtechtalks.com/2018/02/06/ar-vr-security-privacy-concerns/

[10] Dunne, A., & Raby, F. (2013). *Speculative Everything: Design, Fiction, and Social Dreaming (The MIT Press)* (Illustrated ed.). The MIT Press.

[11] Ellenmacarthurfoundation. (2017, January 17). *A New Textiles Economy Full Report*. Circular Economy - UK, USA, Europe, Asia & South America - The Ellen MacArthur Foundation. https://www.ellenmacarthurfoundation.org/news/one-garbage-truck-of-textiles-wasted-every-second-report-creates-vision-for-change

[12] FXMirror. (2018). *FXMirror: The World's Best Virtual Fitting Mirror Solution*. http://www.fxmirror.net/en/fitnshop

[13] Giunta, L., Dekoninck, E., Gopsill, J., & O'Hare, J. (2018). A Review of Augmented Reality Research for Design Practice: Looking to the Future. *A Review of Augmented Reality Research for Design Practice: Looking to the Future*. Published.

[14] Gravity Sketch. 2016. Gravity Sketch | 3D design and modelling software. Retrieved from https://www.gravitysketch.com/

[15] Guler, S. D., Gannon, M., & Sicchio, K. (2016). *Crafting Wearables.* Apress.

[16] Gupta, S., & Gentry, J. W. (2018). Evaluating fast fashion. *Eco-Friendly and Fair*, 15–23. https://doi.org/10.4324/9781351058353-2

[17] J. (2019, October 8). *Design Fiction: A Short Essay on Design, Science, Fact and Fiction*. Near Future Laboratory. https://blog.nearfuturelaboratory.com/2009/03/17/design-fiction-a-short-essay-on-design-science-fact-and-fiction/

[18] Kim, M., & Cheeyong, K. (2015). Augmented Reality Fashion Apparel Simulation using a Magic Mirror. *International Journal of Smart Home*, *9*(2), 169–178. https://doi.org/10.14257/ijsh.2015.9.2.16

[19] Kirby, D. (2009). The Future Is Now: Diegetic Prototypes and the Role of Popular Films in Generating Real-World Technological Development. *Social Studies of Science*, *40*(1), 41–70. https://doi.org/10.1177/0306312709338325

[20] Lindley, J., & Coulton, P. (2015). Back to the future: 10 years of design fiction. *Proceedings of the 2015 British HCI Conference*. Published. https://doi.org/10.1145/2783446.2783592

[21] Mackey, A., Wakkary, R., Wensveen, S., & Tomico, O. (2017). "Can I wear this?" Blending clothing and digital expression by wearing dynamic fabric. International Journal of Design, 11(3), 51-65.

[22] Marseglia, M. (2017). Design Process and Sustainability. Method and Tools. *The Design Journal*, *20*(sup1), S1725–S1737. https://doi.org/10.1080/14606925.2017.1352711

[23] Matsuda, K. (2021, June 7). *HYPER-REALITY* [Video]. Vimeo. https://vimeo.com/166807261

[24] Melnick, K. (2020, October 29). *Snapchat Reveals 3D Full-Body Tracking For AR Lenses*. VRScout. https://vrscout.com/news/snapchat-3d-full-body-tracking-lenses/

[25] Microsoft. (2021). *Introducing Microsoft Mesh | Here can be anywhere.* https://www.microsoft.com/en-us/mesh

[26] Miell, S., Gill, S., & Vazquez, D. (2017). Enabling the digital fashion consumer through fit and sizing technology. *Journal of Global Fashion Marketing*, *9*(1), 9–23. https://doi.org/10.1080/20932685.2017.1399083

[27] Nguyen, H.T. et al. 2020. Enhancing sustainability in the contemporary model of CSR: a case of fast fashion industry in developing countries. Social Responsibility Journal. 17, 4 (2020), 578–591.

[28] Noris, A., Nobile, T. H., Kalbaska, N., & Cantoni, L. (2020). Digital Fashion: A systematic literature review. A perspective on marketing and communication. *Journal of Global Fashion Marketing*, *12*(1), 32–46. https://doi.org/10.1080/20932685.2020.1835522

[29] Orth, M., Post, R., & Cooper, E. (1998). Fabric computing interfaces. *CHI 98 Conference Summary on Human Factors in Computing Systems*. Published. https://doi.org/10.1145/286498.286800

[30] Roberts-Islam, B. (2020, August 21). *How Digital Fashion Could Replace Fast Fashion, And The Startup Paving The Way*. Forbes. https://www.forbes.com/sites/brookerobertsislam/2020/08/21/how-digital-fashion-could-replace-fast-fashion-and-the-startup-paving-the-way/?sh=3efcf01e70d8

[31] Rocks, T. (2018, October 29). *The Dangers of VR Cyberbullying*. VR Voice. https://vrvoice.co/the-dangers-of-vr-cyberbullying/

[32] RTFKT Studios. (2021, February 17). *Introducing the Metajacket! Which design would you rock?* [Video]. Instagram. https://www.instagram.com/accounts/login/?igshid=1d0a7ck7uwgd0

[33] RTFKT Studios. (2021, February 24). *THE METAJACKET, the future of fashion born from gaming*. SuperRare Editorial. https://editorial.superrare.co/2021/02/18/the-metajacket-the-future-of-fashion-born-from-gaming/

[34] S. (2021, March 9). *WebAR Wearable Digital Fashion NFT, Bio-Sensors, 3D DNN Shape Completion, Animations, Gan Synthesis*. Medium. https://medium.com/silicon-valley-global-news/webar-wearable-digital-fashion-nft-dnn-shape-completion-dnn-animations-gan-synthesis-sensors-39ff447fef04

[35] Saakes, D., Yeo, H. S., Noh, S. T., Han, G., & Woo, W. (2015). Mirror mirror. *SIGGRAPH 2015: Studio*. Published. https://doi.org/10.1145/2785585.2792961

[36] ShiftWear Inc. (2015). *Design In Motion: ShiftWear Sneakers*. ShiftWear. https://www.shiftwear.com/

[37] SuperRare. (2021). *SuperRare | Authentic Digital Art Market*. https://superrare.co/artwork-v2/metajacket-og-19616

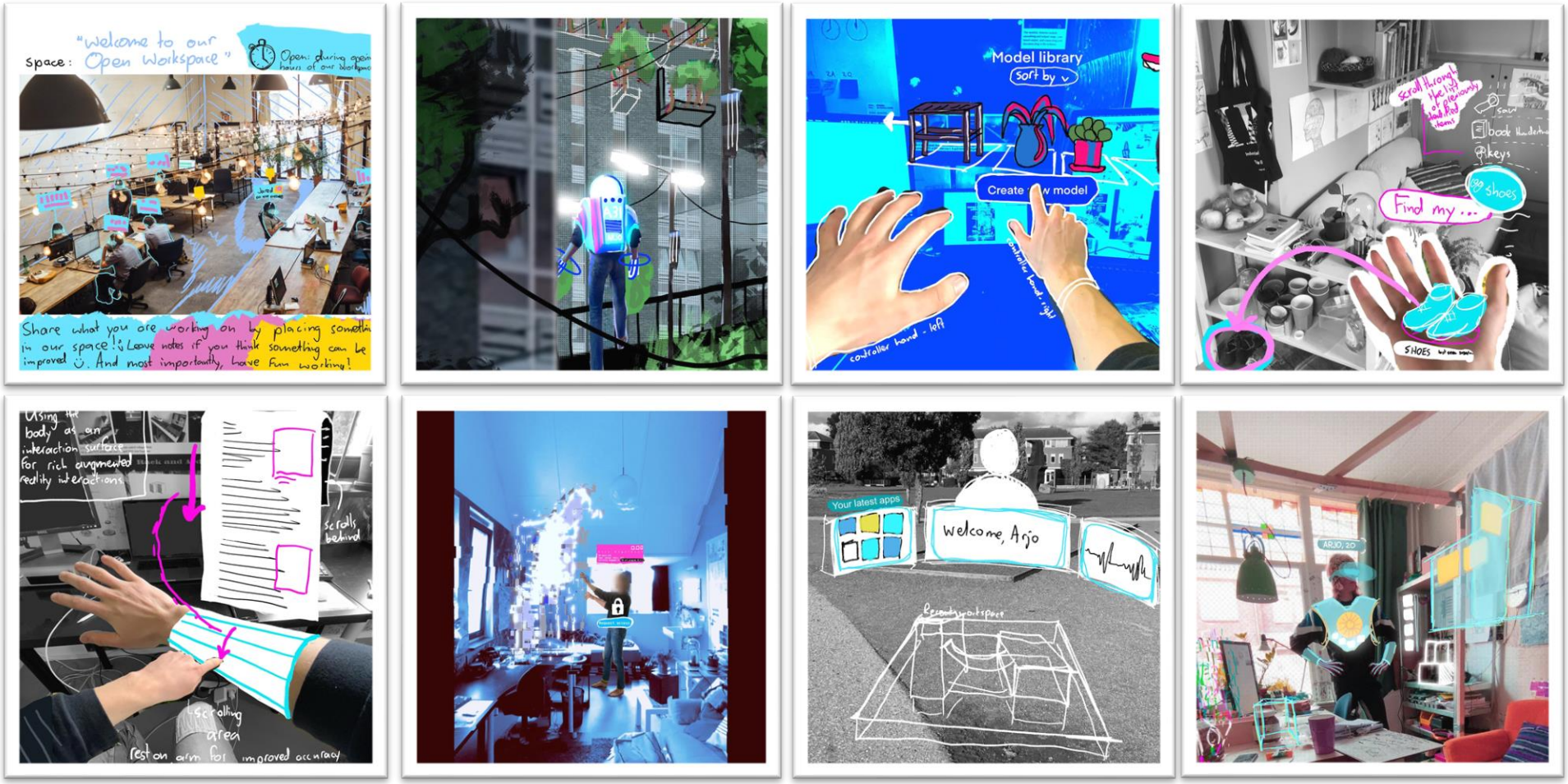
[38] Tilt Brush. 2016. Tilt Brush by Google. Retrieved from https://www.tiltbrush.com

[39] Valerie Lamontagne. (2010, February 23). *Interactive weather dresses*. Designboom | Architecture & Design Magazine. https://www.designboom.com/art/valerie-lamontagne-interactive-weather-dresses/

[40]Virginia Braun and Victoria Clarke. 2006. Using thematic analysis in psychology. Qualitative Research in Psychology 3, 2, 77-101, DOI: https://doi.org/10.1191/1478088706qp063oa

10. APPENDICES

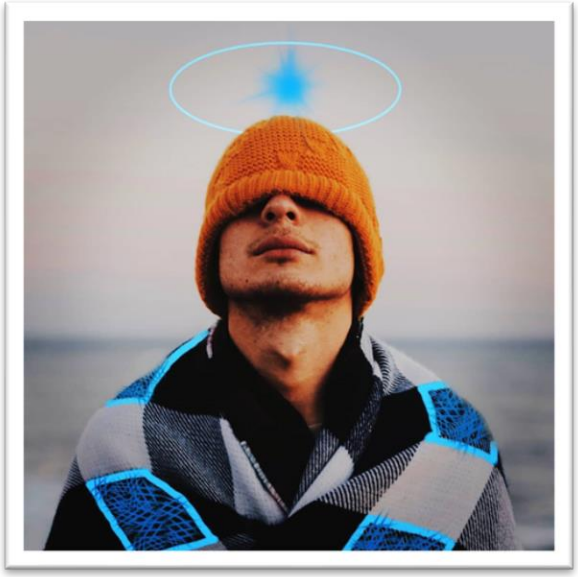
10.1 Visuals throughout the process



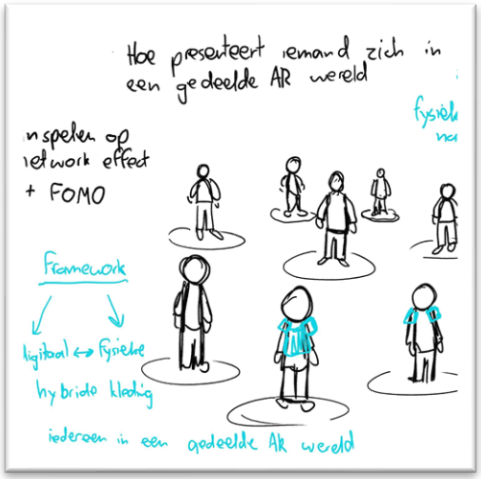
1 PICK PART OF THE PATTERN
2 CHOOSE A COLOR
3 THE PATTERN CHANGES

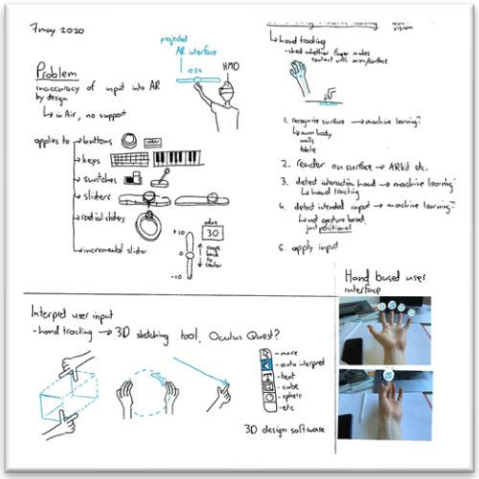
1 PICK PART OF THE PATTERN
2 CHOOSE A COLOR
3 THE PATTERN CHANGES

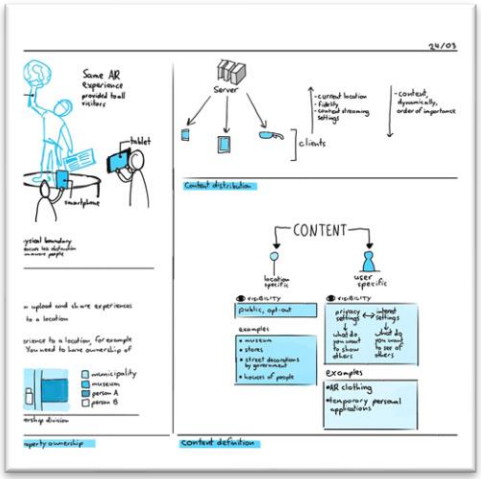
1 PICK PART OF THE PATTERN
2 CHOOSE A COLOR
3 THE PATTERN CHANGES

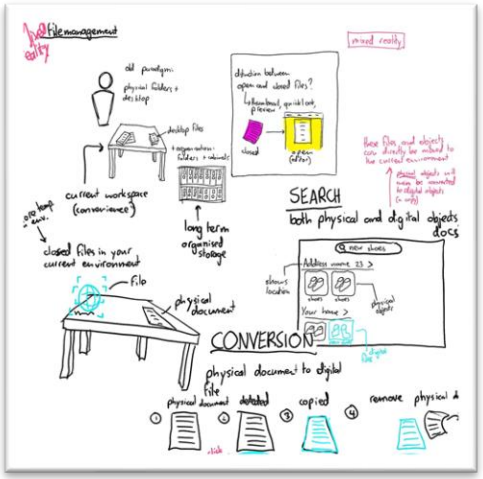


VETEM

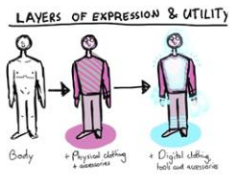






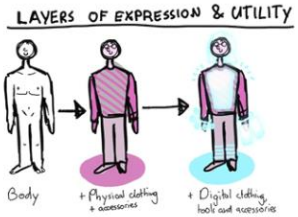


We aim to answer these questions in our research on **"Ubiquitous Augmented Fashion"**: what will fashion look like in an everyday setting when augmented reality-collaboration, -spaces and -events become a reality.



Layers of bodily presence

Augmented reality shines in making people move and moving people by connecting them with each other, either while in the same space, or in an entirely different continent. Now, how does this relate to fashion?

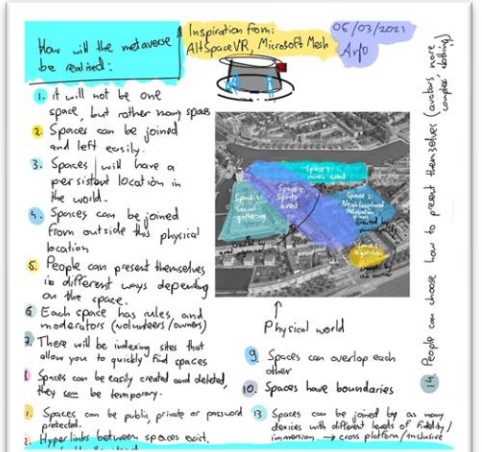


When people join a certain space in augmented reality, they have their physical appearance, combined with their digital appearance. This can be from a purely functional standpoint, such as showing your name above your head, communicating other information such as age or gender and showing a certain role one fulfills. However, as can be seen in every platform in which people present themselves, be it digital or physical, people want to express themselves and their personalities. In digital worlds people create avatars, collect skins, add items in a way that makes them feel like it properly represents them as a person. And this doesn't have to be the way they physically appear in the real world.

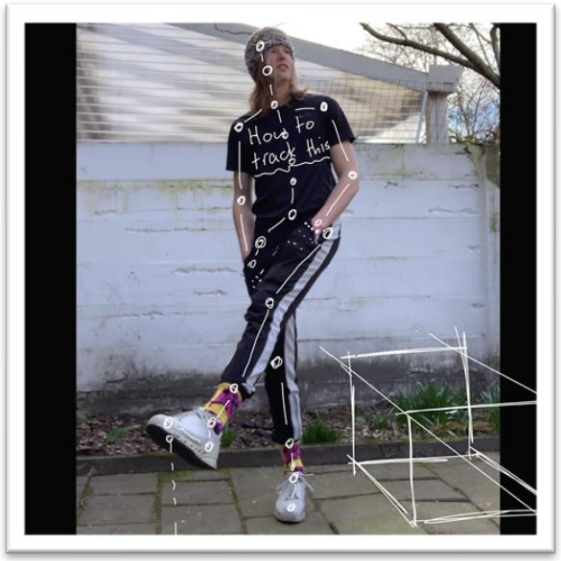
So many questions and implications...

This is where the power of augmented fashion comes in. When we are getting accustomed to collaborating with people in augmented reality and being with people in the same shared augmented space through events, certain augmented reality content, games and social venues, we will want to express ourselves. And exactly that question; how will fashion and the way we express ourselves be impacted by the introduction of collaborative shared augmented reality spaces?

Will phenomena as fast fashion move into the digital realm? Allowing for a more sustainable physical fashion environment? Will people wear extravagant, carefully crafted outfits to special events? Will there be a marketplace or openness? Will people want to be in a certain shared space that also contains people they don't identify with? Such as is currently prevalent in cities and physical shared spaces? Will people occasionally go into these augmented reality spaces or spend a lot of time there? Will there be a distinction between augmented reality spaces in certain environments such as a café and a public street space?
How often will people change outfits? How translatable is the avatar concept from games and digital worlds to real life, where we have physical bodies on which we can overlay more intricate and delicate fashion design?

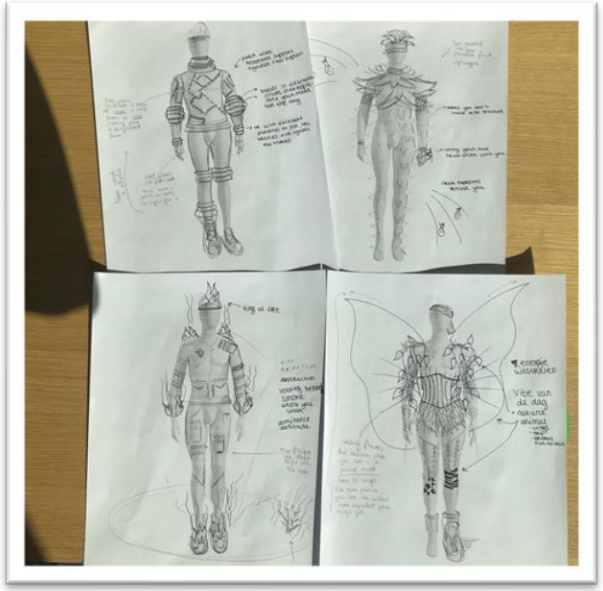


+ some ideas
+ inspiration

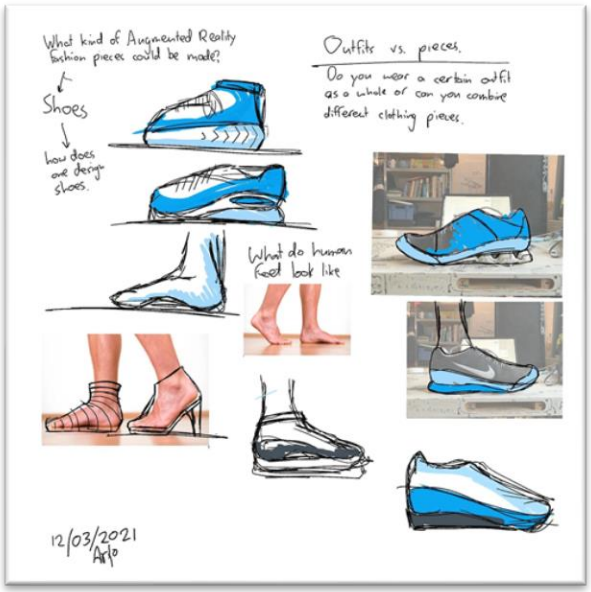

How to track this

tracking points
Visible mending trackpants x digital fashion

Pattern
Handini
Substance Designer
3D lineart?
that's some



Fashion brand
14/03/2021
Interactive clothes?
Music clothes?
Beat dress
Reactive clothes?
"Fills up" when the bass
Stylish/discreet looks
Weird types of fabric
Animated fabric
waving up.
Physics
defying fabric
Piano dress outfit


What kind of Augmented Reality fashion pieces could be made?
Shoes
how does one design shoes.
Outfits vs. pieces.
Do you wear a certain outfit as a whole or can you combine different clothing pieces.
What do human feet look like
12/03/2021
Arjo

Mini 3D world "inside" the shoe using AR
Aerobic shoes.
Meshes, leather urban fashion
Water physics

Rocket shoe
14/03/2021

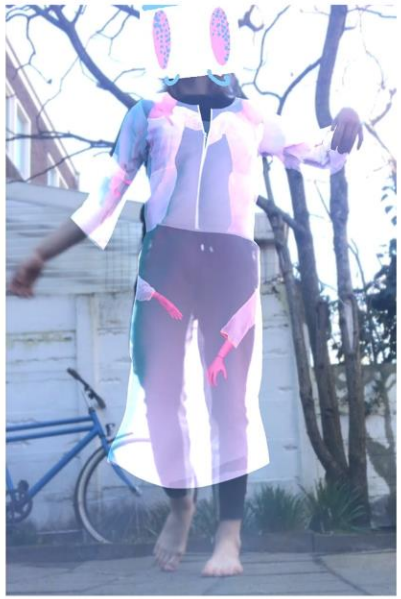
Hair experiments Blender
More designs
19-03-2021

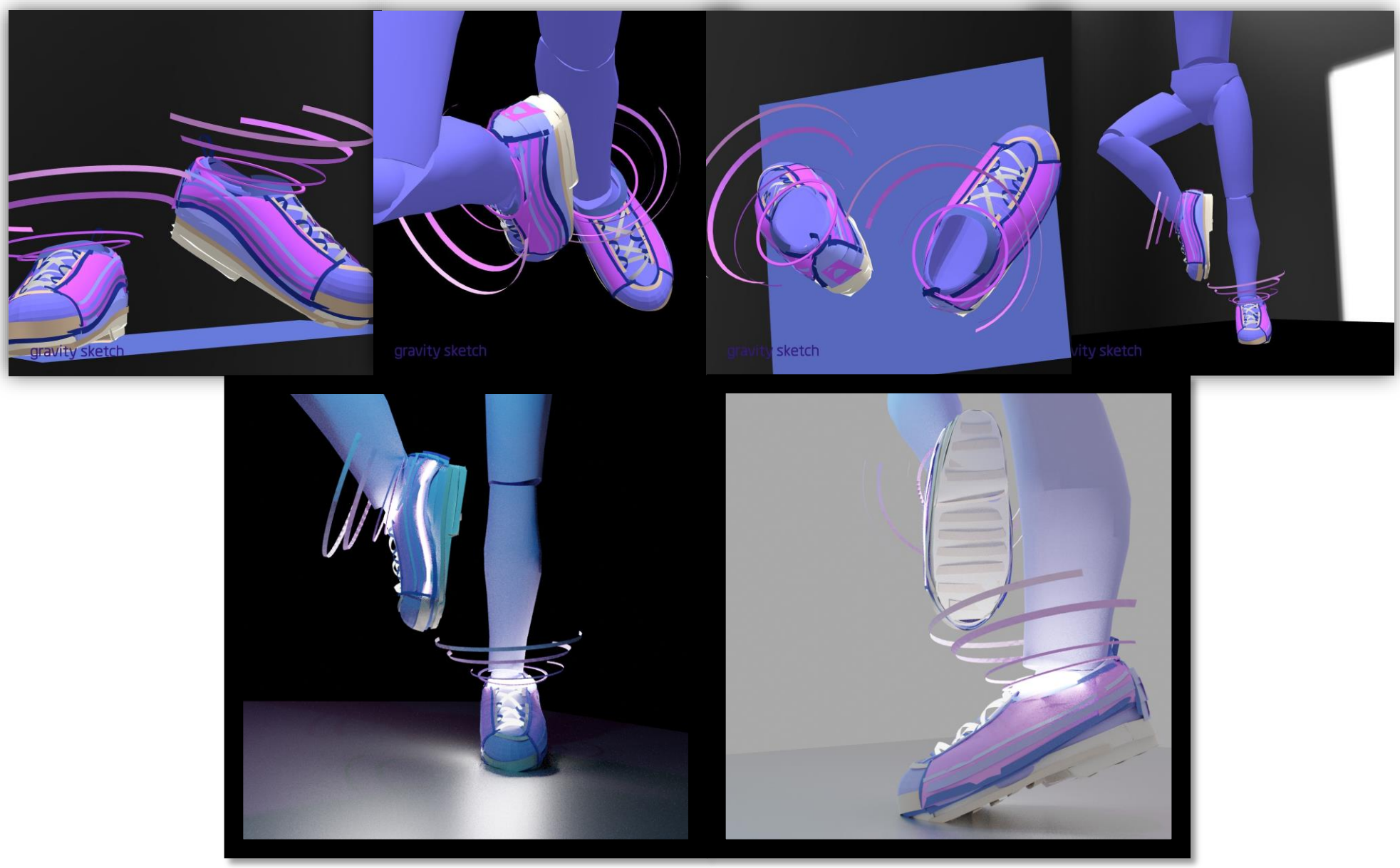
Blender hair particle system tests #1
2021-03-19

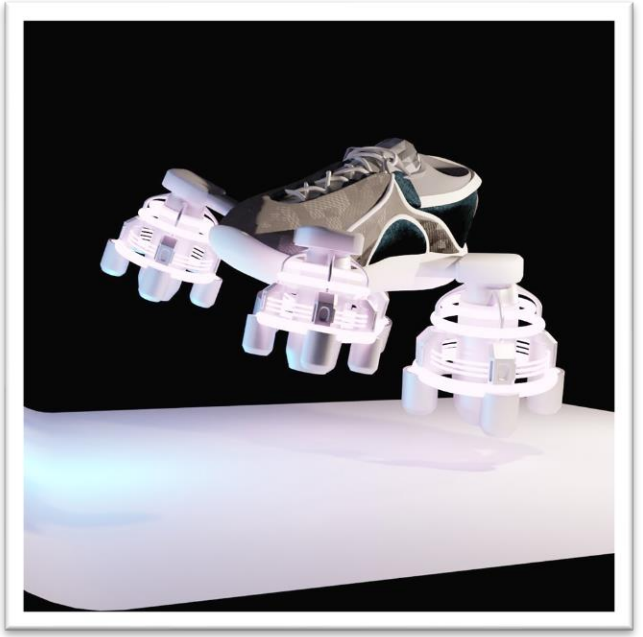
It's kind of like one of those gold fish

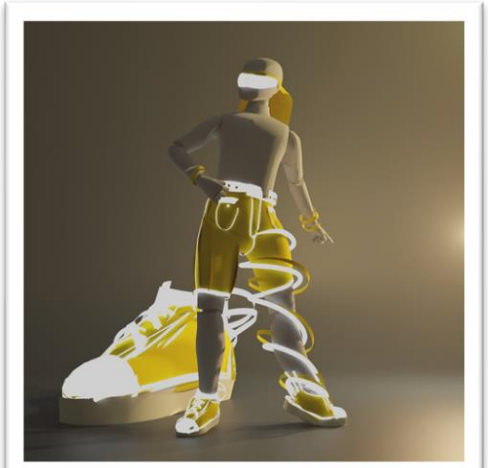
Something went wrong
Blender crash counter
14
Scary
Scary

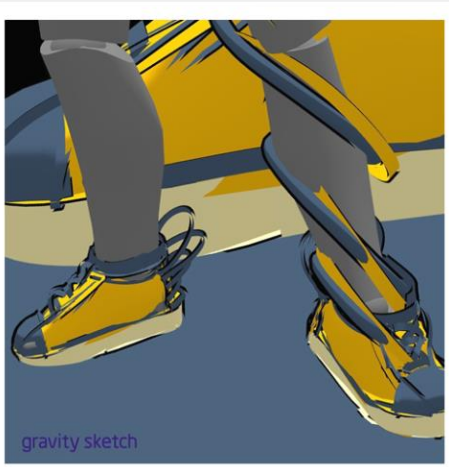
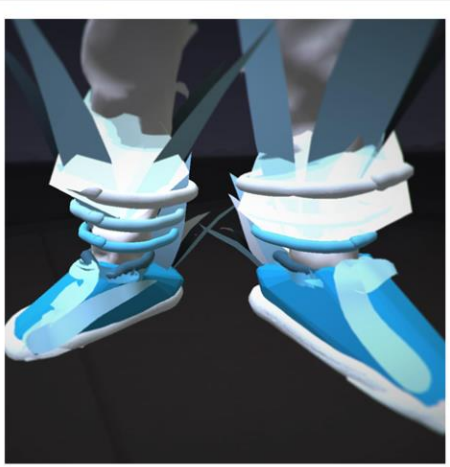
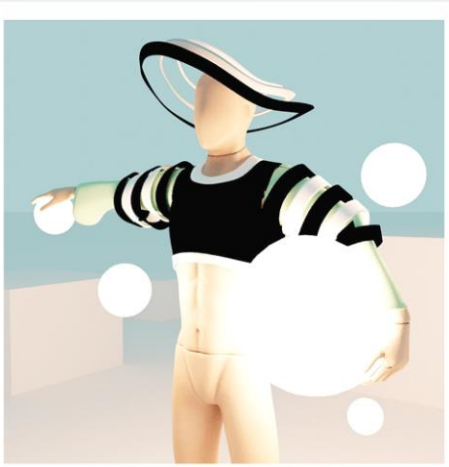
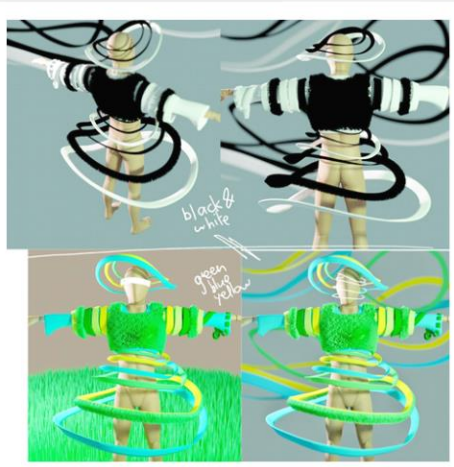
Step 1
Step 2
Step 3
Blender camera alignment / scaling
Step 4
Step 5
Align rigged human mesh with the 3D points and photos
Step 6
Import mesh into Marvelous Designer
Export to FBX and import into Blender
Step 7
Render
Step 8
Post processing in Procreate
How to digital/ fashion
(warning, bad workflow, will improve next time)

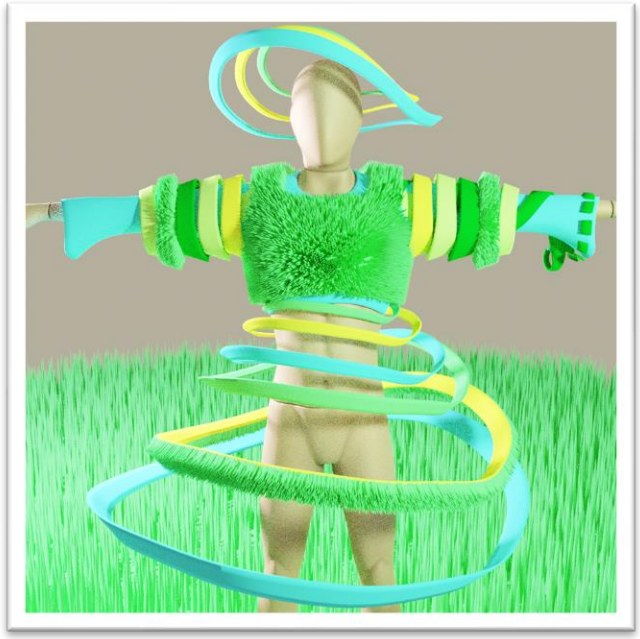
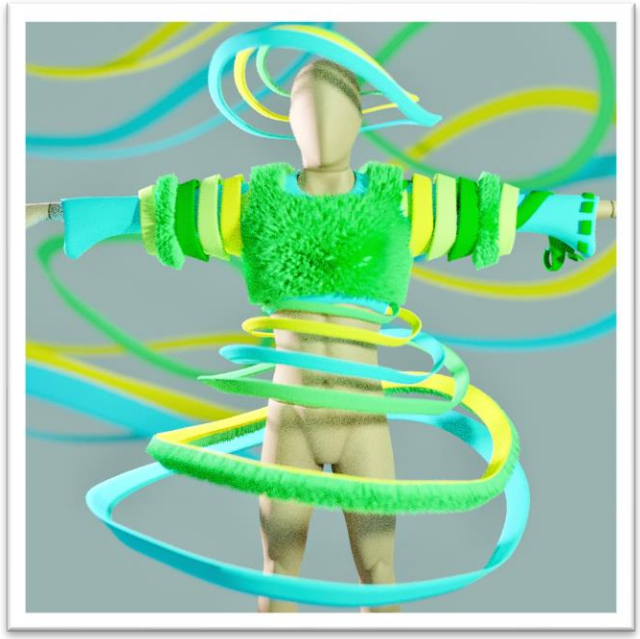
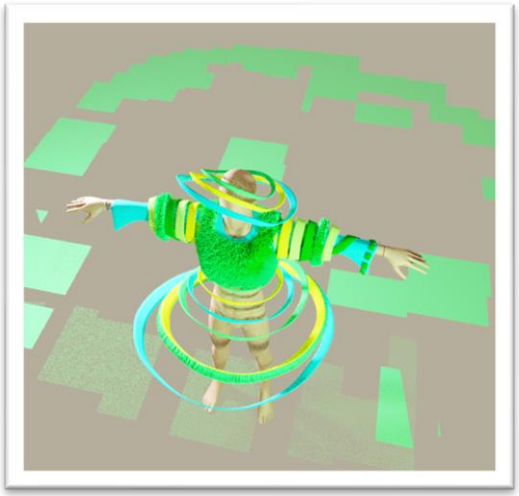


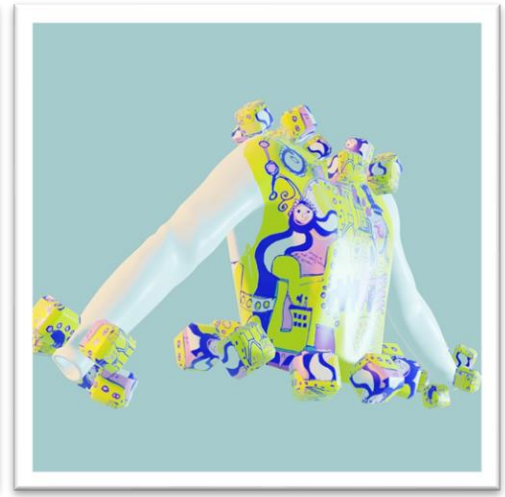

gravity sketch
gravity sketch
gravity sketch

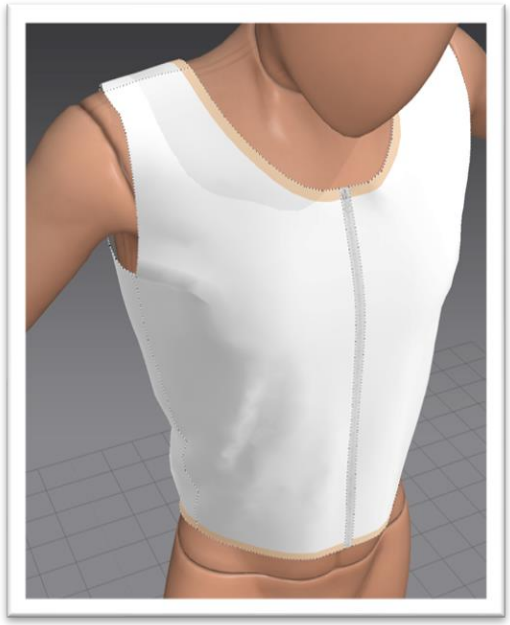
floating
USE
the ground
as a canvas


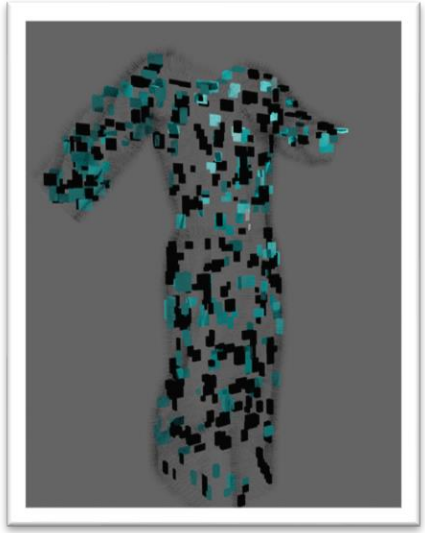


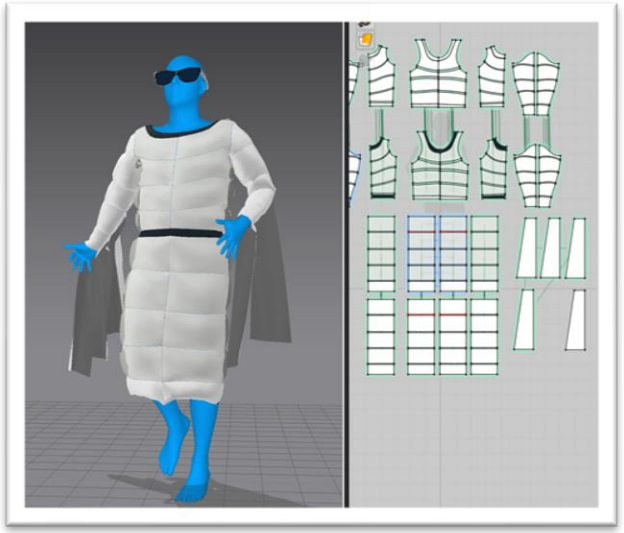

gravity sketch



black & white
green blue yellow

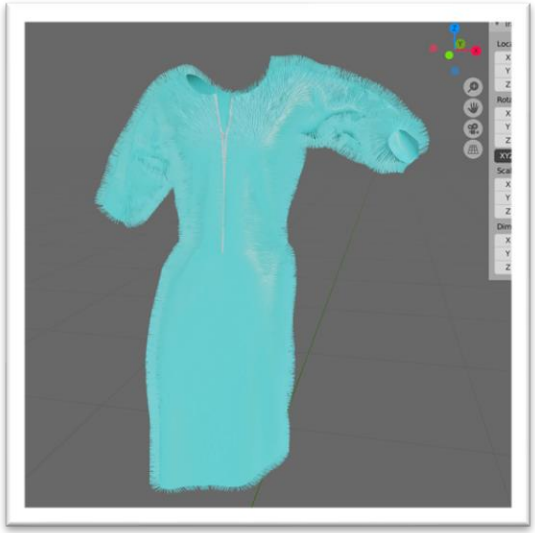
20·03
2021




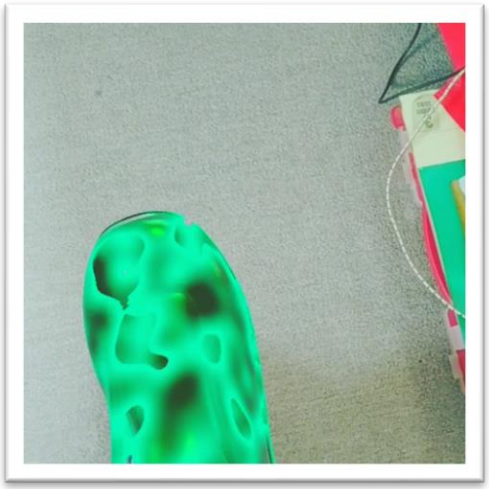


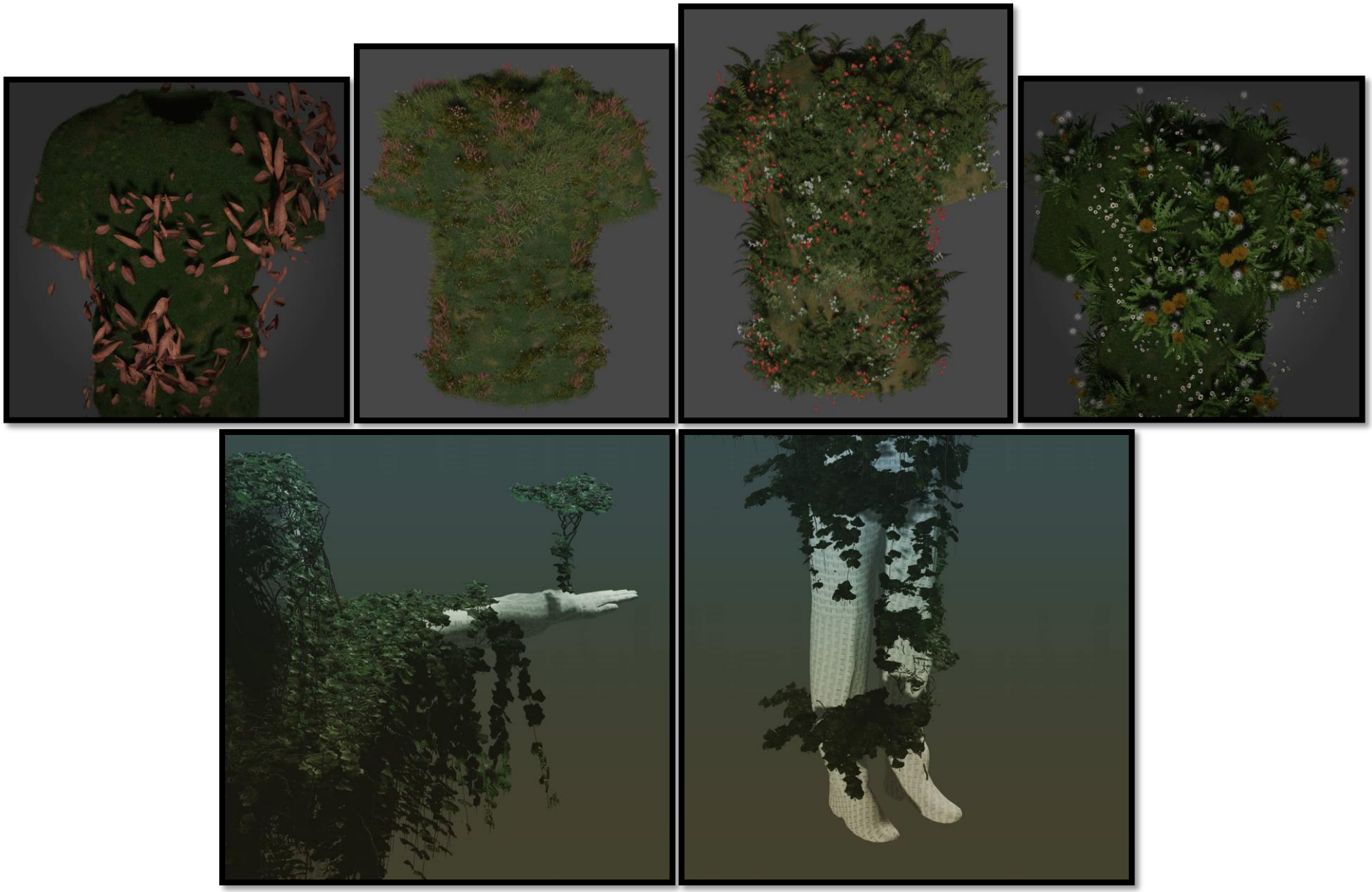


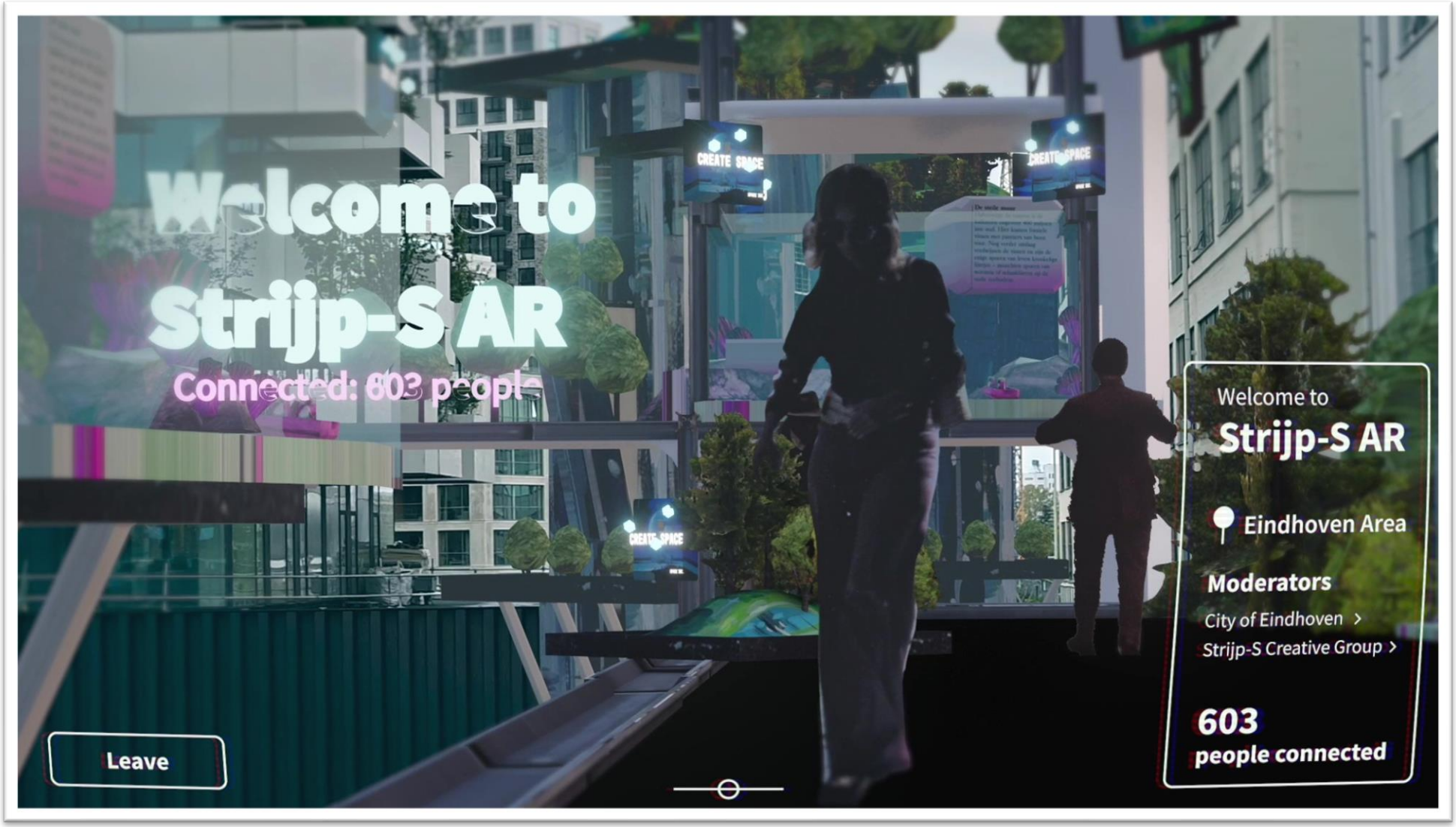




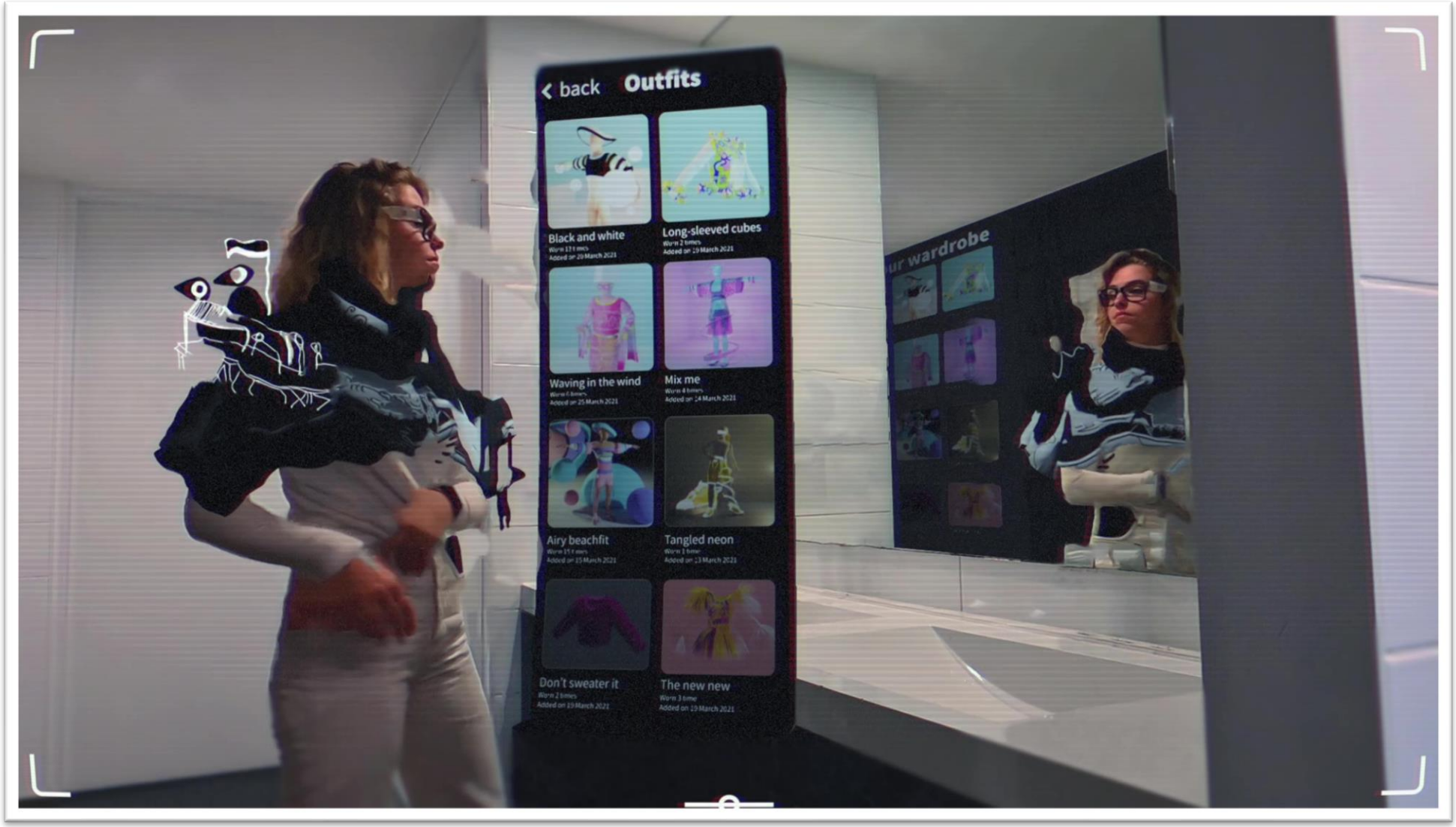







Welcome to
Strijp-S AR
Connected: 603 peopl
CREATE SPACE
CREATE SPACE
CREATE SPACE
Welcome to
Strijp-S AR
Eindhoven Area
Moderators
City of Eindhoven
Strijp-S Creative Group
603
people connected
Leave

Welcome to
Strijp-S AR
Eindhoven Area
Moderators
City of Eindhoven ›
Strijp-S Creative Group ›
603
people connected
Leave


back
Outfits
Black and white
Worn 171 times
Added on 20 March 2021
Long-sleeved cubes
Worn 2 times
Added on 19 March 2021
Waving in the wind
Worn 6 times
Added on 25 March 2021
Mix me
Worn 4 times
Added on 24 March 2021
Airy beachfit
Worn 15 times
Added on 15 March 2021
Tangled neon
Worn 1 time
Added on 13 March 2021
Don't sweater it
Worn 2 times
Added on 19 March 2021
The new new
Worn 3 time
Added on 19 March 2021
ur wardrobe

10.2 Consent Form

Informed Consent Form

Ubiquitous Augmented Fashion

Introduction

Dear Sir/Madam,

You are asked to take part in a scientific study. Participation is voluntary. Participation requires your written consent. Before you decide whether you want to participate in this study, you will be given an explanation about what the study involves. Please read this information carefully and ask one of the investigators for an explanation if you have any questions. You may also discuss it with your partner, friends or family.

1. General information & purpose of the study

This study has been designed by 4 students of Industrial Design, Tu/e. The Investigators:

- Simone Cooijmans - s.cooijmans@student.tue.nl
- Arjo Nagelhout - j.a.nagelhout@student.tue.nl
- Lara Potma - l.a.potma@student.tue.nl
- Thomas Wezel - t.s.wezel@student.tue.nl

The coach: Stephan Wensveen - s.a.g.wensveen@tue.nl

5 study subjects will be needed for this interview. Our goal is to explore, in an open ended way, how AR will influence digital fashion and the world around it.

2. What participation involves

During the study, the following will happen:

- data is collected about your knowledge and opinion about this subject.
- we will record the interview and meet for 10 to 15 minutes with you.

3. What is expected of you

In order to carry out the study properly it is important that you follow the study instructions. It is important that you contact one of the investigators:

- if you no longer want to participate in the study.

It is up to you to decide whether or not to participate in the study. Participation is voluntary.

If you do participate in the study, you can always change your mind and decide to stop, at any time during the study. You do not have to say why you are stopping, but you do need to tell the investigator immediately. The data collected until that time will still be used for the study.

4. Usage and storage of your data

Your personal data will be collected, used and stored for this study. This concerns data such as your name and opinions. The collection, use and storage of your data is required to answer the questions asked in this study and to publish the results. We ask your permission for the use of your data.

Confidentiality of your data To protect your privacy, your data will be given a code. Your name and other information that can directly identify you, will be omitted. Data can only be traced back to you with the encryption key. The encryption key remains safely stored in the local research institute. The data that is sent to the coach will only contain the code, not your name or other data with which you can be identified. The data cannot be traced back to you in reports and publications about the study.

Access to your data for verification Some people can access all your data at the research location. Including the data without a code. This is necessary to check whether the study is being conducted in a good and reliable manner. Persons who have access to your data for review are the students and coach. We ask you to consent to this access.

If you have questions about your rights, please contact the person responsible for the processing of your personal data. For this study, that is one of the investigators.

5. Any questions?

If you have any questions, please contact one of the investigators.

If you have any complaints about the study, you can discuss this with one of the investigators.

6. Signing the consent form

If you give permission, we will ask you to sign this consent form. By your written permission you indicate that you have understood the information and consent to participation in the study. The signature sheet is kept by the investigators.

Signature Participant _____ Date _____

Thank you for your attention.

10.3 Link to Instagram and Youtube

Instagram:

https://www.instagram.com/ubiquitous.augmented.fashion/

Video:

https://youtu.be/pTU5q-BCaiE

10.4 Miro board