HONEST MISTAKES

EXPLORING IMPERFECTIONS IN DIGITAL DESIGN

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INTERACTION DESIGN DIPLOMA

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Honest Mistakes:
Exploring Imperfections in Digital Design

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abstract

This diploma explores the aesthetics of imperfection within the realm of digital design.
By actively pursuing digital imperfections and flaws through open exploration, the goal has been to come up with novel expressions and see how they may be used to enhance an interaction design experience.
These explorations have carved a path through glitch art, 3D-printing, and 3D-scanning.
The result - inspired by current technological trends - is a speculative, future-oriented prototype dubbed The Memory Machine. It allows users to explore a virtual world populated by personal memories. The memories are built up of broken and bent 3D-scans which, instead of being disruptive elements, add value to the experience.

acknowledgements

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imperfection

n.

fault; flaw.[1]

misuse

n.

erroneous, improper, or unorthodox use.[2]

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part 1: introduction & background

This first chapter of the report is meant to give the user an overview of the diploma. What is it about? How is it relevant to us? What do I hope to achieve? How will I achieve it?
The chapter also describes how the report is structured. It proceeds to discuss relevant background research into the topics of *Imperfections in Analogue Media* and *Glitch Art*, before moving on to my practical explorations into digital imperfections.

introduction

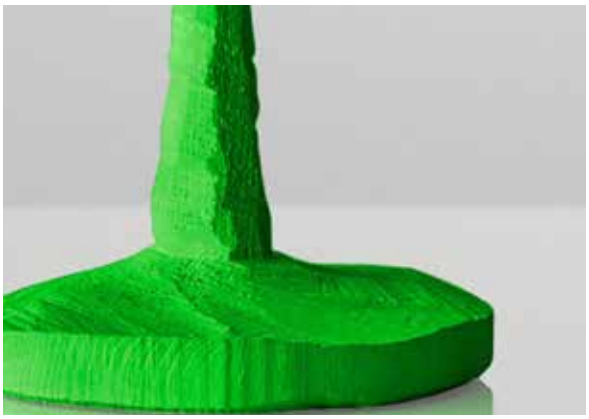
This thesis outlines and chronicles my research and exploration into the imperfections of digital media. I wanted to see if I could use my research of the imperfect to come up with novel expressions and experiences in the digital realm. In interaction design, we are taught to flee from the broken and imperfect, to always strive for cold perfection. As an experiment, I wanted to explore what would happen if I actively pursued and embraced digital flaws, and designed *for* them, rather than against them.

Relevance

Every year, Apple releases a new iPhone. And for every iteration of the admittedly fantastic product, it grows smoother. High-gloss surfaces and brushed aluminium have become calling cards for the luxurious smart phone. Simple geometric shapes reflect an almost modernistic aesthetic. The interface reflects the refined exterior. Extreme cleanliness. Extreme readability. Extreme functionality. ***Extremely sterile.***

In digital media and products, we have become slaves of perfection. We worship the smooth and the cold. Why is that? If one compares digital media to analogue media, it makes little sense. For centuries both artists and designers have been embracing the imperfections and randomness dormant in the medium of their choice. Whether it be Pollock splashing paint in a seemingly chaotic fashion[3], Lyonel Feininger misusing his camera by exposing the same frame twice[4], or Tejo Remy designing a chair that will look different for every production[5], it seems the analogue realm is a good arena for experimenting with the lo-fi, the handmade, and the arguably more honest. Meanwhile, digital media is going in the opposite direction. It's a constant pursuit of higher fidelity and faster processing. Yes, our phones are getting more and more functional, yet at the same time we are alienating ourselves from our digital products. We love dogs for their stupidity. That stupidity is nowhere to be found in the devices we spend every waking hour with. We have no emotional connection to them.

Additionally, there is a great injustice being committed to digital media, in the form of pseudo-analogue filters. Whether it be the Instagram-filters we apply to our digital photos, digitally applied vinyl crackle on audio files or digitally manifested super-8 effects on a music



ABOVE: *THE MUUTO RAW FURNITURE SERIES USES THE IMPERFECTIONS OF HAND-CARVED WOOD AS AN AESTHETIC EXPRESSION.*

***RIGHT**: EARLY MOVIE MAGIC FROM GEORGE MÉLIÈS' "A TRIP TO THE MOON"*
***BOTTOM**: EACH RAG CHAIR FROM DROOG DESIGN.IS UNIQUE.*



video, we seem reluctant to embrace the true nature of modern media. If honesty in materials is something we should strive for, we need to acknowledge the fact that film is dead[6], and instead embrace the true expressions of our time.

There are also examples of the misuse of the analogue mediums resulting in magical new experiences. Where would the special effects industry be today, hadn't it been for pioneers such as Georges Mélièr? He used his background as a working magician to misuse his camera in just the right ways, and his experimentation resulted in our first examples of cinematic special effects.[7]

Of course, if one turns to the art world it is quite easy to find artists who embrace digital flaws. Glitch artists have for decades been bending and destroying digital files for aesthetic, political and disruptive purposes.[8]

But as a designer, it is not my goal to use the imperfections of digital media to disrupt an experience, but rather to enrich it. To make the glitch an indisposable aspect of the user experience. This is not glitch art - this is glitch design.

Approach

The diploma can be seen as a practical material exploration in the digital realm, ending in a design proposal based on my findings.

Through the tools of the interaction designer, I've taken a hands-on approach to researching how to generate imperfections, and what they might be used for. My explorations take the shape of a series of self-contained experiments, where I explore various ways of bending digital media for aesthetic and sometimes functional purposes. Each experiment concludes with an evaluation of the results, where I analyse my findings and discuss how they might be used as inspiration for future concepts within the realm of interaction design.



These conclusions also act as natural bridges into new experiments. Of course, when doing exploratory work such as this, objectivity is absolute key. Therefore, also experiments that have failed or lead nowhere have been included, to give an honest image of the process.
After the exploratory phase, I switch to a more traditional user centered design approach, and systematically develop my final design proposal based on prototyping, testing and user input.

Aim

With this diploma, I hope to be able to use my explorations to design a brand new experience, where the imperfections of the digital realm could take centre stage, and enrich a design rather than disrupting it.
It is not my goal with this diploma to propose a new design methodology, but contribute to future design possibilities, and find ways of enhancing user experiences.
Hopefully the project may inspire other designers to cast aside some of their preconceptions about the concepts of beauty within the digital realm, and be more accepting of digital flaws which may arise within their own work.
Personally, I saw this diploma as an excellent opportunity to test and hone my own skills in conducting open-ended explorative design work. I wanted to push my own skills as a designer both technically and conceptually, ending up with something I would be proud to put in my portfolio. Something that communicated who I am as a designer.

My Role as a Designer

Of course, any given design outcome will drastically vary based on the designer behind it. It was important for me that my diploma reflected my own identity as a designer, as well as pertaining to the brief. I am a hands-on, practical designer. Prototyping, testing and evaluating is my preferred process of iterating on a given design. I prefer the conceptual, meaning that the idea behind a design is more important to me than its realisation. I focus on engaging users with emotional and visceral experiences, presenting them with new, inspiring ideas.

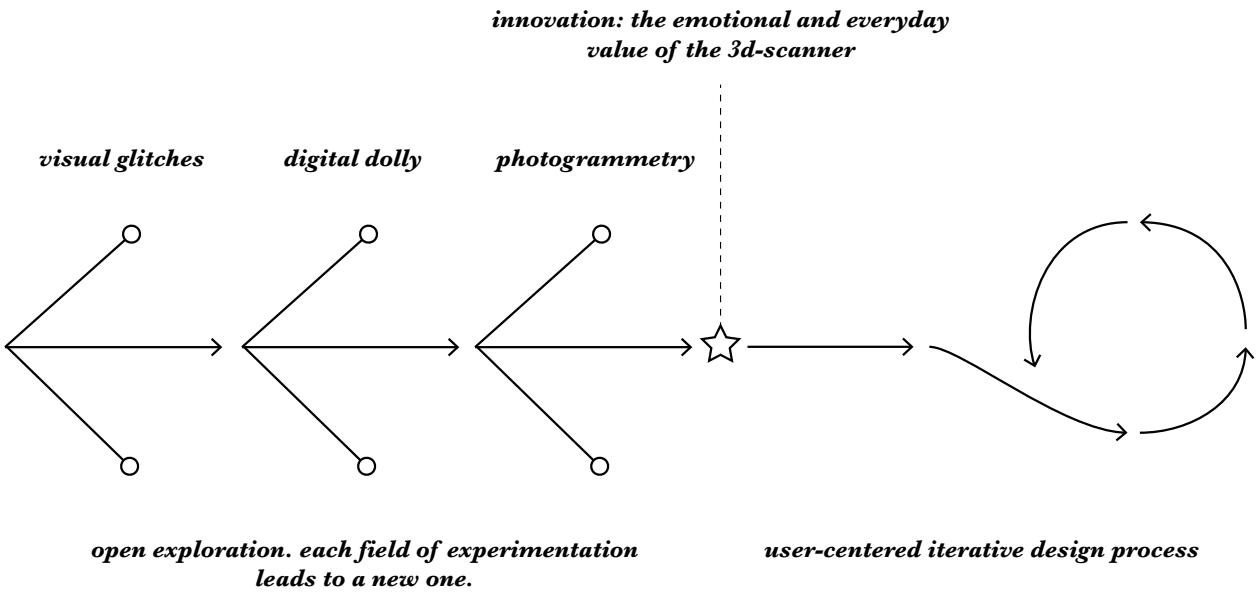
Structure

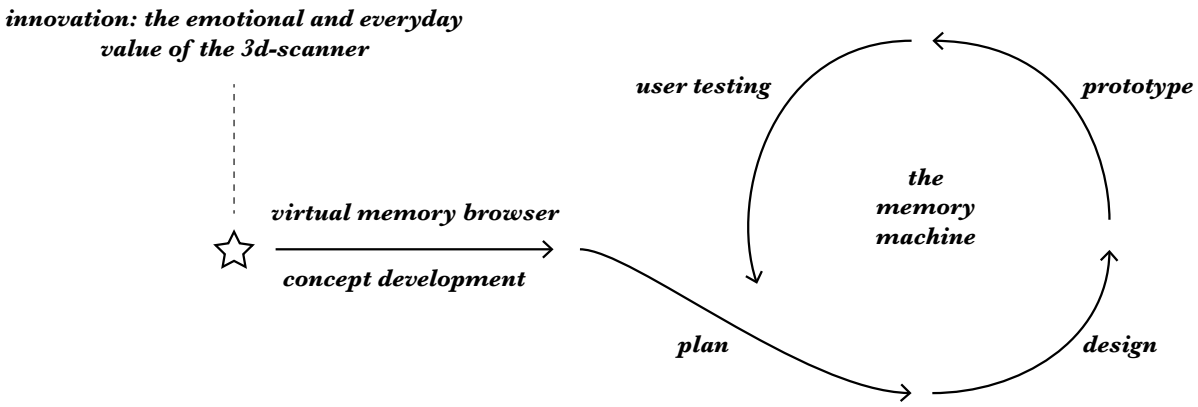
This report is divided into four parts. The first one - the one you are currently reading - is meant to give the reader an introduction to the report, as well as presenting relevant background research.
The second part chronicles the practical open explorations into the realm of digital imperfections. How they are generated, what they feel like, what they might be used for.
In the third part, the most interesting findings of part two will be used to develop a design proposal, where the imperfections of the digital are used to enhance an experience, rather than disrupt it.
The fourth part of the report discusses the impact of my findings. What sort of conclusions we are left with, and what the outlook for the future might be. The report concludes with an evaluation of my own process throughout the diploma.
At the very back of the booklet you will find reference lists for images and sources. In a few cases where similar references were not available elsewhere, Wikipedia has been cited.
Depending on how this report has been presented to you, you may or may not have received a number of digital video clips. Please refrain from viewing these until you are prompted in the report. Look out for the video resource boxes detailing what film is relevant for that given part of the report. They are outlined in red and easy to spot. When you see these, you are free to view the video in question. If you have not received video clips along with this report, the video resource boxes will also contain a Vimeo link to where the video may be accessed online. This is what they look like:



process overview

My creative process can be broken down into two parts. An open, exploratory part, followed by a more traditional, iterative design process.
In the open exploration, I have tried to keep an open mind as to where my explorations would lead. It has been a metaphorical tumble down the rabbit hole, so to speak. Each field of exploration has naturally bridged into the next, ending at an expression and innovation that I was pleased with. The project then turns to a more traditional, user-centered approach, focusing on iterating by prototyping and testing with real users.


innovation: the emotional and everyday value of the 3d-scanner
visual glitches
digital dolly
photogrammetry
open exploration. each field of experimentation leads to a new one.
user-centered iterative design process


innovation: the emotional and everyday value of the 3d-scanner
virtual memory browser
concept development
user testing
prototype
the memory machine
plan
design

imperfections in analogue media

The realm of analogue media is ripe with material explorations and experimentation. Sometimes these experimentations lead nowhere. Other times they effectively reinvent the medium, changing people's perception of what constitutes "misuse", resulting in brand new visual expressions, and in some cases - experiences. In fact, there are so many cases of misuse of analogue media leading to brilliant new ideas that one could not possibly hope to cover them all in one thesis. Instead, I will present a select few and describe how they pertain to my diploma.



Painting

What is imperfection when it comes to painting? To answer that, perhaps it would help to define what perfection in painting means. Is it aiming for photo-realism? If so, it would be futile to try to name all the movements and techniques which could be defined as "imperfect". Impressionists, cubists and minimalists (To list but a few) would all be deemed practitioners of an imperfect style. Maybe we need to lower the standards of what "perfection" means. Is perfection using a paintbrush to apply the paint? Still, we are left with a whole plethora of artists seemingly misusing the medium.

Imperfection is so widely accepted in the art of painting that it has become the norm. From Jackson Pollock's seemingly random paint splashes[3] to the technique of intentionally aging images - also known as craquelure[9] - painting is perhaps the most accepting medium for bold, new techniques that may have been seen as a misuse of the medium before brave pioneers broke the norm.

***LEFT**: JACKSON POLLOCK SPLASHING PAINT IN HIS STUDIO*
***RIGHT**: AN EXAMPLE OF A SPROCKET HOLE EXPOSURE, COMPLETE WITH TYPICAL TOY CAMERA ARTEFACTS SUCH AS LIGHT LEAKS.*

Photography

So-called Toy Cameras have since the early nineties been praised for their lo-fi aesthetic. Cheap plastic components result in shots full of optical abberations, vignetting and light leaks. Notable Toy Cameras include the *Diana*, the *Holga* and the *LOMO LC-A*.[10] The latter one spawned an entire photography movement - Lomography.[11] Lomographers actively seek out the imperfections inherent in plastic film cameras. Blurriness, double exposures and warped perspective are all wanted outcomes. There seems to be quite a universal appeal to these imperfections, to such a degree that people go to great lengths to recreate them digitally. In fact, many of Instagram's built in filters are based on Toy Camera film.[12] Now, one might argue that the appeal of Instagram filters are based on a nostalgic yearning for the analogue, but I would argue that it might instead be a yearning for the imperfect.

The Toy Camera aesthetic - when used in analogue media - has a certain honesty to it because it is an aesthetic which is inextricably linked to the medium itself. Consider sprocket hole exposures - 35mm photographs where the entire width of the film has been exposed, making the sprocket holes an important part of the composition. What could be more honest than a photo including the very material and texture of the film itself? Analogously, what could be more honest than digital media revealing the very algorithms it is based on?

I would also like to comment on the abstraction inherent in Lomographs. With photos often coming out of development looking blurry and full of light leaks, details are inevitably lost. Irrelevant details fade into obscurity. This leaves us to only ponder the mood of the composition. Its colour, shape and overall tone. In a way, it can be seen as impressionist photography, where the mood is key, not the details. We will return to this key aspect in the discussion of my final design concept.

Of course, there are more examples of the misuse of a camera leading to novel new expressions and experiences, such as double exposures or burning holes in the film roll for a dramatic look, but instead, let us move into a medium closely tied to photography - cinematography.

Cinematography

At the very end of the 1800's, the Lumière brothers invented the cinematograph[13], and thus became the fathers of the moving picture. An early adopter of the new invention was Georges Méliès[7], who had made his living as a magician. He saw enormous potential in the cinematograph, and set out to create movies. One day, filming an inconspicious street scene, his camera jammed. After quickly unjamming the camera, he began recording again. When later developing the



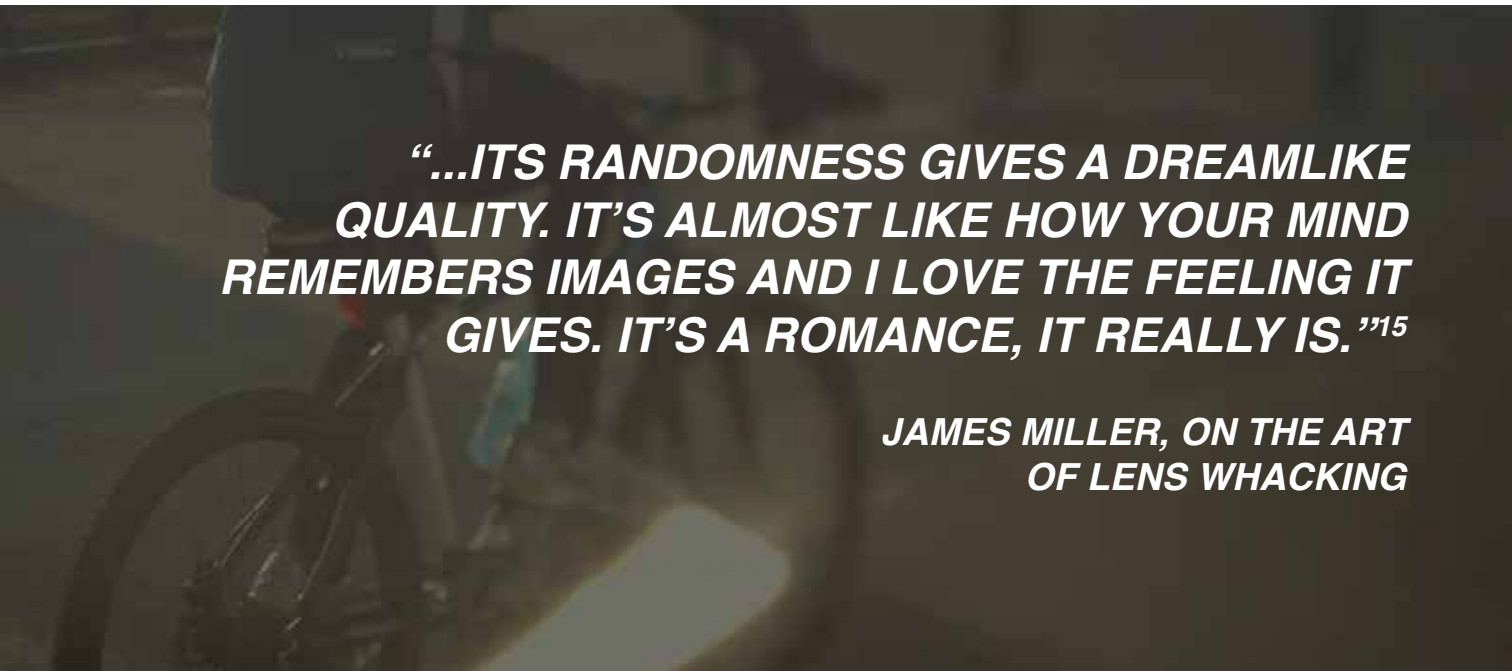
film, he saw a bus magically transform into a hearse. Men had turned into women. Out of pure accident, he had discovered the stop-edit, which could make objects magically appear and disappear in the frame. Thus he was dubbed the "Father of Special Effects"[14] and went on to create over 500 movies, packed with various special effects, in just under a decade. By way of an unintentional misuse of his camera, he had paved the way for a century of constant innovations within cinematic special effects.

Even today, cinematographers continue to employ unorthodox camera techniques for unique effects. One such method is called *Lens Whacking*[15] - and is meant to simulate light leaks - glare in the frame caused by light leaking through the camera body and hitting the sensor in unexpected ways. Lens Whacking constitutes detaching the camera lens from the camera body, and - holding the camera in one hand - tilting the lens in various ways, causing light to leak onto the sensor. It is unlikely that that was the intention of Canon when they released their new expensive DSLR, or their even more expensive lenses. Shooting with the lens detached must surely be deemed as a misuse of the camera, or at least to its inventors.

Relevance

Although my medium of choice could be said to be the opposite of those I have just discussed, they serve as a great inspiration for my work in the digital realm. My intention is to view the digital as "just another medium", and so studying the experiments of past pioneers helps me assume an "anything goes"-attitude for the exploratory phase of my work.

***BELOW**: FRAME FROM JAMES MILLER'S SHORT FILM "ROMANCE OF THE LIGHT"*
***RIGHT**: FROM GEORGES MÉLIÈS' FILM "THE MAN WITH THE RUBBER HEAD"*



"...ITS RANDOMNESS GIVES A DREAMLIKE QUALITY. IT'S ALMOST LIKE HOW YOUR MIND REMEMBERS IMAGES AND I LOVE THE FEELING IT GIVES. IT'S A ROMANCE, IT REALLY IS."[15]

JAMES MILLER, ON THE ART OF LENS WHACKING



glitch art

The Birth of The Glitch

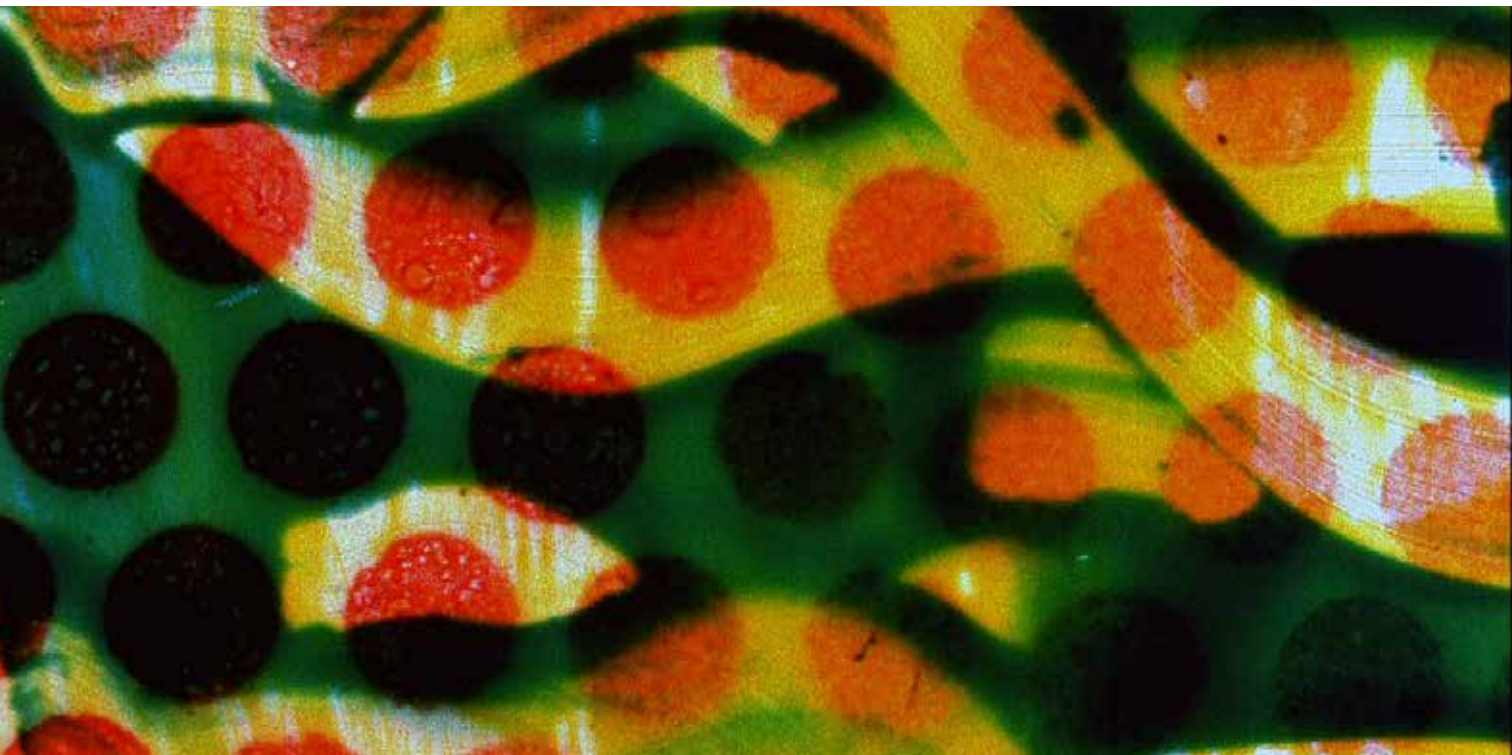
Intentionally provoking glitches in the digital realm is nothing new - glitch artists have for decades been aestheticising both analogue and digital imperfections.[8] Glitch art is Dada. Glitch art is ambiguous. Glitch art is a broken GIF. Glitch art is an evil circuit-bent furby. Glitch art is anti-establishment. Glitch art is gentrified. Glitch art is dead. But where did it start, and what relevance does it have for my diploma?

The term *glitch*, which most likely originates from the Yiddish word for slippage - glitsh - was first popularized by NASA scientists. The American astronaut John Glenn gave a brief explanation in 1962:

"Another term we adopted to describe some of our problems was 'glitch'. Literally, a glitch is a spike or change in voltage in an electrical current."[16]

It's hard to say exactly when glitch art started, although some academics have traced it back to 1937, with Len Lye's short film *A Colour Box*, where the artist painted directly onto a roll of film. Others trace it back even further.

It's easy to draw parallels to early experimental film and photography. In structuralist film and photography, the medium, rather than the content, is



***RIGHT**: "THE ART CRITIC" BY DADAIST RAOUL HAUSMANN IS POKING FUN AT THE ELITIST ESTABLISHMENT, IN THIS CASE AN ART CRITIC.*
***OPPOSITE PAGE, BOTTOM**: A FRAME FROM LEN LYE'S SHORT FILM "A COLOUR BOX"*



key. Structuralist filmmakers such as Hollis Frampton sought to draw attention to the film itself, *"The frame, the projection, and most importantly, time"*[17]. In the same way, Glitch Artists seek to draw attention to the algorithms that run our daily lives. Whether you are reading this as a PDF or on paper, it is very unlikely that you are considering the internal workings of the codecs required to compile these documents, or this body of text, or the shape of its letters. It is not until something s tart s tob reak doww n, that you are forced to become aware of it. When we are presented with a broken jpeg we are suddenly aware of the fact that we are looking at a broken jpeg, rather than its practical use, which is its contents. The german philosopher Martin Heidegger illustrated this concept with a malfunctioning hammer. From William Blattner's book *Heidegger's 'Being and Time': A Reader's Guide*:

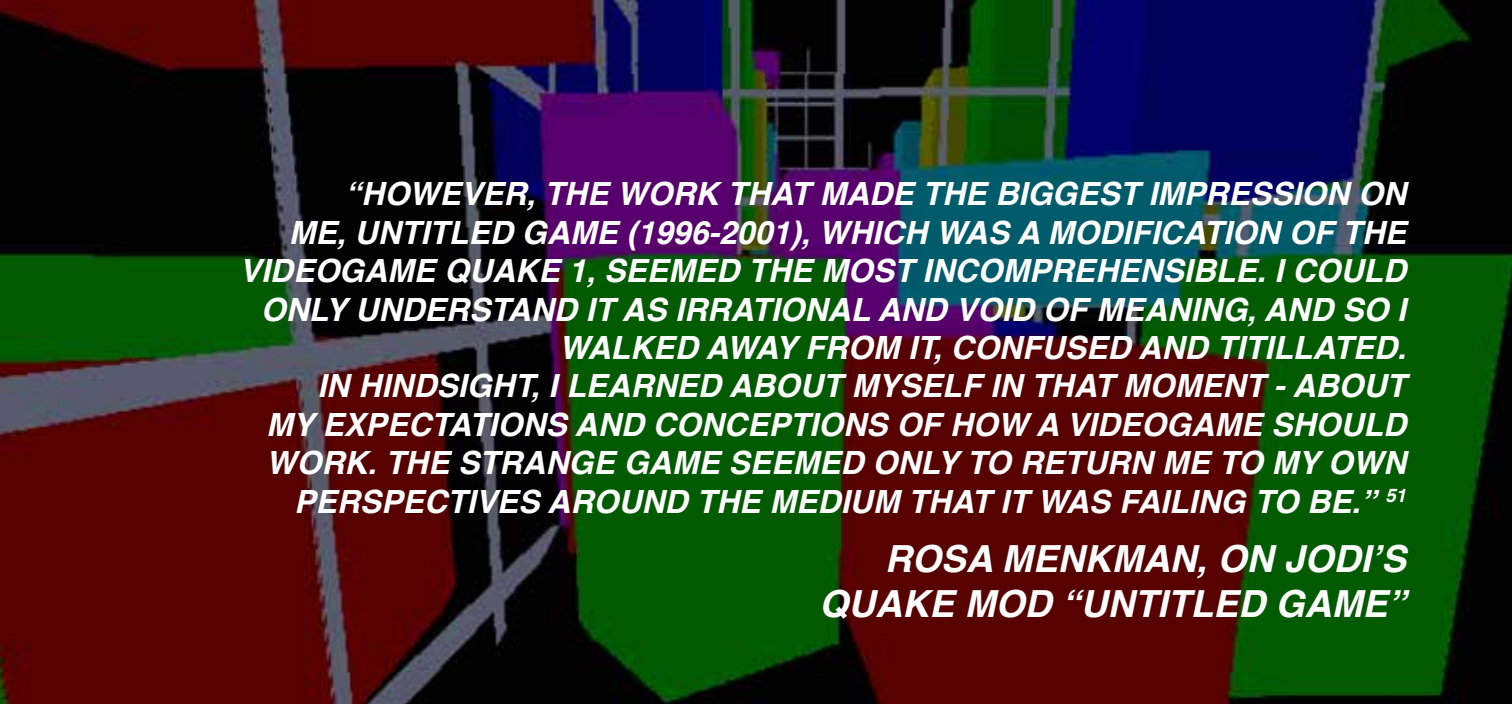
"The practically irrelevant physical properties of the hammer are more salient when the hammer is broken than when it is functioning. It takes me a moment of reflection and searching my mind to remember the color of my hammer (it is brown), because my hammer is in working order and I pay no attention to its color. . . . When my hammer breaks, however, and I just dumbly stare at it, its color becomes more salient to me. Its practically irrelevant physical characteristics become accessible."[18]

So Glitch Art can be seen as a comment on the medium itself, rather than its contents.

In his paper *Glitch Art Historie[s]*, New Media artist Nick Briz traces Glitch Art back to several historical art movements. He compares it to the playful absurdity of Dadaism, and ponders if Glitch Art can be seen as a response to the supposed paradigm shift the digital revolution has led to, and if its role is to question the stability of such a shift. Similarly, the Dadaist movement questioned the stability of the paradigm shift the industrialism of WWI brought about.
He goes further, and compares the very nature of creating Glitch Art to the way Dadaist Art *"could take the form of a complex collage or a simple found object (readymade)"*.

Ugly Commercial Sons of Bitches

These five words comprised the entirety of glitch art collective Jodi's acceptance speech during the 1999 Webby Awards. They were attacking the very event that was awarding them. This incident is a good illustration of the reactionary, anti-establishment aspect of glitch art, particularly prominent in the nineties and early naughts, but still alive and kicking. An anarchic, destabilizing force bent on questioning the supposed stability of the information era. To show how easily our modern world could come apart at the seams.
There is an undeniable sense of "maliciousness" in this activist form of glitch art. Take Jodi's website, jodi.org for instance. It's like opening Pandora's box. There's no telling what may come out. The URL gets a wwwwwwwww.-prefix. Seemingly meaningless code



"HOWEVER, THE WORK THAT MADE THE BIGGEST IMPRESSION ON ME, UNTITLED GAME (1996-2001), WHICH WAS A MODIFICATION OF THE VIDEOGAME QUAKE 1, SEEMED THE MOST INCOMPREHENSIBLE. I COULD ONLY UNDERSTAND IT AS IRRATIONAL AND VOID OF MEANING, AND SO I WALKED AWAY FROM IT, CONFUSED AND TITILLATED. IN HINDSIGHT, I LEARNED ABOUT MYSELF IN THAT MOMENT - ABOUT MY EXPECTATIONS AND CONCEPTIONS OF HOW A VIDEOGAME SHOULD WORK. THE STRANGE GAME SEEMED ONLY TO RETURN ME TO MY OWN PERSPECTIVES AROUND THE MEDIUM THAT IT WAS FAILING TO BE." [51]

ROSA MENKMAN, ON JODI'S QUAKE MOD "UNTITLED GAME"

pops up in arbitrary places. Someone's private photos show up. A hundred pop-ups flood your screen. Like Heidegger's hammer, we are forced to focus on the tool - the internet itself - rather than its use.

The internet itself is in fact integral to the phenomenon of glitch art. It is both the medium and the platform. In many cases it may even be said to be the subject. Everyone has the tools necessary at their disposal both for producing and publishing guerilla glitch art.

Other glitch artists see the art form not so much as anarchic activism, but as a communication with the programmers behind the algorithms we are so used to dealing with in our daily lives. Nick Briz states,

"For example, when u interact w/ur computer there's a long list of assumptions made on ur behalf by the programmers of the operating system u use && the software u use, we're generally unaware of this but it becomes xtreamly obvious when ur glitching stuff. technology isn't neutral, it's pregnant w/the politics && ideologies of the folks who made them (often times straight white dudes from california) + when we use these technologies we [un]conciously subscribe to these politics, glitch art can be a way to bring that hidden relationship to the fore." [8]

Gentrification and Commercialisation

Today, the typical goal of most glitch-oriented experimentation is the animated GIF, which has seen a digital renaissance these past few years. When asked about the internet's new-found love of the GIF, designer Pamela Reed replied,

"Aesthetically, the GIF worked for us because it was a glitchy 8-bit reminder of the excitement we had when we first began using the Web as children" [8]

Is the fascination for glitch art being reduced to cheap nostalgic sentiment? The guerilla activists are giving way to the masses. Everyone is doing glitch art.

For proof, take a quick look at social blogging site Tumblr, or search Flickr or Pinterest for "glitch art". The web is overflowing. There are Facebook groups dedicated to what was once a niche shared by a few hacker-activists. There are not one, but *two* subreddits devoted to posting and discussing glitch art. With thousands of pieces of glitch art being produced daily, it's hard to imagine all of it having the same thought put into it as the works of early glitch artists such as Jodi and Nam June Paik.

The flood of glitch art may be due to the fact that - compared to many other visual art forms - it's easy to achieve results. Everyone has the tools necessary to perform the most common methods of glitches such as databending and datamoshing. Furthermore, the

paradoxical side of glitch art is that it's often more effective the more broken it is. Wrong is right, in a sense. Anyone can move a piece of text around to break a jpeg. Anyone can be a glitch artist.

With the masses embracing glitch art, it was only a matter of time before it was commercialised. This is not necessarily a bad thing. Something being commercialised only means it needs to be tailored to fulfill some sort of need or want in consumers. Rather than being glitch art for art's sake, it is glitch design. And knowing the chaotic nature of working with glitches, I respect the craftsmanship these talented people have exhibited.

In 2009, Nabil Elderkin directed the music video for Kanye West's hit "Welcome to Heartbreak".[19] The video features heavy use of a glitch art technique known as *datamoshing*, and lifts the video up from being another run-of-the-mill hip-hop music video into being something truly unique. Shapes seem to appear from inside one another, and colours are mixed together in mesmerising ways.

One design field that has been particularly embracing of digital flaws is the field of fashion and textiles. *Glitch Textiles* is a design label which specialises in producing blankets, scarves and carpets with digitally glitched-out motifs.[20] It's easy to see the relevance of glitches for this field. Looking at their designs, it immediately becomes apparent that a large part of visual glitches "naturally" look like textile patterns. Individual stitches reflect the individual pixels of the digital image. There is an exciting contrast between the cold and digital and the warm, analogue and fluffy.

Relevance and Reflection

So what relevance does glitch art have to my own diploma? To me, the greatest value of studying glitch art is that it gives me all the tools I need to get started with seeing how we can bend digital media. My first few experiments are based on some of the most popular glitch art methods, such as databending and datamoshing. So the methods employed are much the same, just like the methods used by a fine arts painter and an illustrator are much the same. However, while the illustrator indeed uses the same tools as the fine arts painter, their intentions are different. While the fine arts painter seeks to ask questions, the illustrator answers them. In the same way, while I am using the same tools as the glitch artist, my intention is not to use the glitch as a disruptive element. My intention is to work *with* the glitch, seeing how the glitch can be used as an indispensable part of a design.

BOTTOM: *FRAME FROM THE KANYE WEST MUSIC VIDEO "WELCOME TO HEARTBREAK"*
OPPOSITE PAGE, TOP: *SCREENSHOT FROM JODI'S QUAKE MOD "UNTITLED GAME"*



part 2: exploring imperfections

In this part of the report, I chronicle my practical explorations into the imperfections of the digital world. How and why are they generated? How do they feel? What may they be used for?
This part contains three fields of experimentation with accompanying sub-experiments. At the conclusion of each field, I will discuss the most interesting aspects of my findings, which will serve as a bridge into the next experimentation field.
The first field, Visual Glitches, has been heavily cropped. There were simply too many results to be able to include them all while still keeping the report concise and to the point. The third field leads into my final design proposal, which is based on discoveries made during my practical explorations.

VISUAL GLITCHES

I began my practical explorations by employing some of the techniques used by glitch artists to bend audio, video and images. I also invented a technique of my own. Glitch art seemed like a good place to start as it would give me a feel for generating imperfections in the digital medium. What will typically break a file? What can be replicated? How can this be used in design?
NOTE: Although the Visual Glitches were vital to my further explorations, they are not integral to understanding my final concept development.

databending

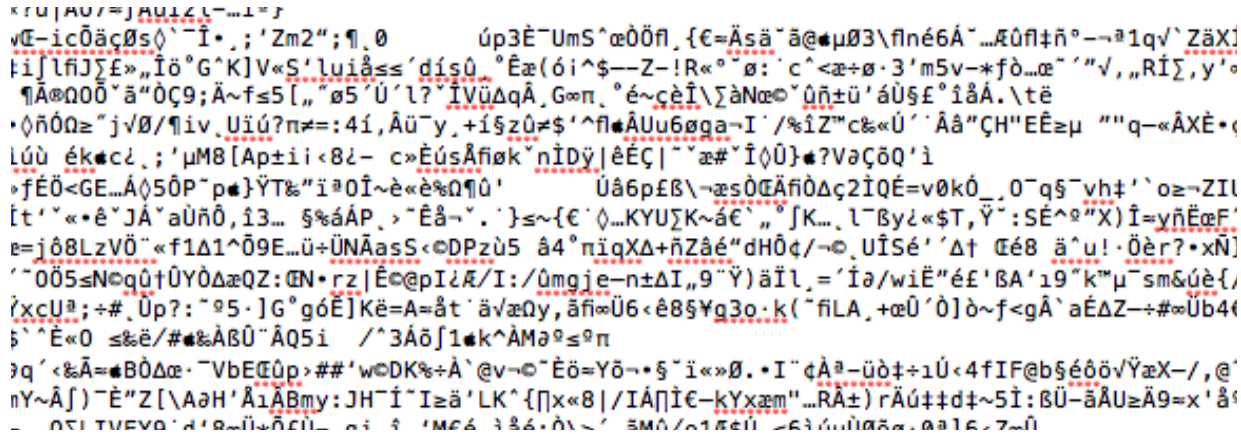
Databending is one of the most accessible ways of bending digital files, and is therefore a glitch art long-time-favourite.

Databending works from the premise that all digital media, whether it be audio, video or image files, is comprised of raw data. When that data is manipulated in unintended ways - for instance by editing a photo as a text file - quite severe glitches may occur. It's an incredibly unstable method and it's very easy to break the file and make it unreadable, so backups are essential for safe data bending. Different file formats (Even within the same category of filetype) will also produce vastly different results, as the experimentation will prove.

When doing any sort of databending, one should be careful not to disturb the metadata of the file. This is typically located towards the beginning or the end of the file, and making changes here will corrupt the file in question, making it unreadable.

Databending with a Text Editor

The experimentation begins with the simplest form of Databending - manipulating a file by opening it in a text editor. By moving, removing, copying or adding text and then saving the file, the file will be manipulated.

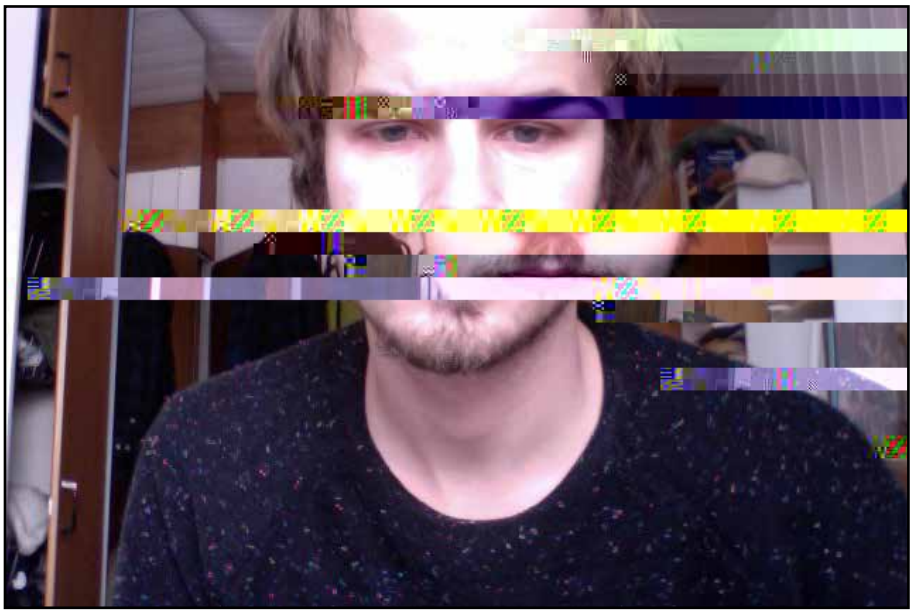


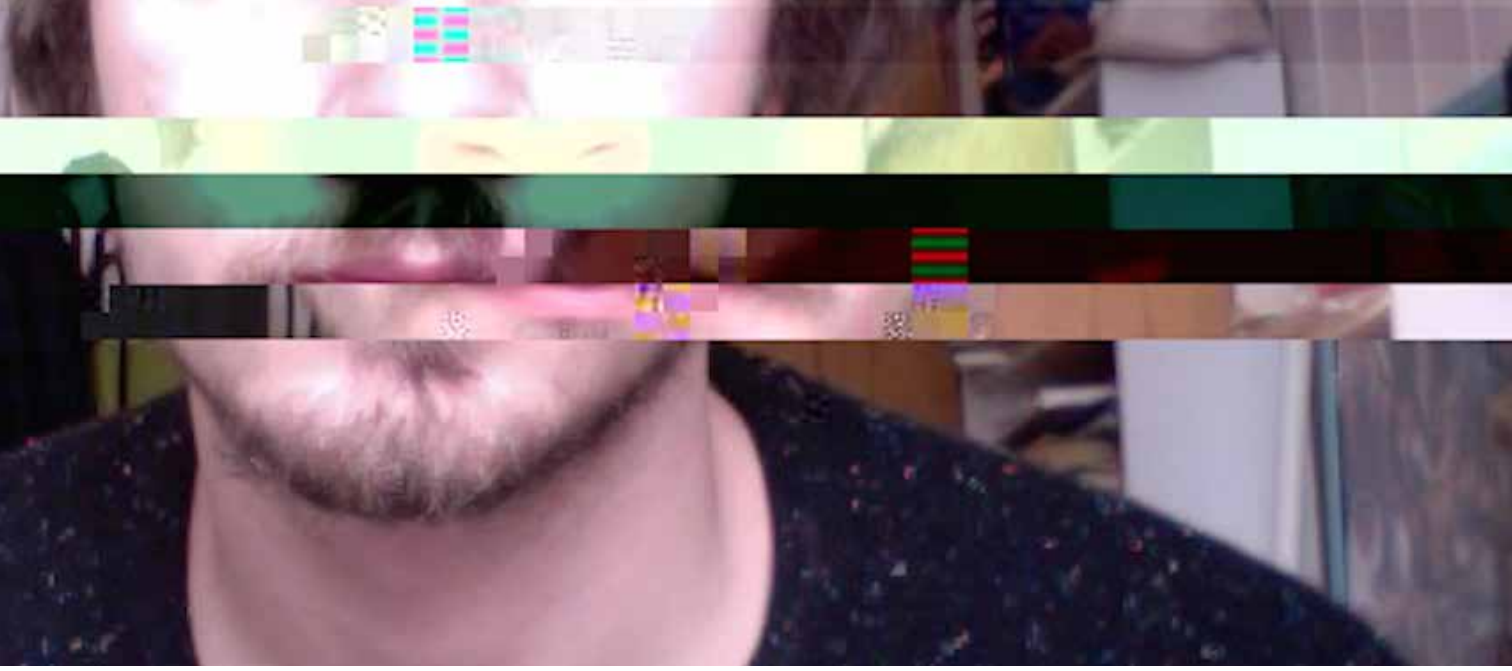
ABOVE: *THE RAW DATA OF A JPEG IN TEXT FORM. BY MANIPULATING THIS DATA AND SAVING THE FILE, THE VISUAL REPRESENTATION OF THE FILE WILL BEGIN TO CHANGE.*



TO MAINTAIN CONSISTENCY, THE SAME IMAGE WAS USED FOR ALL THE IMAGE EXPERIMENTATION. THE IMAGE IS A LOW-RESOLUTION WEBCAM IMAGE. THE ASSUMPTION IS THAT THE LOW RESOLUTION GIVES US LESS INFORMATION TO MANIPULATE, THUS MAKING IT EASIER TO GET CONSISTENT RESULTS.

A TYPICAL RESULT OF EDITING THE RAW DATA OF A JPEG IN TEXT FORMAT. HORIZONTAL STREAKS OF DIGITAL ARTEFACTS GIVE AN UNMISTAKABLY GLITCH-ARTY FEELING TO THE IMAGE. NOTICE THE LITTLE PATTERNED "ICONS" APPEARING IN THE ARTEFACTS.



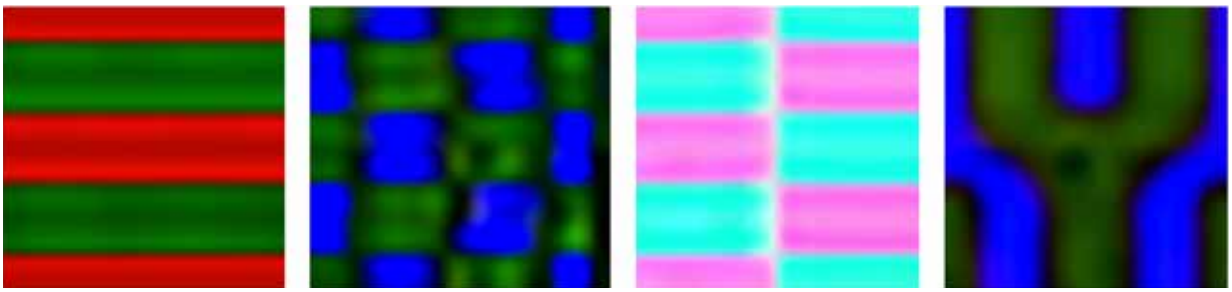


Jpeg Observations

An interesting point to note with regards to the jpeg images are the little pattern tiles that seem to arise out of nowhere.

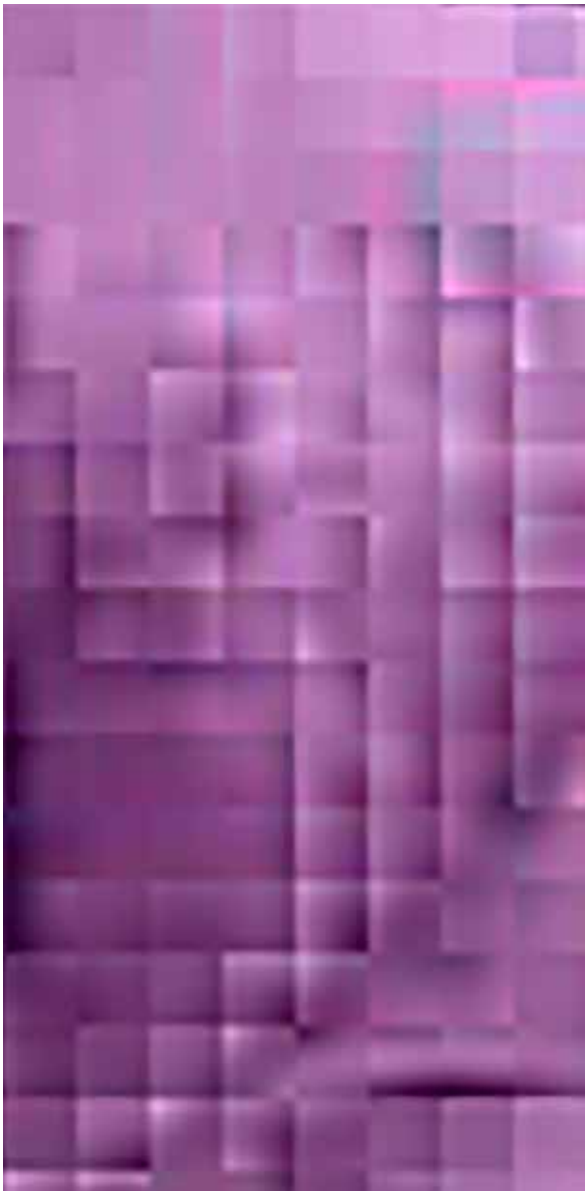
One of the major challenges with trying to dissect file formats is the lack of transparency into their inner workings. Jpeg compression works by compressing 16x16 or 8x8 blocks of pixels, also known as MCUs (Minimum Coded Unit)[21] , which might explain why each of these tiles was exactly 16x16 pixels. It is my assumption that these are a few of the shapes by which Jpeg compression analyses pixel configurations, a bit like how a facial recognition algorithm overlays pre-programmed patterns onto an image to determine whether or not it is indeed a face. The misuse of the raw data may have caused these patterns that weren't meant for human eyes in the first place to emerge from their hiding place.

Aesthetically speaking, they look horrendous. The color schemes don't feel right, and the patterns themselves are plain and dull. The extreme use of Photoshop's image resize algorithm doesn't help the matter, either. But we should nonetheless forgive them for their aesthetic shortcomings. They are still traces of the inner workings of the world's most widely used image format, brought out into the visible spectrum by misusing and abusing the raw data.





A somewhat more aesthetically pleasing result of the jpeg databending can be found in the extreme pixellation of the jpeg that was rotated in Photoshop before being abused. These blocks are each 8x8 pixels, which is another standard MCU size, and it's fascinating to see how the jpeg compression gives them all a separate gradient, giving them a three-dimensional look, as if they were made of cobblestone. The blocks, despite all being part of the same neck, also have a very vibrant color scheme. The hues range from red to purple to bright pink to turquoise. Of course, by resizing, cropping and isolating such a small part of an image, I realise it's quite easy to aestheticise many things. The original photo, after being bent, was not exactly a thing of beauty.



***OPPOSITE PAGE, TOP**: JPEG WITH DISTINCTLY DIGITAL ARTEFACTS*
***OPPOSITE PAGE, BOTTOM**: FOUR JPEG PATTERN TILES, ENLARGED AND ISOLATED*
***THIS PAGE, TOP**: A JPEG WHICH WAS FIRST ROTATED 90 DEGREES IN PHOTOSHOP, AND THEN DATABENT.*
***RIGHT**: PART OF THE ROTATED JPEG, ENLARGED AND ISOLATED.*




IMAGINE THE SHISH KA-BOB YOU COULD GET WITH THESE!
HIGH SCORE
PLAYER
SKI A DIE
BURTON
RODNEY

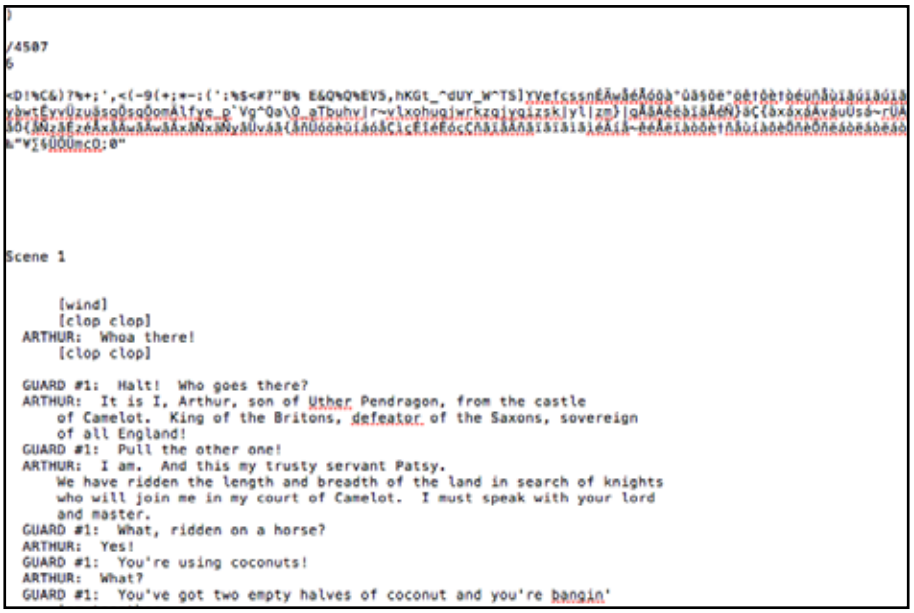
PNG Observations

After bending a few PNG images, the first thing that became apparent was that although it takes more to break the file, it's an incredibly unstable format. The slightest change in the data will completely corrupt the image from the point the change was made. If the change is made at the very start of the image data (After the metadata), the whole picture will be covered in white noise, with specks of colour thrown in inbetween. The PNG seems to be a very inflexible format, in that every change one does seem to yield the same visual result. As with the other formats, data bending a PNG will produce horizontal artefacts, here seen as streaks of bright colour. The glitching - as well as producing the horizontal streaks - seems to cause the colours to invert themselves, as well as give each of the colour channels only four levels of fidelity, which becomes evident when viewing one channel after the other in Photoshop.

The aesthetic qualities of the glitched image, with its extreme pixellation and bright colours, are reminiscent of early 1990's DOS games, such and Ski or Die[22]. When checking a screenshot from the game, it turns out that the fidelity of each colour channel is the same as in the glitched PNG.

Thus the visual expression of the corrupted PNG file may indeed hold sentimental value for people who grew up in the eighties and nineties, but isn't successful in being more than a nostalgic keepsake. The 8-bit aesthetic that the image is representative of has been explored time and time again, and doesn't bring much new to the table visually speaking.

OPPOSITE PAGE, TOP:
DATABENT PNG,
OPPOSITE PAGE, BOTTOM:
SCREENSHOT FROM THE 1990 DOS GAME "SKI OR DIE"



/4507
6

Scene 1

[wind]
[clop clop]
ARTHUR: Whoa there!
[clop clop]

GUARD #1: Halt! Who goes there?
ARTHUR: It is I, Arthur, son of Uther Pendragon, from the castle
of Camelot. King of the Britons, defeator of the Saxons, sovereign
of all England!
GUARD #1: Pull the other one!
ARTHUR: I am. And this my trusty servant Patsy.
We have ridden the length and breadth of the land in search of knights
who will join me in my court of Camelot. I must speak with your lord
and master.
GUARD #1: What, ridden on a horse?
ARTHUR: Yes!
GUARD #1: You're using coconuts!
ARTHUR: What?
GUARD #1: You've got two empty halves of coconut and you're bangin'

THE BMP FORMAT IS INCREDIBLY STABLE. NOT EVEN INSERTING THE ENTIRE SCRIPT OF "MONTY PYTHON AND THE HOLY GRAIL" WOULD BREAK IT.

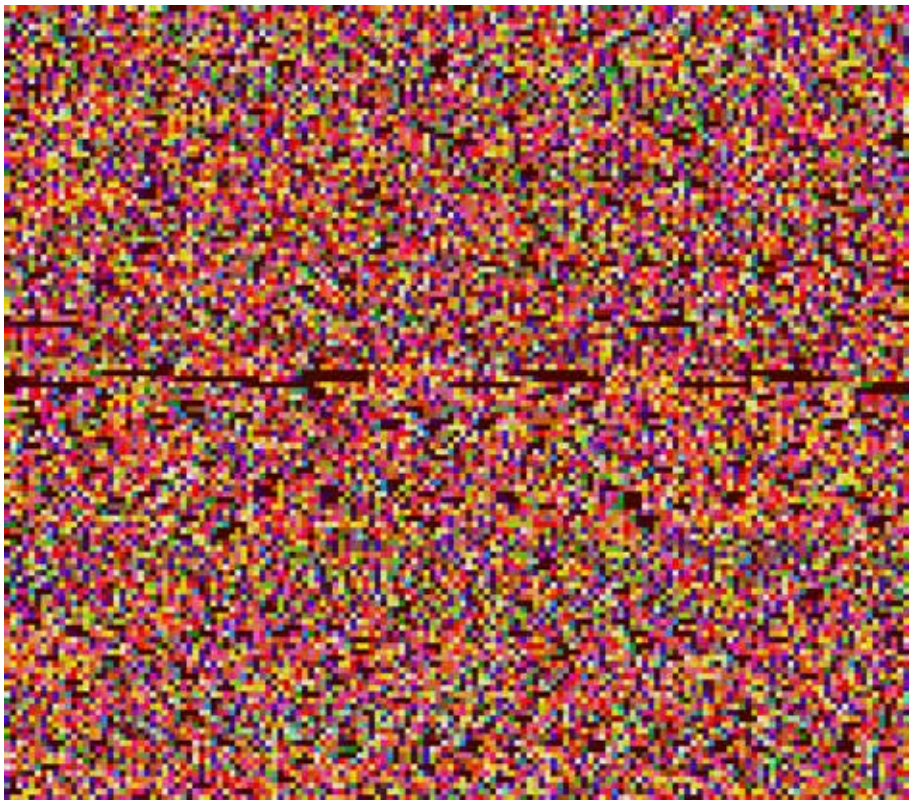


THE VISUAL EFFECT OF INSERTING THE SCRIPT INTO THE RAW DATA. ASCII CHARACTERS ARE CONVERTED INTO COLOURED PIXELS.

BMP Observations

To someone who is just starting out with databending, it is easy to recommend the BMP format. It's incredibly forgiving and hard to permanently break. As long as one doesn't delete data from the file without replacing it with something else, very few things will make the format unreadable. Also, it's very easy to see the visual consequences of inserting extra lines of text into the file, as is evident when inserting the Monty Python screenplay into the raw data. I wanted to isolate the artefacts generated by the script by cropping the image, but was faced with two issues: The first being the fact that since the image is in a landscape format, the artefacts themselves had an even more horizontal character, encompassing only a thin strip of the canvas.

The second issue was that the colours generated by the inserted text were dull and dreadful. Fortunately, the BMP format offers several different encoding options, which will all yield different results. By switching to 16-bit encoding instead of the Photoshop-standard 24-bit encoding, the colours were made significantly more vibrant. The glitch was also made to an image that was originally in a portrait orientation, which allows us to end up with a more square result.



***RIGHT**: THE SCRIPT OF "MONTY PYTHON AND THE HOLY GRAIL" AS A 16-BIT BMP*

The technique was repeated with the script of *2001: A Space Oddyssey*, to see if the results would look much different. It would be interesting to see if this was a viable technique to convert any block of text into an image with a unique character. Unfortunately the two images came out looking quite alike.

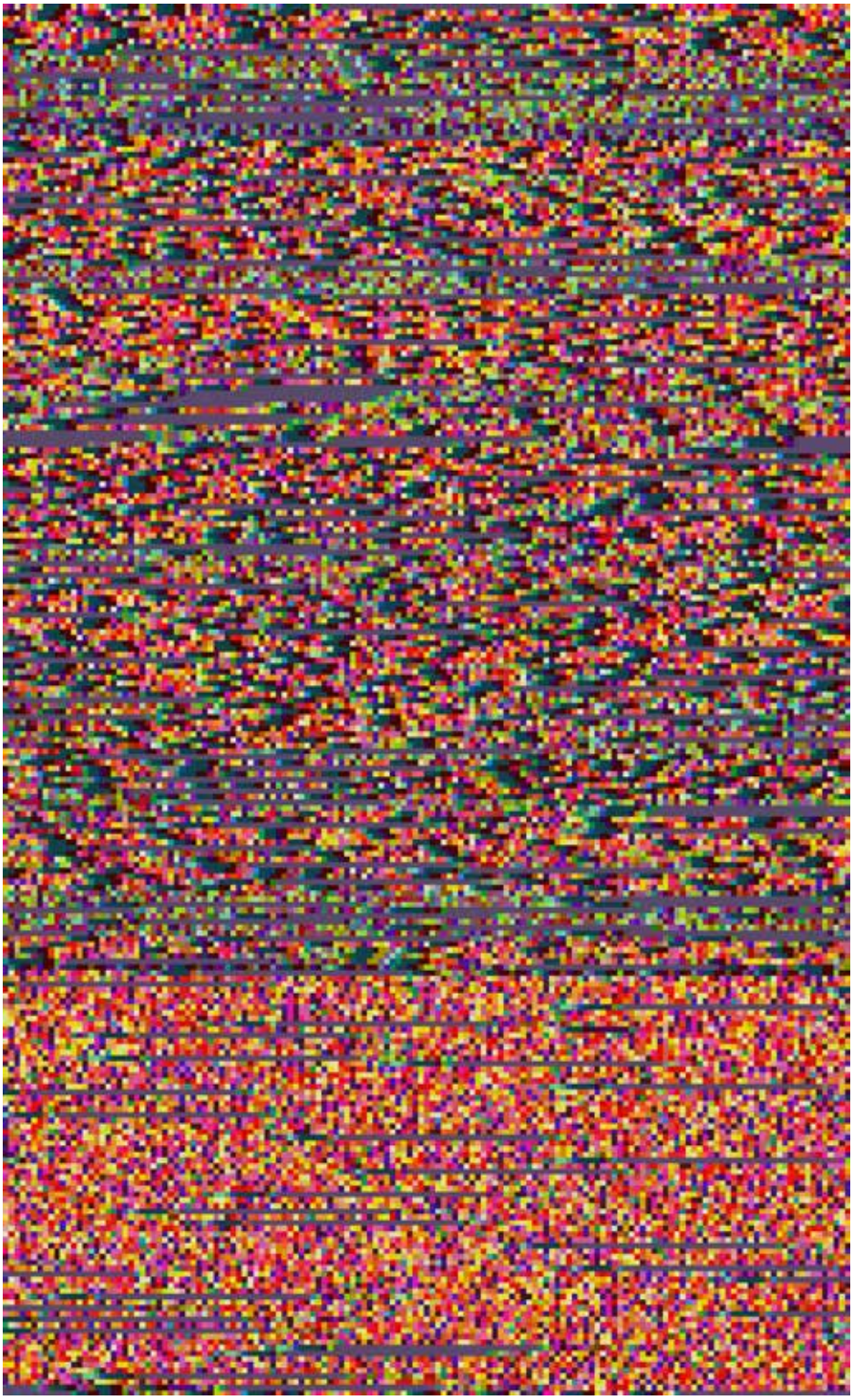
The major difference was that the Space Oddyssey image was larger than the other, due to it's significantly longer script. There are a few minor colour variations in the top three quarters of the larger image, but all in all they look quite similar and I am only able to tell one from the other because I made them. Furthermore, I suspect the minor differences between the two are more due to the formatting of each script rather than their actual content. However, it is inspiring to see how one could give a text file a visual expression. That leads me to believe that by using the technique of databending, one can transfer data between all formats. The possibilites aren't only text as image, but also video as image, text as video, audio as image and so on.

When looking at the scripts as images, especially the latter one, one may notice that it somewhat resembles a textile, such as a rug or scarf or other woven material. There is quite an interesting contrast between the glitchy, modern aesthetics of databent imagery and the traditional craftsmanship of weaving. The cold and digital meeting being outputted into the warm, fuzzy and physical.

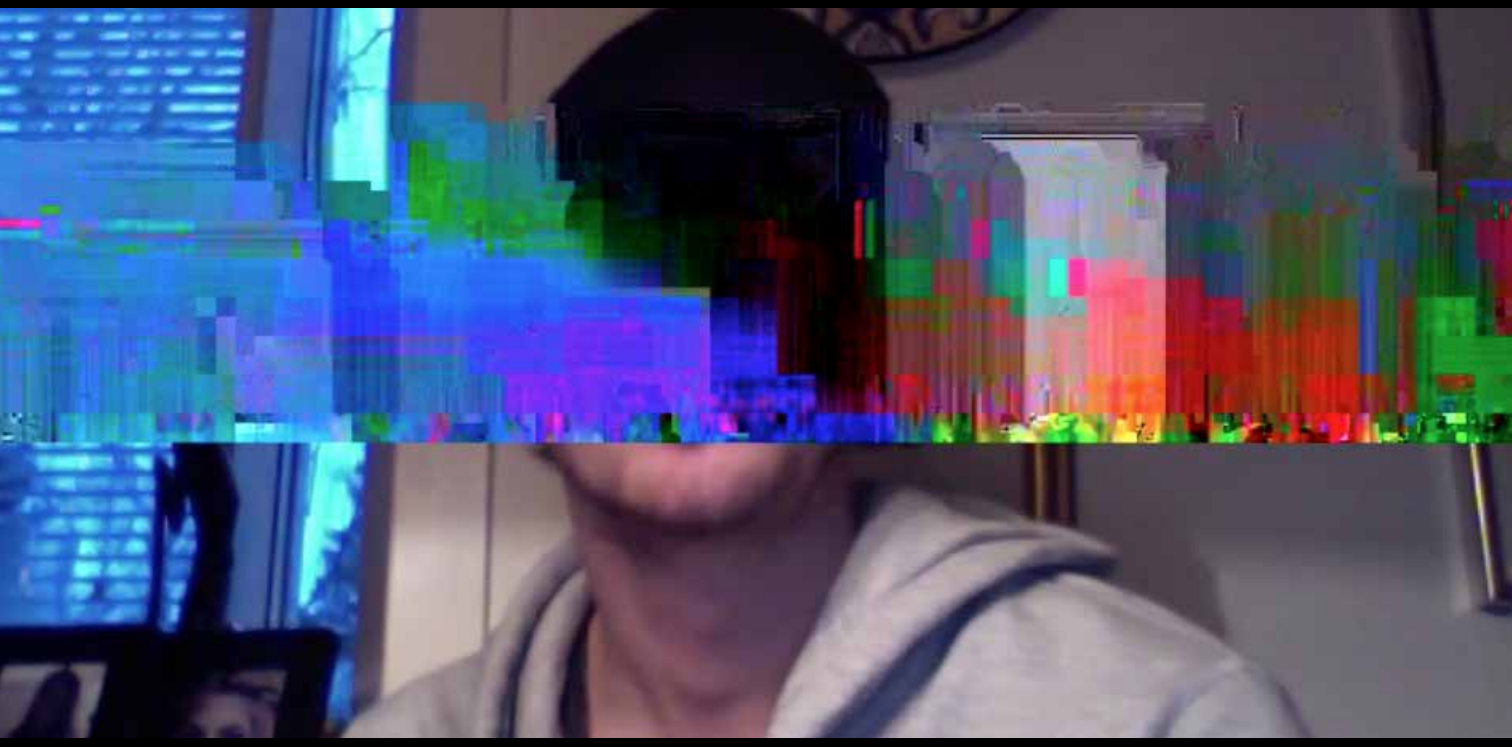
However, I am not the first to arrive at this conclusion. There are entire textile brands already devoted to turning glitch art into fabrics.[20]



***ABOVE**: A WOVEN RUG.*
***OPPOSITE PAGE**: THE SCRIPT OF "2001: A SPACE ODDYSSEY" AS A 16-BIT BMP*







Video Observations

Databending videos by editing them in text format is quite a painful and inefficient task. It's very rare to see an interesting glitch, and when one does, it is next to impossible to determine how to recreate it in this raw data that was never designed to be human-readable. Of the three formats tested, the results from the MOV files were the most interesting to behold as a video. As with much glitch art, there is something unmistakably "creepy" about the databent MOV files. In this particular case, it is likely due to the fact that we are databending a human face. In some of the results, the original face will freeze and a new face will emerge from it, almost as if it is coming from the inside. Also in this particular example, a yawn might be mistaken for a scream, making it all the more terrifying.

The MP4, when bent, will freeze for the remainder of it's duration at the point where the glitch is introduced. Therefore, it is more fulfilling to view the glitches produced in the MP4 as images than it is to see them in video format.

As still images, the colourful glitches of the MP4 sometimes have a very painterly feel to them. The gradients present are reminiscent of colourful paints pulled out with a palette knife, as if it was a glitch-induced abstract painting.





***OPPOSITE PAGE, TOP**: DATABENDING A MOV VIDEO CAN PRODUCE TERRIFYING RESULTS.*
***OPPOSITE PAGE, BOTTOM**: DATABENDING AN MP4 VIDEO RESULTS IN COLOURFUL GLITCHES*
***THIS PAGE, TOP**: A DECORATIVE ABSTRACT PAINTING*
***THIS PAGE, BOTTOM**: A DATABENT MP4 VIDEO, CROPPED*

Databending with an Audio Editor

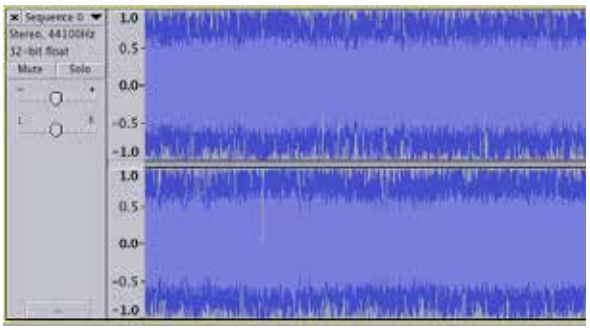
In the same way we can open and edit raw data as a text file, we can do the same with audio. The free audio editing software Audacity is ideal for importing the raw data of different file formats for manipulation. Databending with audio only works with uncompressed formats such as .avi and .bmp. One of the key strengths of databending with audio as opposed to text editors is that it's easy to maintain consistency and replicate results. The same preprogrammed audio filter over the same file format will always yield the same result. As with databending using text editors, it's important to leave the metadata in the beginning of the file intact.

Probably the most interesting aspect of databending using audio was that the finished visual result would often resemble what one would imagine a visual representation of the effect to look like.

The Sound of Glitch

As was the case with most audio that was somehow corrupted during my explorations into glitch art techniques, the sound of the raw data is very unpleasant. Like an incredibly violent, choppy white noise. Listening to the raw data of a file makes one appreciate just how much work goes into making computers sound pleasant. With every glitched noise sounding worse and worse, I decided not to focus on audio in my diploma.

Furthermore, the field of sound and music combined with glitches is a thoroughly explored and accepted field, so I was doubtful that I would be able to make any breakthroughs.



ABOVE: *THE RAW DATA OF A FILE IN AUDIO FORM.*
BELOW*: A 24-BIT BMP WITH AN ECHO FILTER APPLIED. NOTICE HOW THE REPEATING PATTERNS REFLECT THE NATURE OF THE ECHO EFFECT.*

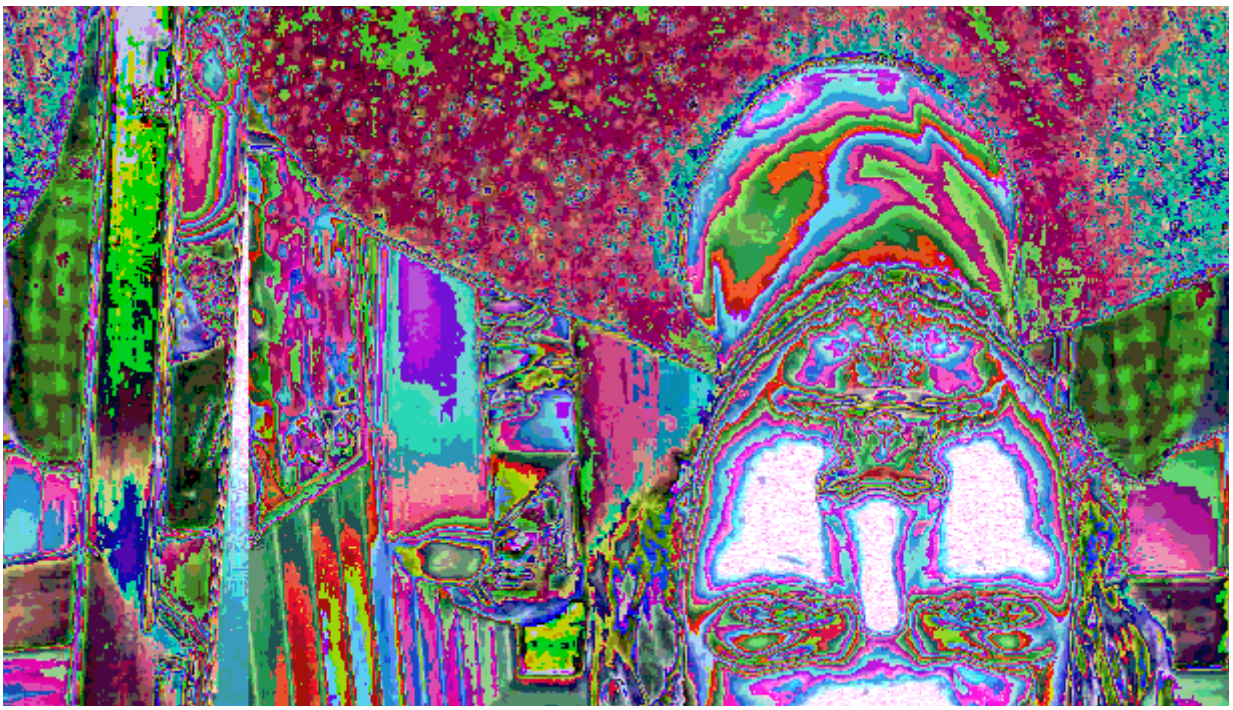




***ABOVE**: APPLYING A REVERSE FILTER TO A 24-BIT BMP WILL FITTINGLY FLIP THE IMAGE UPSIDE-DOWN*

***BELOW**: A 24-BIT BMP WITH A WAH-WAH FILTER APPLIED*

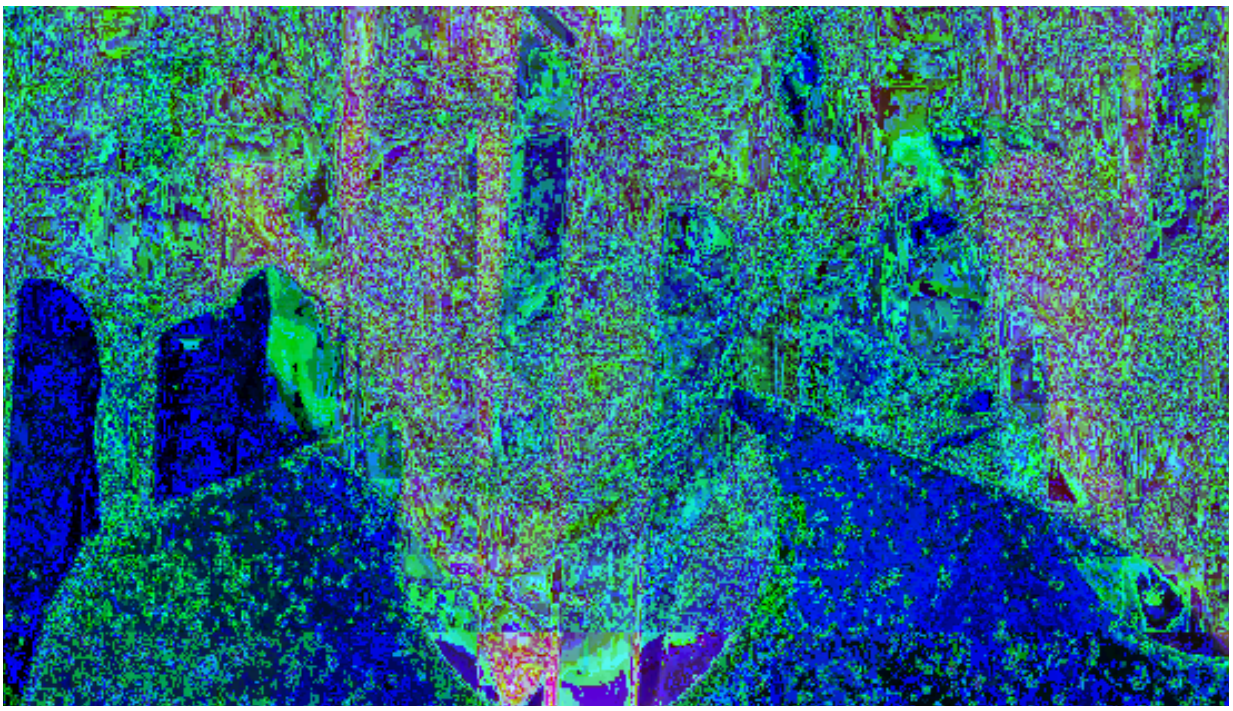




***ABOVE**: 16-BIT BMP WITH A REVERSE FILTER*

***BELOW**: 16-BIT BMP WITH AN INVERT FILTER. THE FILTER IS INAUDIBLE TO HUMAN EARS BUT STILL HAS A DRAMATIC EFFECT ON THE VISUAL OUTCOME.*





***ABOVE**: 16-BIT BMP WITH AN ECHO FILTER.*

***BELOW**: 16-BIT BMP WITH A TREMOLO FILTER. THE CHOPPY NATURE OF THE RESULT REFLECTS THE CHARACTERISTICS OF THE FILTER.*



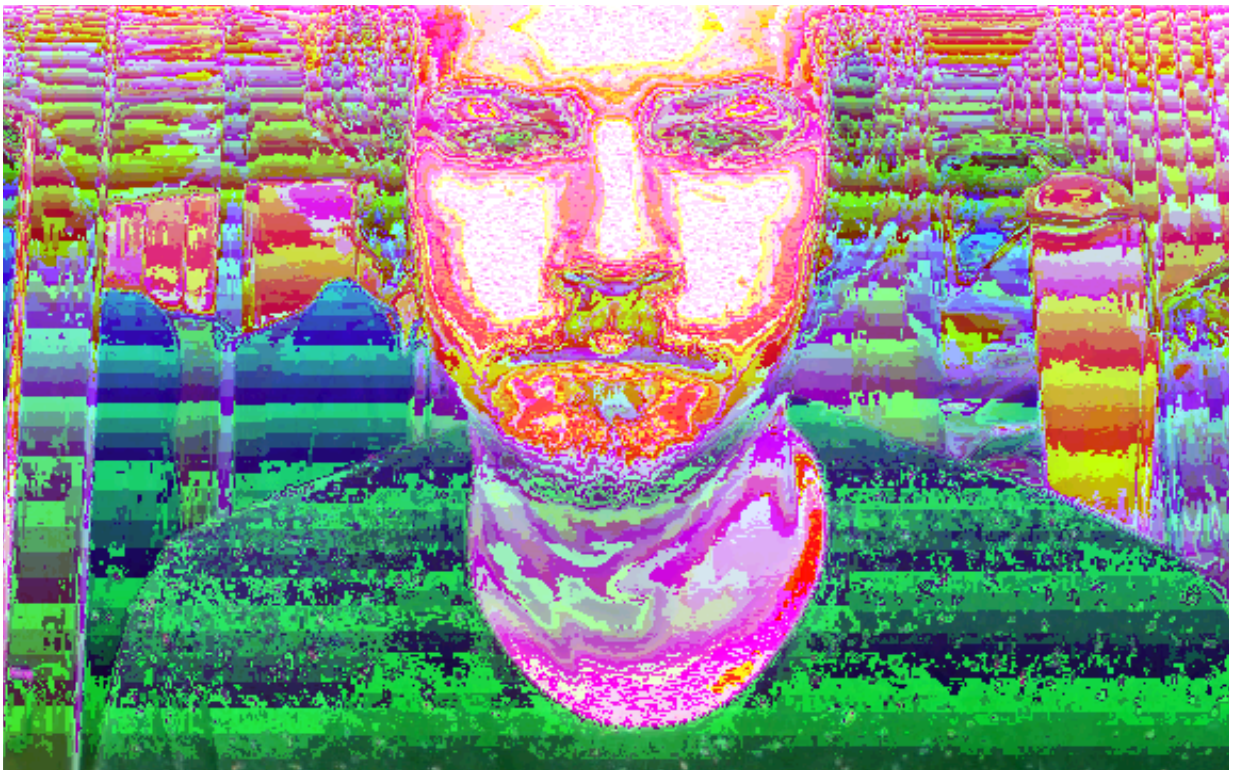
Databending with Audio Observations

Pictured below is the 16-bit .bmp with a fade out filter applied. In audio terms, this just means gradually and linearly turning the volume all the way down to zero. The bright, vibrant colours coupled with the flowing patterns particularly prominent around the neck area make the image reminiscent of psychedelic band posters from the 60's and 70's. The filter also has a good spacial quality to it. Horizontal lines gradually grow thicker towards the bottom of the image, which gives it an enhanced sense of perspective, like the top of the image is disappearing into the horizon.

To see if the results were reproducible, the effect was applied to an image that might benefit from a stronger sense of the landscape disappearing into the distance. To get a more honest impression of what colours would appear, a grayscale photo was chosen. The effect does indeed give a good impression of the horizon disappearing into the distance.

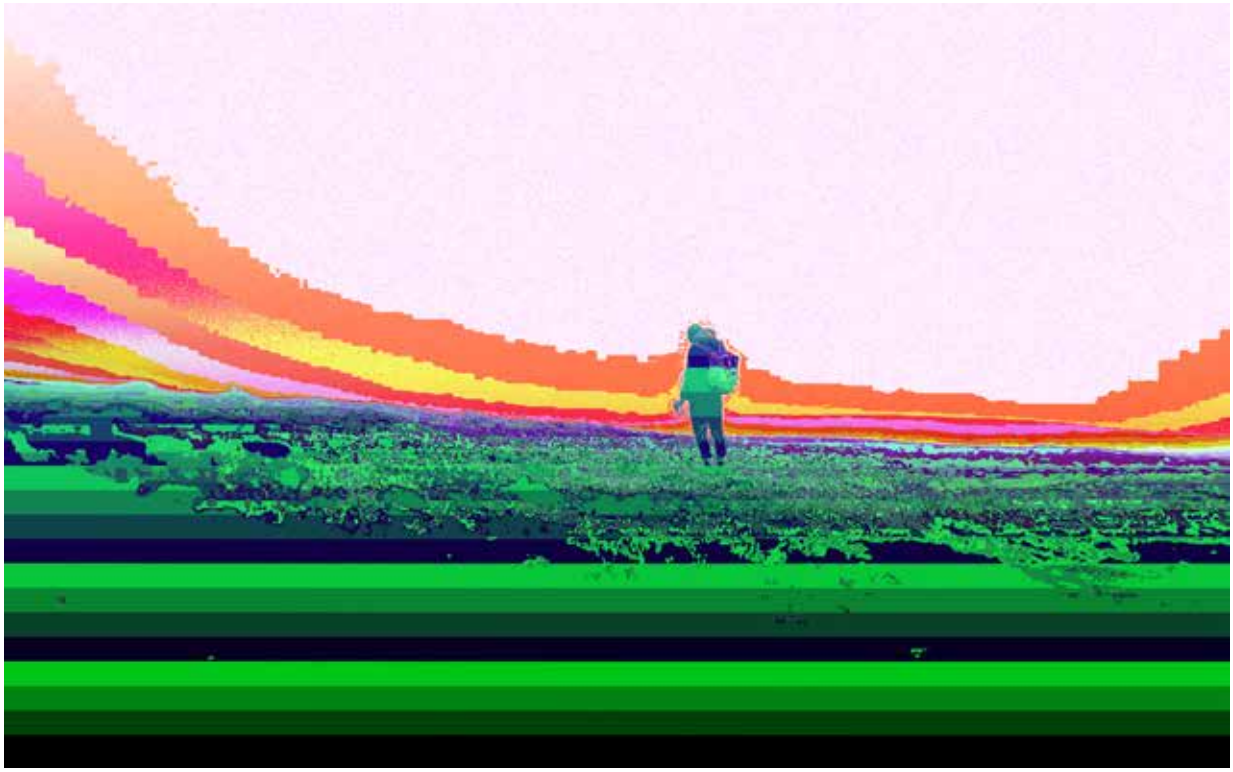
It seems dark tones are more prone to receiving a blue/green tint, which we often associate with the ground, or water, while bright tones such as the sky are given pinks, oranges and yellows. Colours which are often associated with beautiful sunsets. The colours correspond with the way we are used to reading the world, so the result is quite pleasing to the eyes. There is quite a bit of harsh pixellation going on, especially in the oranges and pinks of the sky, which is likely caused by the image not having enough fidelity to begin with. This is one of the major shortcomings of the 16-bit .bmp - it doesn't handle gradients very well. What is perhaps most impressive about the result is that it would be incredibly hard to replicate using any other method, such as Photoshop. We have successfully discovered a new somewhat attractive expression based on the misuse of digital media.

Of course, selecting the correct photo to apply the filter to is vital, as the technique will often make an image harder to read if the image contained too many details to begin with.



***OPPOSITE PAGE**: 16-BIT BMP WITH A FADE OUT FILTER*
***RIGHT**: ORIGINAL BLACK & WHITE PHOTO*
***BOTTOM**: REAPPLYING THE FADE OUT FILTER TO THE B&W PHOTO*





datamoshing

Video files are compressed using three types of frames: I-frames, P-frames and B-frames.[23] I-frames contain the colour information of the image, while P-frames contain information on the direction these colours will move in. B-frames reference both the frame before and after itself. In short, an I-frame is an image, a P-frame is basically just a bunch of arrows dictating which way the coloured pixels will move, and a B-frame is similar to a P-frame but gets its information based on the frames that are before and after itself.

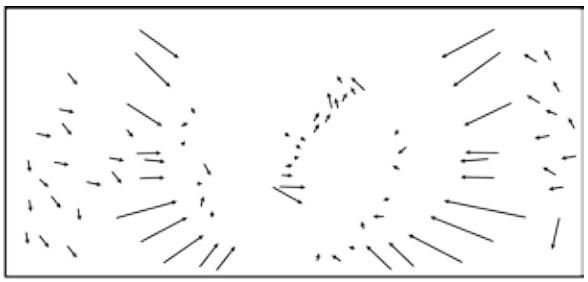
To datamosh, all we need to do it to start rearranging these framse. Using this technique produces the same digital artefacts which we are used to seeing in low-quality DVD-copies, particularly when skipping ahead in the video. The effect has been used in several pop-culture productions, such as the aforementioned Kanye West music video.

There are a few different ways of applying the technique. The most popular one is to use a free software called Avidemux[24] to go in and manually delete I-frames from the video file. I found this technique to be incredibly long-winded, slow and complicated. Fortunately I was able to find a plugin for the Mac developer's tool Quartz Composer which streamlined the process of datamoshing videos live.

Rather than simply exploring the visual artefacts generated by this glitch art technique - there are enough examples of that on YouTube - I wanted to see how this might be used in creating a new user experience. After some experiments with moshing together different



I-Frame



P-Frame

ABOVE: *I-FRAMES CONTAIN INFORMATION ON COLOUR, WHILE P-FRAMES ONLY DICTATE WHICH WAY THOSE COLOURS WILL MOVE..*

***RIGHT**: COMBINING FACIAL FEATURES USING DATAMOSHING*
***BOTTOM**: HEAVY ARTEFACTING AND TERRIFYING FACES.*

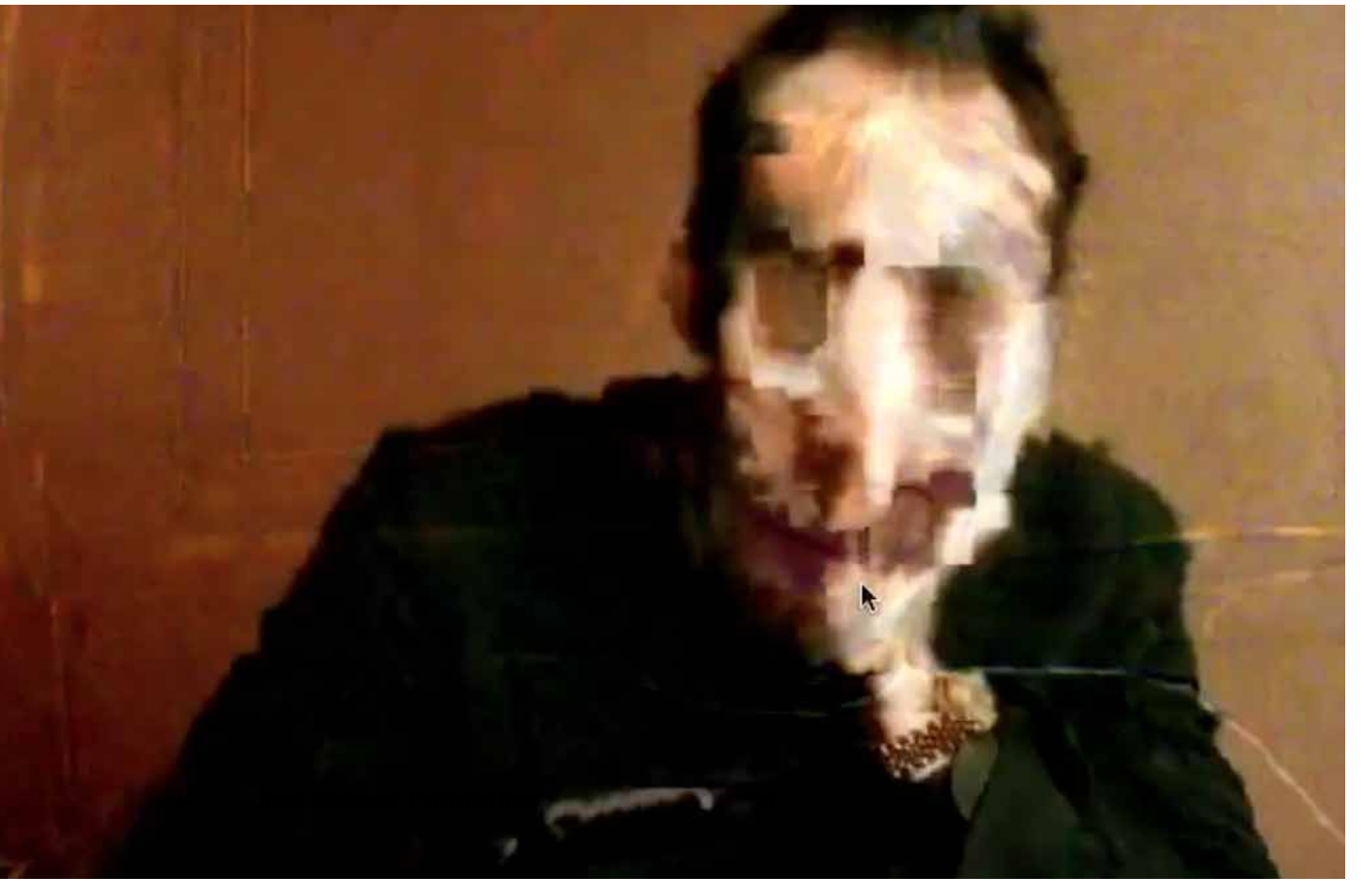


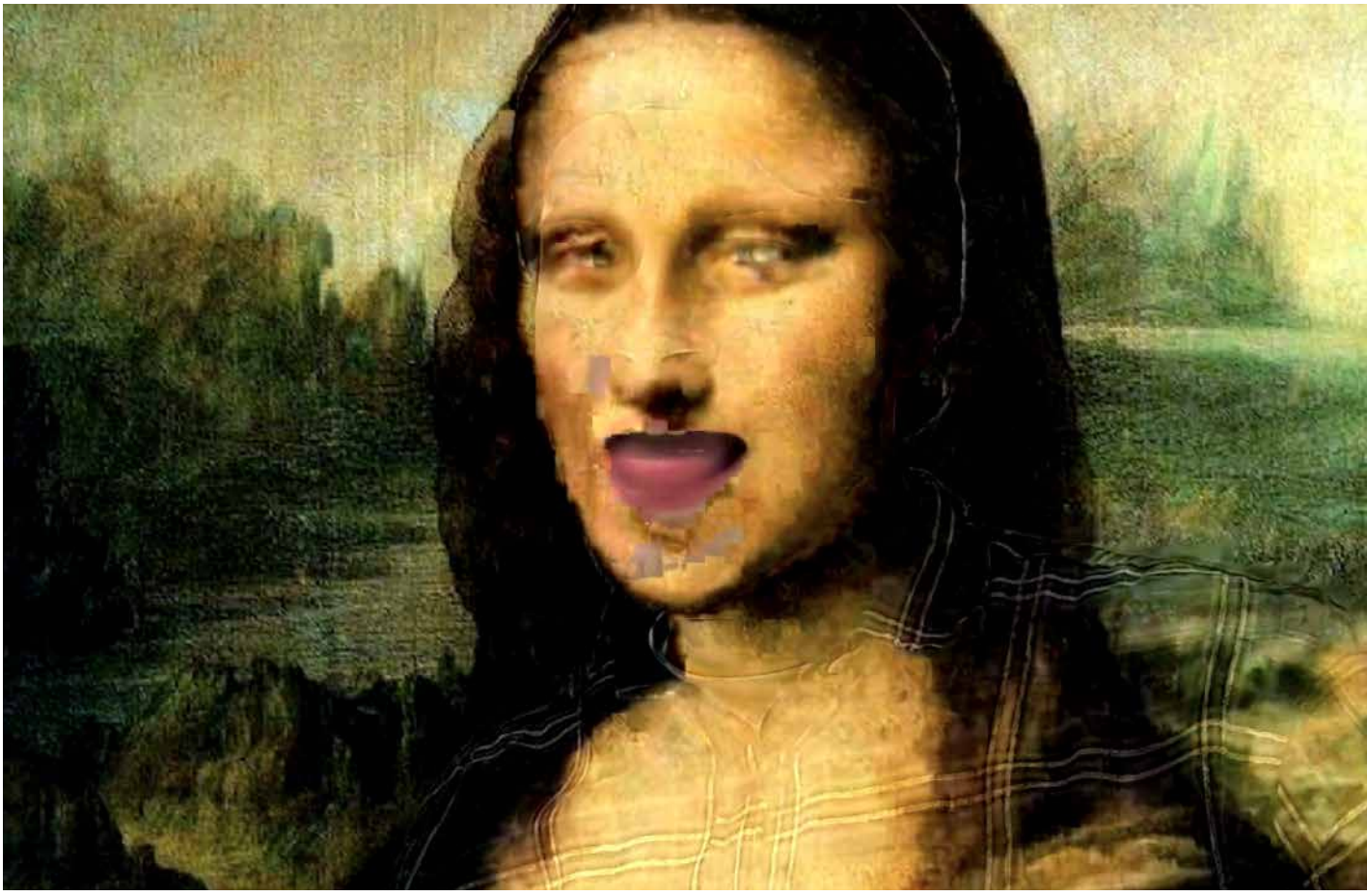
video clips and familiarizing myself with the technique, I plugged a webcam into each of the two video feeds. I sat down in front of one of them, and got a willing participant to sit down in front of the other one. Using this configuration, we were able to "take over" one another's faces by carefully placing our heads in the correct position and then mixing the two video sources together. It was an incredibly fun experience, perhaps just for the sake of the pure weirdness of the outputted video. Facial features would appear in unexpected places and our clothes were mixed together like something straight out of a horror movie. Every once in a while we would be able to somewhat accurately line up our facial features to give a feeling of swapping faces for a little while, before the digital artefacts took over and destroyed the illusion.

To minimise the room for error in this unique way of swapping faces, I switched one of the webcams out with still images of celebrities such as Robert de Niro, Brad Pitt and Mona Lisa. This made it much easier to accurately line up my own facial features with theirs, thus giving me control of some of the worlds most famous faces.




electronic
Cadillac







***OPPOSITE PAGE, TOP**: TAKING CONTROL OF 50 CENT'S HEAD.*
***OPPOSITE PAGE, BOTTOM**: NICHOLAS CAGE, MELTING*
***ABOVE**: CONTROLLING MONA LISA'S FACIAL EXPRESSIONS.*
***RIGHT**: TRYING TO CONTROL OBAMA PROVING DIFFICULT.*

generation loss

There were a couple of drawbacks to the glitch art techniques I had experimented with. One was that the results - apart from a few of the audio databending techniques - were next to impossible to replicate. They were born out of randomness and accident, and I struggled to see how they could be used in a design context if they weren't consistent and reproducible. Secondly, throughout all my experimentation up to this point, it felt like I was walking in someone else's shoes. I wasn't breaking new ground with any of these experiments.

So I decided to come up with my own way of provoking distinctly digital artefacts. To do that, I drew inspiration from analog media. I was fascinated by the concept of generation loss, which is the loss of quality between subsequent copies of data. It is very apparent when working with analog media. It is the loss of detail when scanning subsequent prints of the same image. It is the loss of fidelity when copying a VHS tape over and over again.

What is fascinating about the phenomenon is the question of what will remain when all detail has been erased. When all human input has been removed from the medium, what are we left with? In the case of a VHS tape, we are left with a horizontal visual white noise with accompanying audible white noise. Removing all human-inputted data leaves us only with the very essence of the medium itself. It's an honest expression of the medium of the VHS tape.

Another enticing element to this concept is the lack of human intervention. My hypothesis was that if an interesting result was found, it would be easy to replicate the effect later.

So how does this apply to the digital realm? As we all know, one of the key strengths of digital media is that it retains its quality when copied. It is the exact same file. Generation loss in the digital realm instead takes the shape of recompressing digital media. Even if we compress to the exact specifications as before, there will be a tiny, almost invisible change, completely undetectable by human eyes.

Some files need something done to them before recompressing, like rotating an image or compressing between two formats. For it to be detectable, the recompression often has to be performed thousands of times. Compressing videos usually shows results quicker than images, and are also more prone to breaking and becoming unreadable. For performing generation loss on videos, a software called Adapter was used, and for images Automator was used.



ABOVE: *THE 23RD COPY OF A VHS-TAPE. VIRTUALLY ALL TRACES OF THE ORIGINAL DATA HAVE BEEN LOST.*



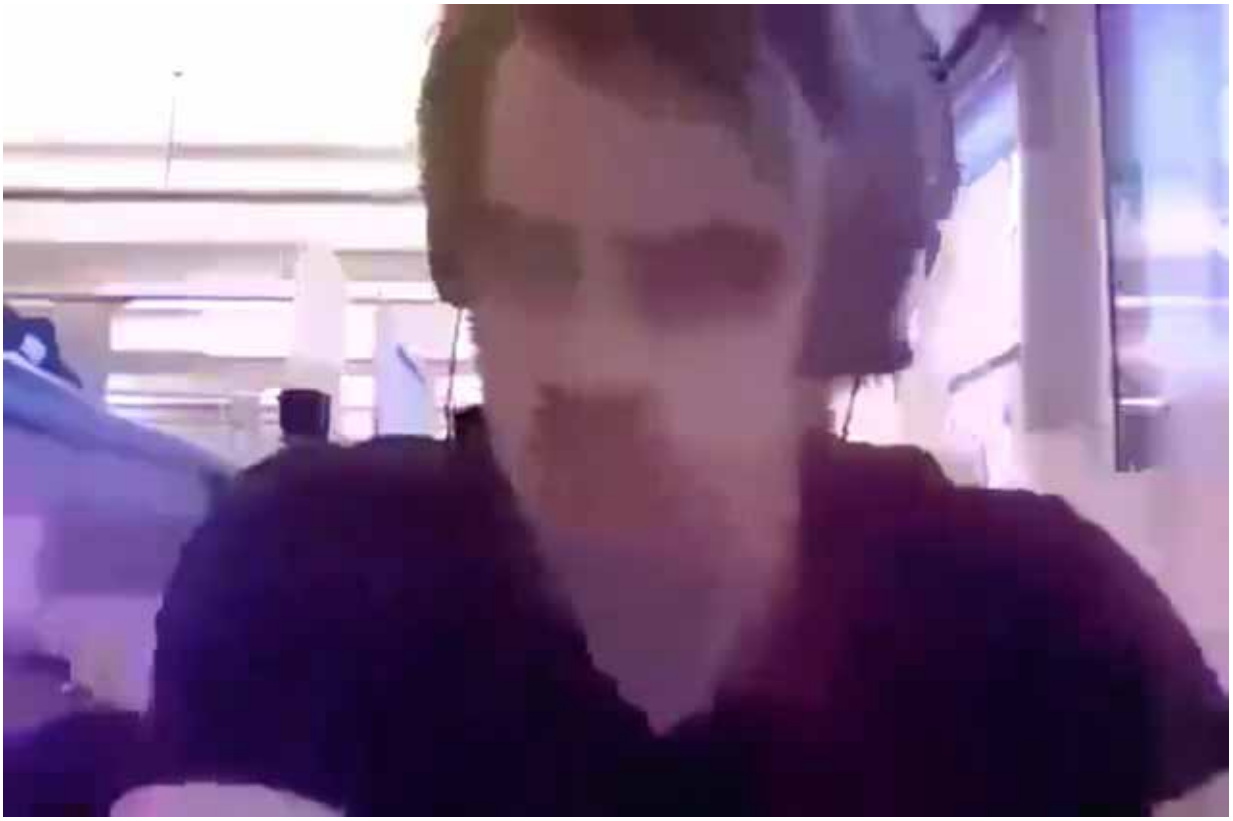
CONVERTING BETWEEN JPEG AND JPEG 2000, 9500 TIMES. BY THE 9500TH GENERATION, ALL TRACES OF THE ORIGINAL ARE LOST.



The main drawback to this technique is the time it takes. Even when automating the entire process through simple programs, it takes hours to make a media file unrecognizable from the original. There were, however, a few noteworthy results.

The MKV video format, when recompressed dozens of times, begins to take on a very characteristic visual expression. In stark contrast to the other video formats that were tested, the edges maintain most of their fidelity. Different shades that are close together are blended into one. Although detail is lost, it looks like an intentional stylisation of the image. Edges receive a soft, warm glow. Often magenta, sometimes drifting towards orange. Colour tones are smeared into one another, reminiscent of the databent MP4 which started to look like an abstract painting.

I was interested to see what the effect would look like if it was applied to a more filmatic video clip. This was, after all, just a low resolution webcam video, only lasting a few seconds. The new video clip was recorded at 240 frames per second, at a resolution of 720p.



After recompressing the clip into the MKV format 160 times, it has taken on a strikingly different expression from the original. Although the original already follows classic principles of composition such as roughly aligning points of interest to the golden ratio, the recompression adds to the aesthetic. It has a certain warmth and glow to it that the original does not. The edges of forms have generally maintained their fidelity, as is evident in the lower arm of the subect. Still, tones which are more closely related blend together. Details such as windows, cracks in the pavement and road markings fade from view, and we are left to ponder the mood and tone of the image. Our mind automatically fills in the blanks. Of course, one might ask if the image would be readable without the original for comparison, but bear in mind: This is a video. The stream of frames helps us construct a mental image of how forms are related to one another. The result is a warm, glitch-induced watercolor painting in motion. Again, the degradation of data is not used to disrupt, but rather to enrich the original video.



***OPPOSITE PAGE, TOP**: MAGNIFIED PORTION OF RECOMPRESSED MKV.*
***OPPOSITE PAGE, BOTTOM**: FRAME FROM RECOMPRESSED MKV*
***ABOVE**: ORIGINAL VIDEO FRAME.*
***BELOW**: RECOMPRESSED VIDEO FRAME.*



conclusions & reflection

So where does this first set of experiments bring me? What have I learned? And in what direction does this push my diploma?

These experiments were meant to give me a practical introduction to the craft of bending digital media. By drawing inspiration from the world of glitch art, I experimented with techniques for bending digital media files. The glitch artist seeks to use the glitch as a disruptive element. To draw attention to it. The glitch is the point. The glitch is the subject. I, on the other hand, wanted to see if the glitch could be used as a complimentary element. Enriching the experience, rather than disrupting it. Our tools are the same, but our intentions are different.

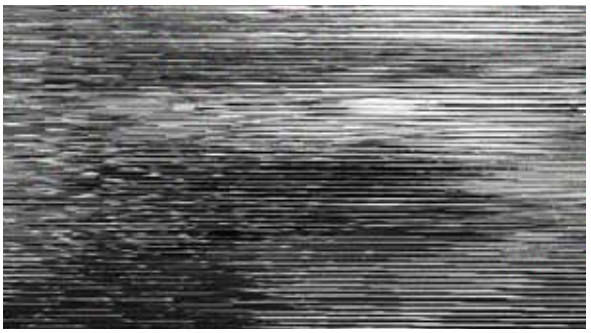
Thoughts on Databending

Databending makes it easier to understand that data is just another material. It can be bent and change shape. Any file could potentially be accessed and edited as audio, text or even an image.

It's easy to see why databending with a text editor is one of the most popular glitch art techniques. First of all, virtually everyone has some sort of text editing software available. Secondly, it's very easy to achieve results, especially when dealing with some of the more forgiving file formats such as PNG and BMP.

It's easy to see why glitch artists are so fascinated with the technique. There are dozens and dozens of file formats to experiment with, and an astonishing amount of achievable results. Some of them aesthetically pleasing, some ugly, some terrifying. There are, however, several issues associated with dealing with this method in a design setting. Most importantly, results are incredibly hard to replicate, save for with the easier to use formats, such as the BMP. Secondly - and this goes for databending in general - virtually every digital file has some sort of raw data that can be manipulated. Researching the bending of every possible file format would warrant a diploma of it's own.

Databending with audio is without a doubt more consistent than using text editors. It's incredibly simple to replicate results by applying the same filter to separate files. Although I only experimented with images and video, the technique could potentially be applied to dozens of different types of digital files, from 3D CAD-models to Photoshop documents, although because of their specific encoding it is doubtful that one would get anything useful in return.



ABOVE: *THE RAW DATA OF THIS BMP WAS PITCHED DOWN WHILE IN AUDIO FORM.* ***RIGHT****: POSTER FOR "POLTERGEIST"*

The Ghost in The Machine

Pitching the audio of a 24-bit .bmp down with 43 percent will render it as horizontal white noise, only maintaining hints as to what used to be in the image. One can barely make out the darkness of the mouth and eye area, contrasted against the bright forehead and nose area. There is something unmistakably "creepy" about the finished image. It's almost as if a sinister face peers back from the noise. Of course, one can draw parallels to ghost stories about dead people creeping out from the white noise of a television, such as Poltergeist or The Ring. But speaking more personally, the main reason this image sent chills down my spine is tied to the very core of what makes these glitch techniques so fascinating: It almost feels like having a conversation with a machine. Ninety percent of the time when doing these experiments, what is returned makes no sense to human eyes. It's just pure noise, messy and nonsensical. Complete randomness. Which only makes it all the more exciting when the machine instead spits out something we can relate to on a human level, such as this. Something which provokes an emotional response, like fear or laughter. All we're really doing when applying an audio filter to an image is telling the machine "Hello?" without having any clue what to expect. And most of the time, we hear nothing. Maybe a little crackle or a fizz. But every once in a while, for a split second, it almost feels as if it might be replying "Here I am!"

Of course, it is easy to realise what a naïve sentiment this is. Humans have an inherent ability to give supernatural explanations to what they don't understand. Like blaming a thunderstorm on an angry god, or nonsensical political practices on subterranean lizard men. There are no sentient beings in our machines. There are algorithms and bits and bytes, but no life. Still, the idea might help to explain the extreme popularity glitch art has been gaining over the past few years. Part of it might be people eager to get in touch with the so-called ghost in the machine.

Related Projects

There are several designs that could be tied to the concept of data taking many different potential forms. Probably one of the more well-known examples is the barcode and subsequent QR-code[25]. They are simply numbers and characters encoded as black and white shapes.

There are also more modern examples, more directly linked with interaction design. Chirp.io is an app which works from the premise that data can be transmitted as sound.[26] Users can use sound to transmit images,



text and links to other devices running the app. In the case of chirp.io, although the users may be given the illusion that they are transferring the raw data of any given file, they are only transferring links. When a photo is chirped, for instance, the photo is first uploaded to chirp.io's cloud service. The data chirped is just a hyperlink to the photo. Which means that the users need to have cellular data or Wi-Fi activated for the service to work, defeating much of the purpose of the app.

Photosounder[27] is a piece of software developed by Michel Rouzic. It allows the user to turn any image into audio, and vice versa. According to the developer, this opens up for brand new ways of editing audio, making it significantly easier to isolate instrument tracks from a song, for instance. To me, its greatest strength lies in its pure novelty. It's absolutely mesmerising to watch and listen to data being translated between audio and images.

Thoughts on Datamoshing

Probably the most popularized glitch art technique that I tested, datamoshing is also the most interesting way of glitching a video. The flowing patterns generated are fascinatingly hypnotic, as well as holding nostalgic sentimental value for people who grew up on terrible DVD-rips downloaded off Napster.

One needs to ask if datamoshing can still be considered digital imperfection. The phenomenon has come a long way since the days these glitches arose unannounced and unexpectedly. The process has been streamlined. Although the technique I used actually works the same way as a "naturally" occuring encoding glitch, there are tutorials on YouTube on how to replicate the effect in After Effects.[28] As with analog light leaks or Instagram filters, what started out as an honest imperfection has been repurposed as a sought-after visual expression.

It's quite easy to imagine designing an experience based around glitch-induced face swapping, but if good face swapping is the goal, then datamoshing seems to be an incredibly unintuitive workaround to reach that goal. There are already countless face swapping technologies that have been developed over the course of several years. It's a saturated field that I doubt I would be able to revolutionise in a matter of months.

Thoughts on Generation Loss

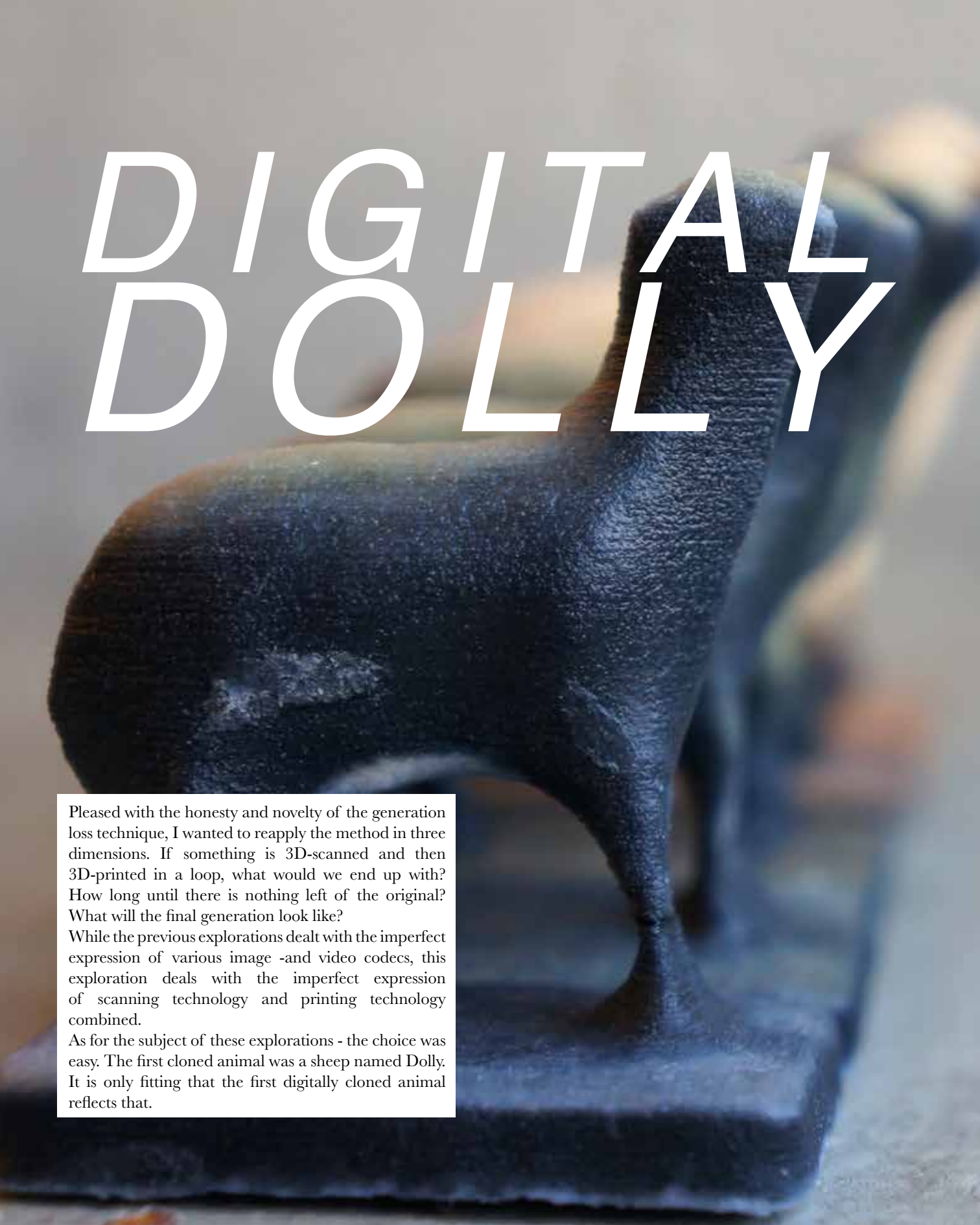
An issue I had with both databending and datamoshing is that they are both well-explored territories. It felt like I was walking in someone else's footprints. If I wanted to come up with something novel, I would have to explore new territory. Drawing inspiration from the analogue world I decided to try and replicate generation loss in the digital realm.

One may argue whether or not the experiments I did are true examples of generation loss. After all, we are doing more to the files than simply copying them. It is however clear that whatever change is made to the media files is a pure expression of the encoder itself. We are simply giving the machine a starting point and then leaving it to its own devices. There is no human input - besides the original footprint of the programmer who wrote the format - on the process of degrading the media files.

I believe it to be a very "honest" material exploration of file formats. It's a minimalist approach to exploring digital aesthetics. We can draw comparisons to the way representatives of the De Stijl movement such as Piet Mondrian wanted to reduce objects to their purest forms.[29] The object in question in my own experimentation is a digital media file. Through compression, it gets reduced over and over again until nothing is left but the very material of the encoder itself.

However, another issue I had with most of the exploration I had done up until this point was that I would at best end up with a fancy image filter. I was still stuck with traditional digital media such as images and videos. With technologies such as 3D printing and 3D scanning on the rise, I wanted to apply generation loss to this new form of digital media.

DIGITAL DOLLY



Pleased with the honesty and novelty of the generation loss technique, I wanted to reapply the method in three dimensions. If something is 3D-scanned and then 3D-printed in a loop, what would we end up with? How long until there is nothing left of the original? What will the final generation look like?

While the previous explorations dealt with the imperfect expression of various image -and video codecs, this exploration deals with the imperfect expression of scanning technology and printing technology combined.

As for the subject of these explorations - the choice was easy. The first cloned animal was a sheep named Dolly. It is only fitting that the first digitally cloned animal reflects that.

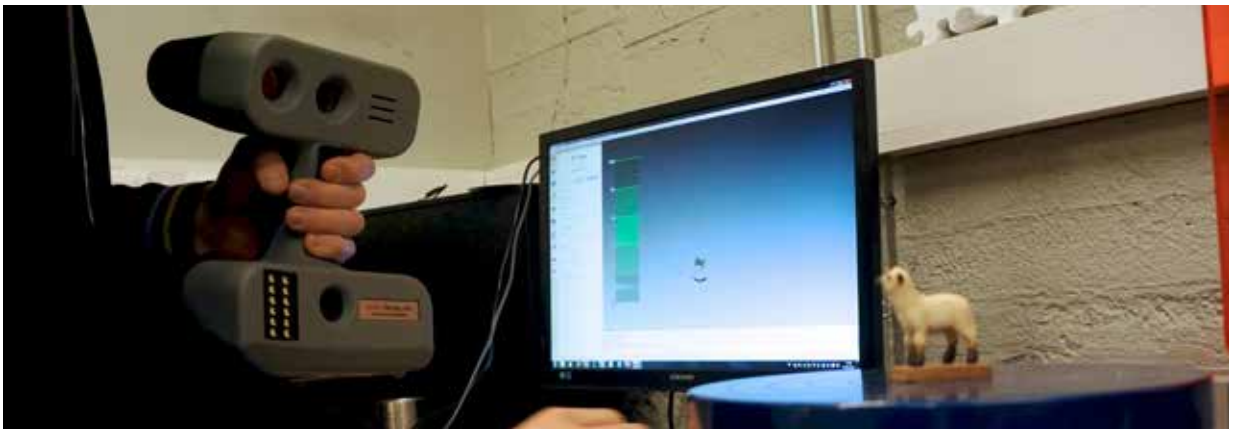
digital dolly

Inspired by the previous audiovisual experiment, I wanted to explore the natural reduction of three-dimensional forms. As advanced as our 3D scanning -and printing technologies have become, they are far from perfect. They are imperfect technologies, which seemed perfect for my practical explorations. By scanning and printing a form over and over, I wanted to see if I would reach a point where the form was no longer changing for each generation. What would it look like? Is such a form the most honest expression of the technologies involved?

When figuring out what subject to select for the experiment, it was important to choose something relatively small, to allow for rapid printing. I settled on a sheep. Not just for poetic reasons, but also for the levels of detail inherent in the model. From the textured surfaces, to the subtle colour variations to the overall shape, there were just so many elements that could become corrupted.

Of course, the results of this little experiment would depend entirely on what technologies I chose. Just as with the media files, the specific tools used in the generation loss technique will all yield vastly different results. An attempt was made on scanning the sheep using a professional Artec MHT scanner. However, the scanner just couldn't cope with the small size of the subject.

As a last resort, an attempt was made to capture the sheep using a free iOS App called 123D Catch.[30] It uses a series of photos to reconstruct a 3D-representation,



ABOVE: *ATTEMPTING TO SCAN DOLLY USING AN ARTEC MHT SCANNER*

***RIGHT**: SCANNING DOLLY USING 123D CATCH*
***BOTTOM**: THE CLEANED-UP 3D MODEL AND NEWLY FINISHED PRINT.*



also known as 3D photogrammetry.[31] The results were quite accurate. Even down to the fine texturing of the model, the free app held its own even against a 10,000€ scanner.

After capturing the model, the mesh was cleaned up and sent to be printed on a Projet 660 3D colour printer. The process was then repeated with the newly printed model, under the exact same conditions. With every new generation, Dolly would fall apart just a little more.

















reflection

Interesting imperfections started to arise as early as the third generation. Dolly's legs were getting increasingly thin. Several prints had to be made before the Projet could keep up with her petite shapes. The last two generations had to be glued together post-print. It was obvious that for every new generation, the scanning technology was removing mass from the model. Interestingly, so was the printer. The fourth generation, which had lost its leg after printing, originally had all four (Three?) legs intact. The fifth generation only came intact out of the printer after the third try. The experiment had to be drawn to a close.

The degradation between generations is radical, at least when compared with the experiments made with digital media files. This makes it easy to see the footprint of the technologies involved manifest itself in new ways with every new clone.

The second generation already displays typical characteristics of using 3D photogrammetry to scan objects: The front legs are starting to grow together. The texture of the wooden base is being pulled upwards. Most of the surface texturing has disappeared. The inside of the legs as are darkened as a result of the capture technology also recording the way light falls upon objects. Every generation was scanned in the exact same lighting conditions, so this effect is magnified throughout the subsequent clones. The printer has also left its mark; The way it prints in layers manifests itself as horisontal ridges running along the entire model.

Spots of white on Dolly's belly area are prominent throughout all the clones. This is a consequence of the capture technology not having enough information about a certain part of the model. It replaces these parts with a default texture, which appears to be white. It might, however, be more valuable to focus on the fifth and final generation, as it represents the culmination of all the imperfections that have arisen.

First off, the fifth generation is nearly black. This is due to the capture technique not only capturing the true colour of objects, but also their lighting. Using a consistent lighting source, such as a flash, actually makes it more difficult to get an accurate model. The technology uses patterns of light and dark as landmarks when reconstructing a 3D-model from photos.

Looking at the silhouette of the model, although it



ABOVE: *DETAIL SHOT SHOWING DOLLY'S LEGS FUSING IN THE 2ND GENERATION.* ***RIGHT****: FIFTH AND FINAL GENERATION.*

hasn't become low poly[32], it is still lo-fi[22] in that the capture technology seems to prefer sleek, long curves over curves with lots of minute details. This abstraction gives the model a sort of prehistoric look to it. Like it was drawn on a cave wall or sculpted from an antler. The collection of models - although not my intention - could also be interpreted artistically. It's hard not to when looking at them side by side and seeing the sheep gradually disappear and almost "melt". The sheep is quite literally losing its physicality through digital degradation. Surely people more tech-phobic than myself may be able to identify with that message.

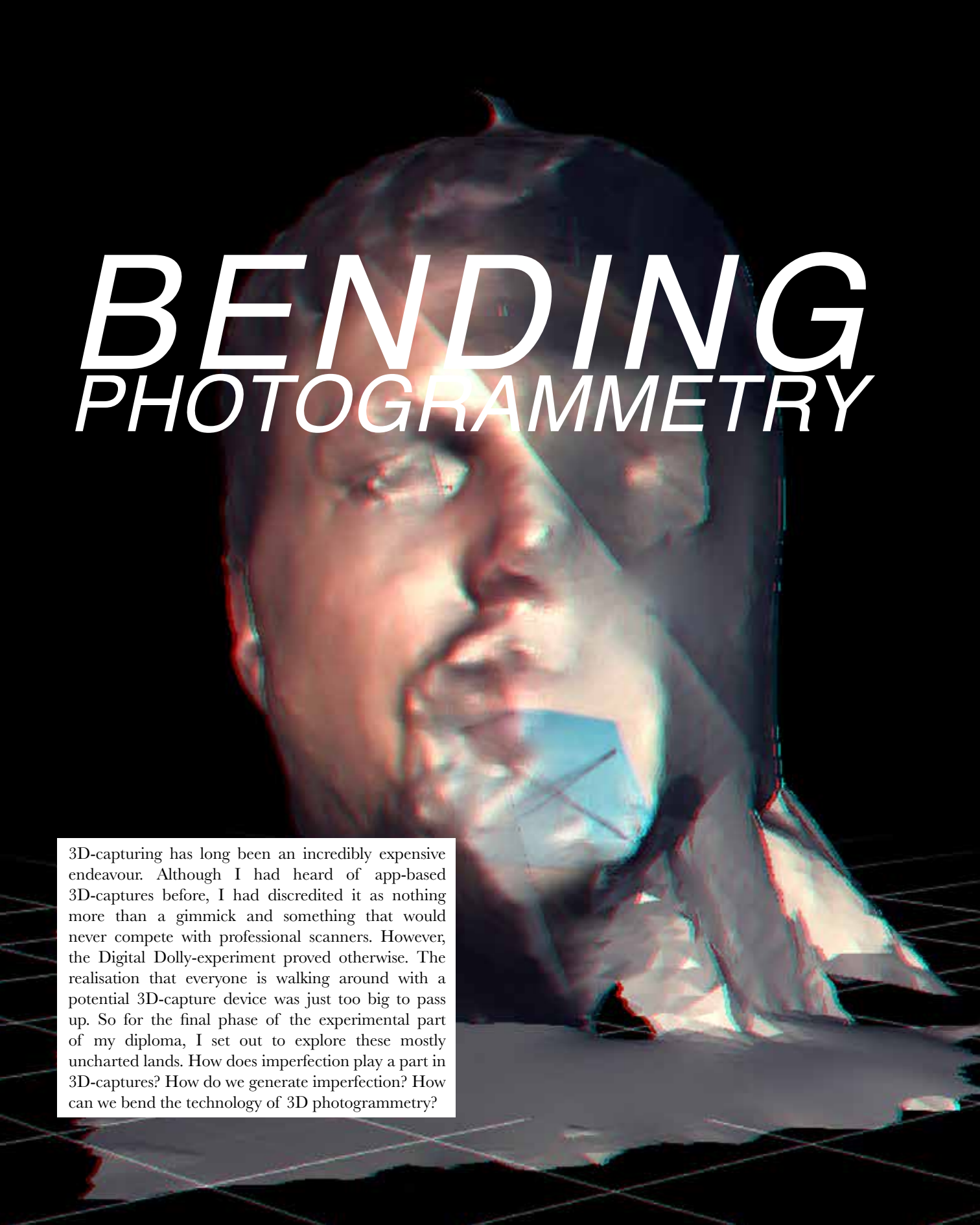
The imperfections of digital media files have been explored time and time again. However, the 3D-scanners that we now download for free on our phones are virtually uncharted territory. It seemed like the perfect field to focus my further explorations into.







BENDING PHOTOGRAMMETRY



3D-capturing has long been an incredibly expensive endeavour. Although I had heard of app-based 3D-captures before, I had discredited it as nothing more than a gimmick and something that would never compete with professional scanners. However, the Digital Dolly-experiment proved otherwise. The realisation that everyone is walking around with a potential 3D-capture device was just too big to pass up. So for the final phase of the experimental part of my diploma, I set out to explore these mostly uncharted lands. How does imperfection play a part in 3D-captures? How do we generate imperfection? How can we bend the technology of 3D photogrammetry?

introduction

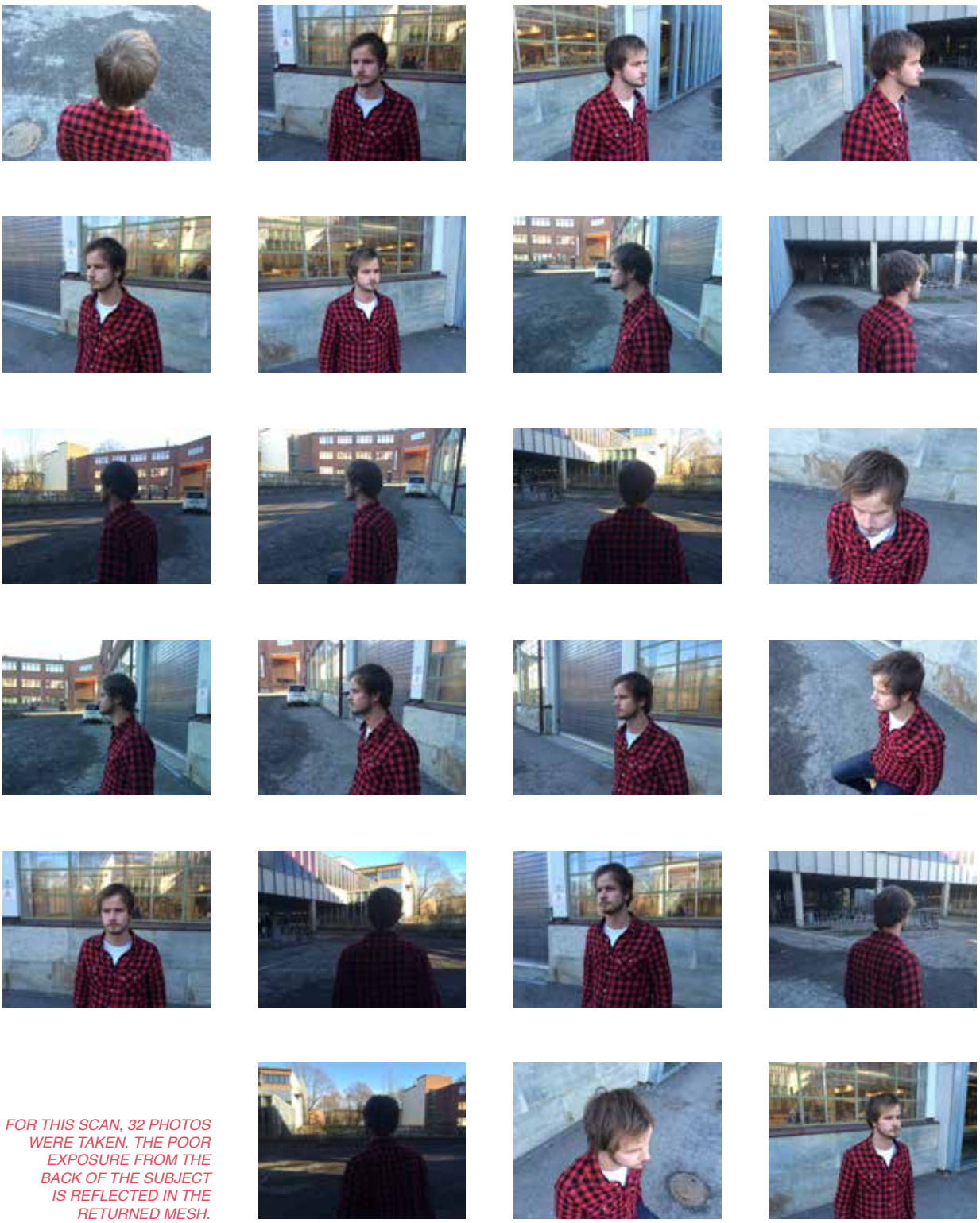
Photogrammetry is the science of taking measurements from photographs.[31] Although photogrammetry itself has been around since about 1850, the concepts it builds upon go back even further. Leonardi Da Vinci experimented with the concepts of perspective and projected geometry as early as the 1400's, and there are those who believe the ideas date as far back as ancient Greece.[34] Photogrammetry has among other things been used in the creation of topological maps, special effects for movies and forensic field work. Today, there is a whole plethora of software[35], both free and premium, for generating 3D models from photos. I chose to work with 123D Catch simply because of its flexibility. It comes both as an iOS App for quick on-the-go captures, as well as a desktop application for more in-depth work. It also has a tablet version.
Note: Although photogrammetry itself only means the science of locating discrete points in 3D space based on 2D photographs, in the context of this diploma I use it as a general term for all the processes involved in generating a 3D-mesh from photos.

123D Catch

The app was first released in 2012, although its roots date back at least to 2011 when it was called PhotoFly.[36] 123D Catch is a part of Autodesks 123D Suite, a collection of apps and programs designed for hobbyist CAD and 3D-modelling. The suite has a community where users can share and download models. Virtually all of the models posted are inanimate objects. Rock formations, food, statues and figurines are among the more popular choices for capturing. Every once in a while someone will post a human bust. This is fully in tune with the way Autodesk markets the app. Throughout the marketing material, the app is pitched as a tool for capturing scans that will ultimately end up as 3D-prints.
It feels as though Autodesk is trying to appeal to the same broad audience that apps like Instagram target. They have introduced likes, favouriting and user profiles. However, their attempt at appealing to everyone has failed. Last weeks most liked scan worldwide had a measly 19 likes. The community is virtually dead. It has become a gimmick app that users (At least the ones I've shown it to) try once, find mildly amusing, and then never open again. It is technology that will only appeal to a small niche of people, such as archeology students, engineers and 3D-printing enthusiasts. As is the case with much cutting-edge technology, it seems Autodesk doesn't quite know what to use it for. By bending and misusing the technology, it was my hope that I would be able to come up with novel ways in which photogrammetry could be used. Could it somehow appeal to a broader audience?

Technique

Before bending the rules, we should learn how to follow them. To create a scan, one should typically shoot a minimum of 20 photographs, but up to 70. The subject must be stationary and well lit from a consistent light source. The photos are uploaded to a server and the user receives a 3D-mesh a couple of hours later.



FOR THIS SCAN, 32 PHOTOS WERE TAKEN. THE POOR EXPOSURE FROM THE BACK OF THE SUBJECT IS REFLECTED IN THE RETURNED MESH.



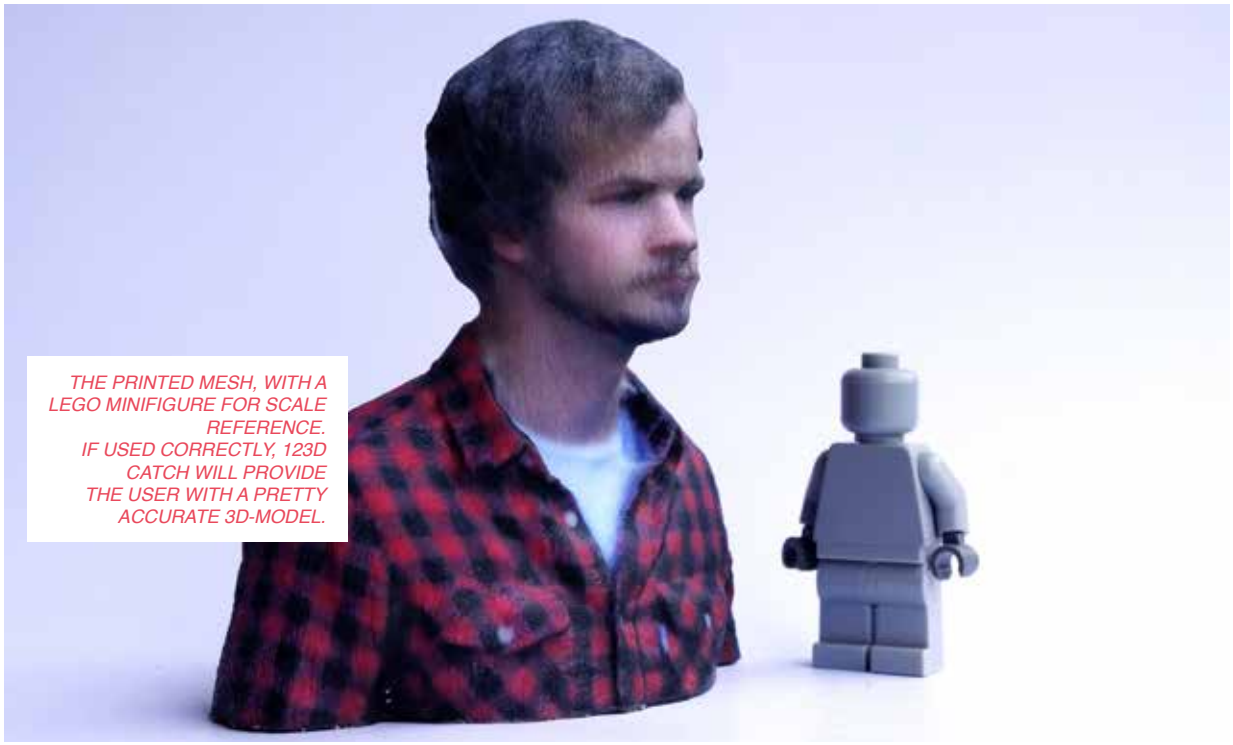
THE SERVICE RETURNS A HIGH-DENSITY 3D MESH.



THE MESH IS DARKER ON THE BACK AS A RESULT OF THE SUBJECT BEING LIT FROM THE FRONT.



THE MESH IS CLEANED UP AND THE BOTTOM IS FLATTENED



THE PRINTED MESH, WITH A LEGO MINIFIGURE FOR SCALE REFERENCE. IF USED CORRECTLY, 123D CATCH WILL PROVIDE THE USER WITH A PRETTY ACCURATE 3D-MODEL.

Bending 123D Catch

One method of bending digital media is to use it in ways the original creator didn't anticipate. Unintended use. Misuse. Exploring the functional side of the imperfect. Following are a few of the explorations I made into the misuse of the app.

Capturing from Moving Vehicles

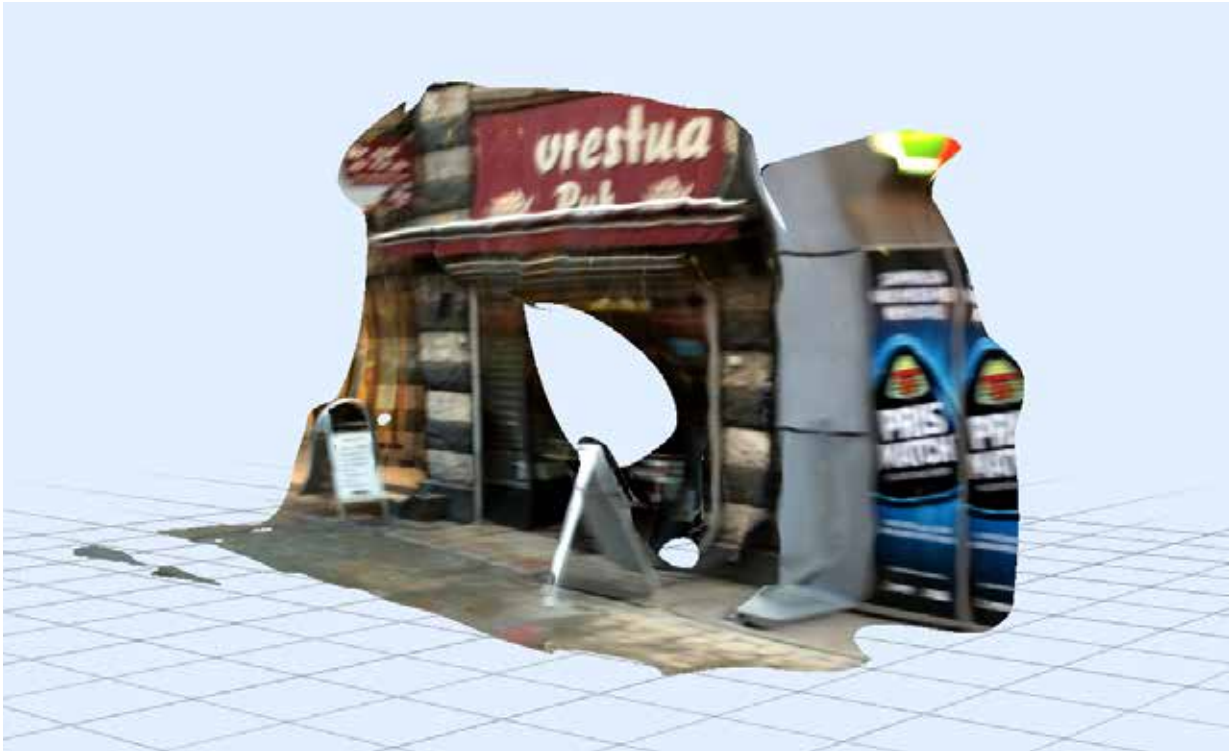
Using 123D Catch in its intended way is a slow and laborious task. It requires the user meticulously moving in tiny increments around the subject, standing still and snapping a sharp photo for every step. The whole process take at least 60 seconds, often more.

All of these scans were taken from moving vehicles, travelling between 20 and 50 km/h. With the iPhone's incredibly fast capture speed, I was able to get off 20 to 35 photos in a matter of three to five seconds. Despite the photos having a good bit of motion blur, some of the scans came out relatively sharp.








vrestua

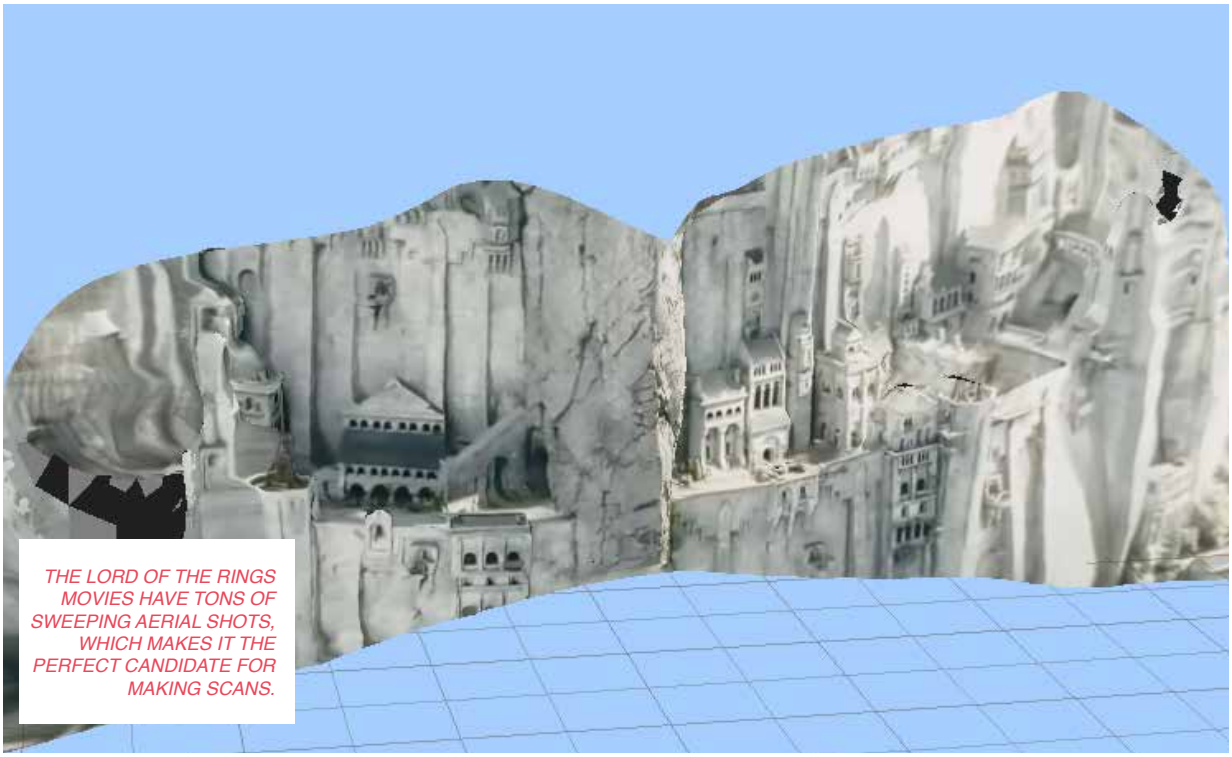
Models from Found Images

Probably the biggest strength of photogrammetry is that it doesn't require scanning hardware. All it needs is a collection of images of the same object from different angles. This would theoretically open up the possibility of feeding the capture software with found images, leaving us with a 3D model of something which previously only existed in two dimensions. However, as I would soon find out, this only works in very specific circumstances. I tried making a face scan based on Facebook photos, which failed with two separate faces. I tried creating a model of a building from Google Streetview photos, but the increments at which the shots are taken are just too long to be able to construct a model based on them. I tried focusing on heavily photographed events, such as 9/11, but even those didn't have enough photos taken of them. I considered generating models of famous landmarks based on tourist photos, but as I quickly found out, these landmarks have already been thoroughly documented, both in two and three dimensions.[38] The one source I could find which allowed me to generate models was films. By carefully selecting the correct tracking shots, one may extract frames to successfully construct a 3D-model.

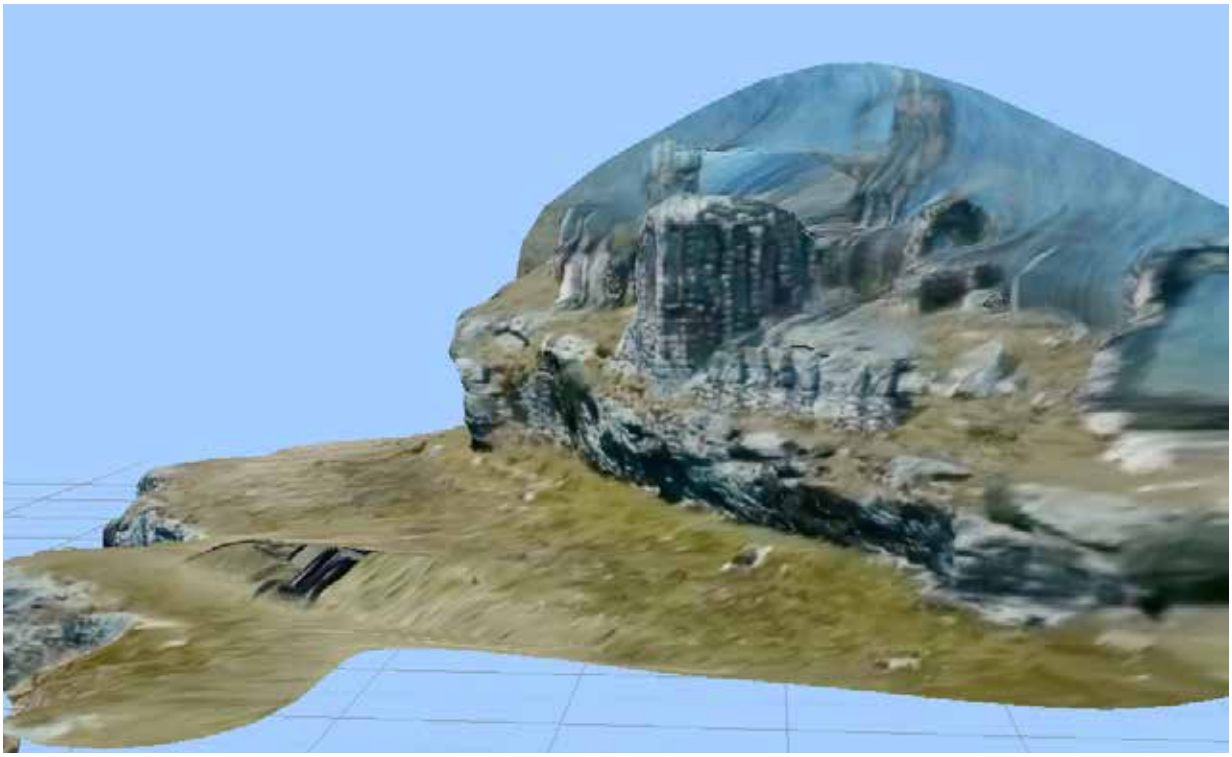




"I'M FLYING, JACK!"



THE LORD OF THE RINGS MOVIES HAVE TONS OF SWEEPING AERIAL SHOTS, WHICH MAKES IT THE PERFECT CANDIDATE FOR MAKING SCANS.



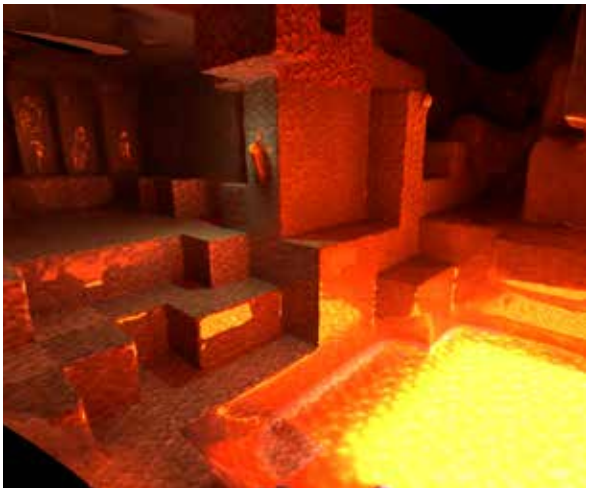
Models from Games

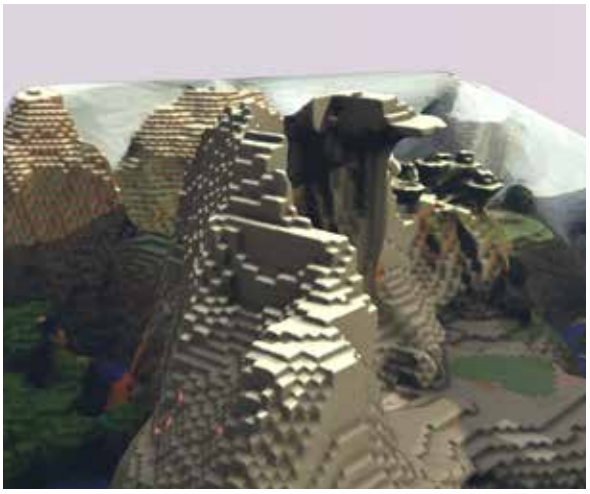
Of course, we don't even have to feed the service with real pictures at all. Autodesk claims its software may be used for historic preservation.[36] By using screenshots from games we can preserve modern relics for the future. By digitising the digital, the mark of photogrammetry becomes more clear. We are taking the imperfections of the camera out of the equation, and only examining the digital degradation.



GIVING MINECRAFT A MUCH-NEEDED FACELIFT BY TAKING SCANS AND REILLUMINATING THEM IN BLENDER.











WARPED, MELTED FURNITURE AS A RESULT OF TAKING SCANS FROM THE GAME "GONE HOME"

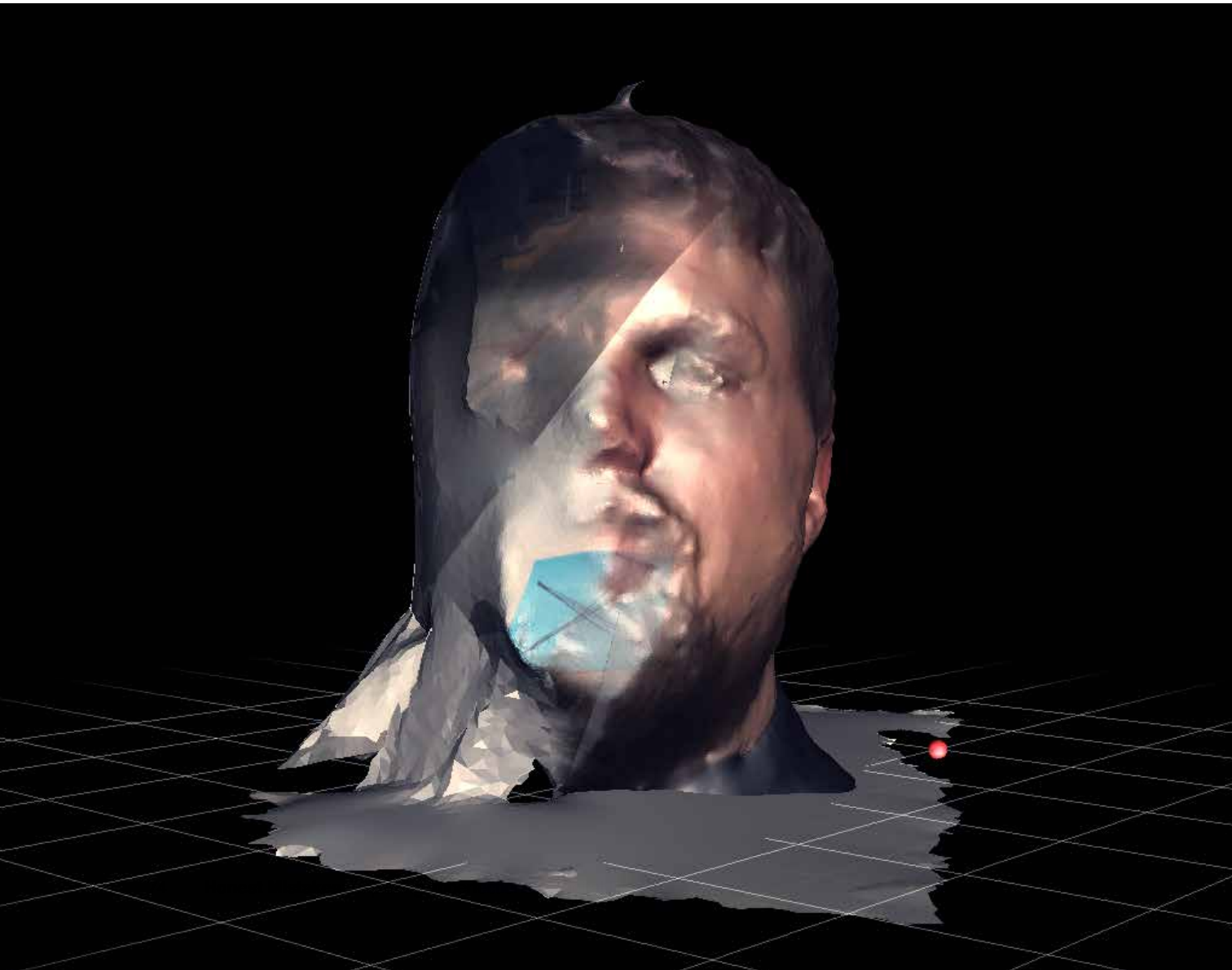


Facemash

123D Catch works by searching photos for landmarks, and stitching photos together based on these. This fact led me to believe that as long as one establishes strong landmarks in the scene, other objects in the scene can be swapped mid-capture to essentially combine them into one object. To test out my theory, I built a simple rig for combining head scans. It consisted of a wooden board with a shoulder mount and a hole fit for a head, with brightly coloured landmarks pasted on top. It was my hope that by switching head mid-scan, a combination of heads would be produced.

Instead of combining faces, the software returned melted monstrosities as the one pictured below.





Reflections on Misusing 123D Catch

Unfortunately, the experiments which in my eyes held the most potential value failed to return 3D-meshes. Namely, capturing scans from Facebook or other found images. Living in the Snowden-era, it felt fitting with the zeitgeist of privacy concerns. Still, I believe the experiments showed that photogrammetry could be used for more than Autodesk markets it for.

By capturing and printing scenes from video games, one could create tangible relics that are honest portrayals of the time we live in. These relics wouldn't require obsolete hardware to view or understand, and so they could function as historical artifacts for generations to come.

Riding around in cars, one could theoretically map a whole city, with a whole new level of three-dimensional detail from what Google Streetview offers.

In 2013, dutch artist Marnix De Nijs created an installation in which the visitor could experience hundreds of famous landmarks as photogrammetric point clouds, based on a huge database of tourist photos.[37] The potential for projects using found images is huge. However, if one takes photogrammetry as a whole, it really can't be considered misuse. It's only misuse according to what 123D Catch markets itself as. Besides, I felt myself drawn more to the strange imperfections inherent in the technology. They were extra apparent when using images from games to generate scans. Taking the camera out of the equation, it becomes apparent how photogrammetry warps and disintegrates forms in its own unique way.

So instead of focusing on the possible functional misuses of photogrammetry, I turned my focus to exploring the aesthetic qualities of broken photogrammetry. How are imperfections generated? What do they look like? How do they feel? And finally, how can they be used to enrich a design?

aesthetics of broken scans

123D Catch, when used correctly, works almost perfectly, as was demonstrated with Digital Dolly. If the user is careful to shoot in a well-lit environment, taking plenty of crisp, sharp photos from every possible angle, the software will produce a model that is on par with those produced by professional scanners. And the fact that we can do this on our phones is most impressive. But the joy and wonder of perfect 3D scans from my phone faded quickly. I found myself more fascinated with the imperfect ones. They possess an abstraction quite unlike anything I had ever seen before. Photogrammetry warps and distorts reality in a way that makes it seem as if forms are melting, or dissolving into thin air. I decided to focus my explorations on these imperfections inherent in the technology.

How to Break Photogrammetry

Before analysing and interpreting the aesthetics of broken scans, let's take a minute to ponder how they are born. In my explorations, the imperfections started coming about at the same time as I started getting sloppy with the capturing technique. With the sheer number of scans I was producing, I didn't have time to be meticulous with the capturing procedure. I was (unbeknownst to myself) breaking every rule in the book. Shooting underexposed photos, shooting blurry photos, shooting too few photos, shooting moving subjects. Each of these factors contribute to deteriorate the quality of the scan in its own way. And usually, it was a combination of these factors that resulted in the most twisted scans. Still, it might help to isolate a few of these poor scanning techniques in order to better see what each of them will do to the finished model. By editing the photos of the first, correctly executed scan and them to be processed again, we may have a closer look at what happens when we intentionally break the rules.



ABOVE: *REDUCING THE NUMBER OF PHOTOS IN THE SCAN FROM 32 TO 16.*



REDUCING THE NUMBER OF PHOTOS FROM 32 TO 16 PRODUCES STRANGE FACIAL GEOMETRIES.



AT JUST 8 PHOTOS, THE SOFTWARE DOESN'T HAVE ENOUGH INFORMATION TO ACCURATELY GENERATE THE BACK OF THE HEAD, AND INSTEAD SUPPLEMENTS WITH A DEFAULT COLOUR.

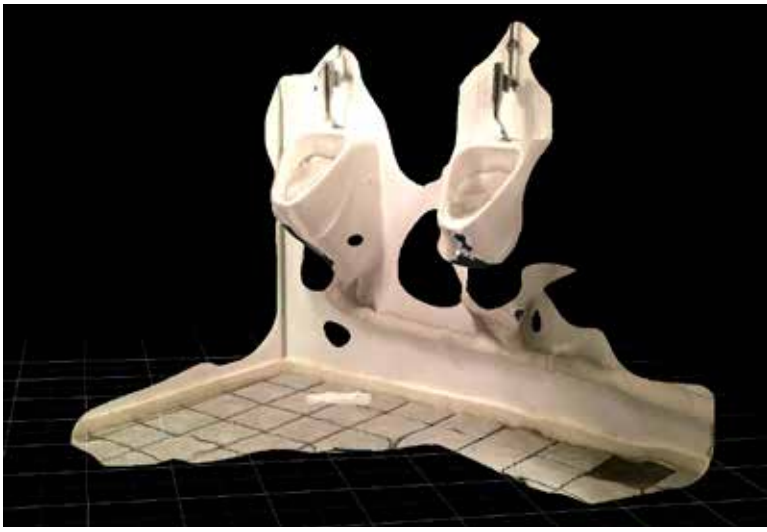


SIMULATING UNDEREXPOSED PHOTOS LEAVES US WITH SMOOTHER CONTOURS AS A RESULT OF THE DECREASED CONTRAST.



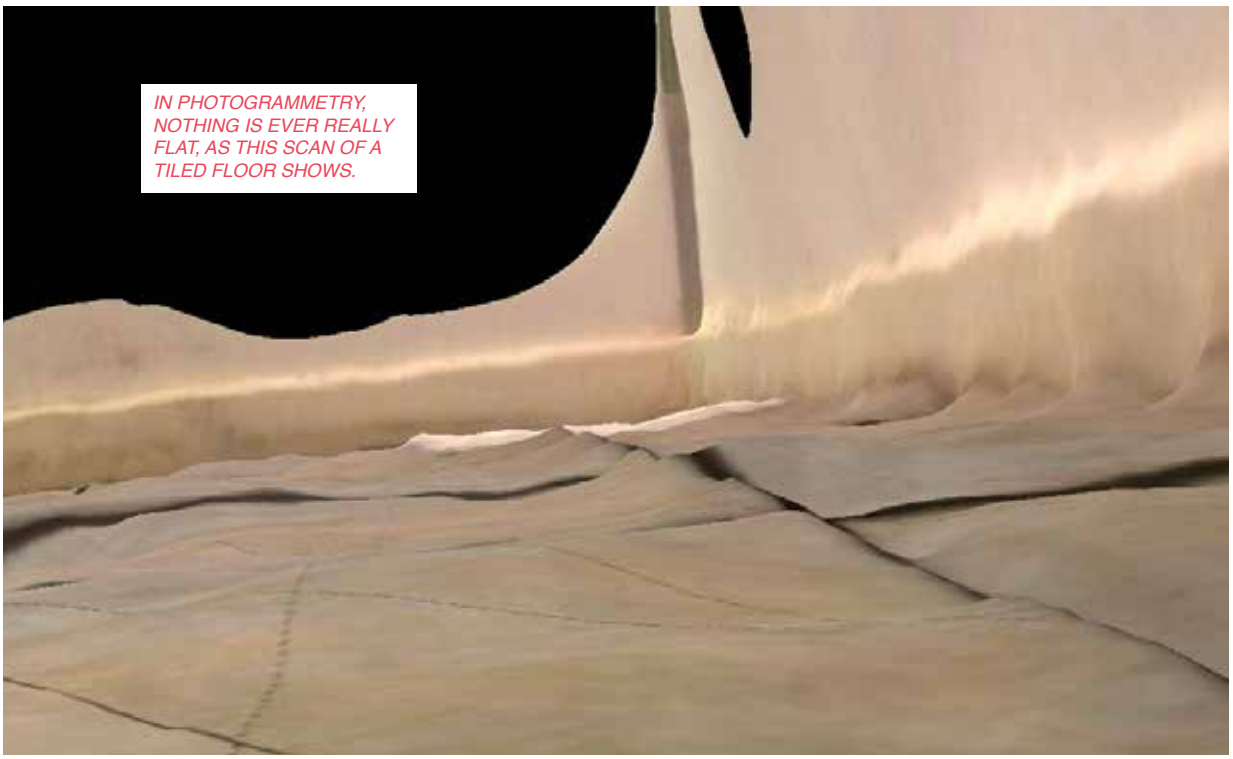
SIMULATING BLURRY PHOTOS CONFUSED THE SOFTWARE INTO THINKING THE BACK OF THE MODEL WAS BROADER THAN THE FRONT, RESULTING IN A "SLICE" THROUGH THE MODEL.

As mentioned earlier, the more interesting scans came as a result of a combination of these misuses. One misuse that is hard to simulate in post-production is shooting moving subjects. Even a few centimeters of movement can result in some truly broken scans. Throughout my diploma, I took well over two hundred scans. If I wanted to truly familiarize myself with the expression of broken scans, I needed to scan all the time, in all sorts of situations. As a consequence, my scans were getting sloppier and sloppier. I started out meticulously shooting thirty or more sharp, well-lit photos, but after a while my scans consisted of just 7-16 photos. Perhaps it was boredom. Perhaps it was the tediousness of taking "correct" scans. Nevertheless, the most interesting results came from this sloppy scanning of everyday life.





THE ABOVE PHOTO SHOWS HOW FEATURELESS SURFACES WILL OFTEN DISAPPEAR COMPLETELY FROM A SCAN. THIS IS REFLECTED IN THE WALL IN THE FOREGROUND OF THE LEFT IMAGE, WHICH IS LEFT LOOKING LIKE A SWISS CHEESE.



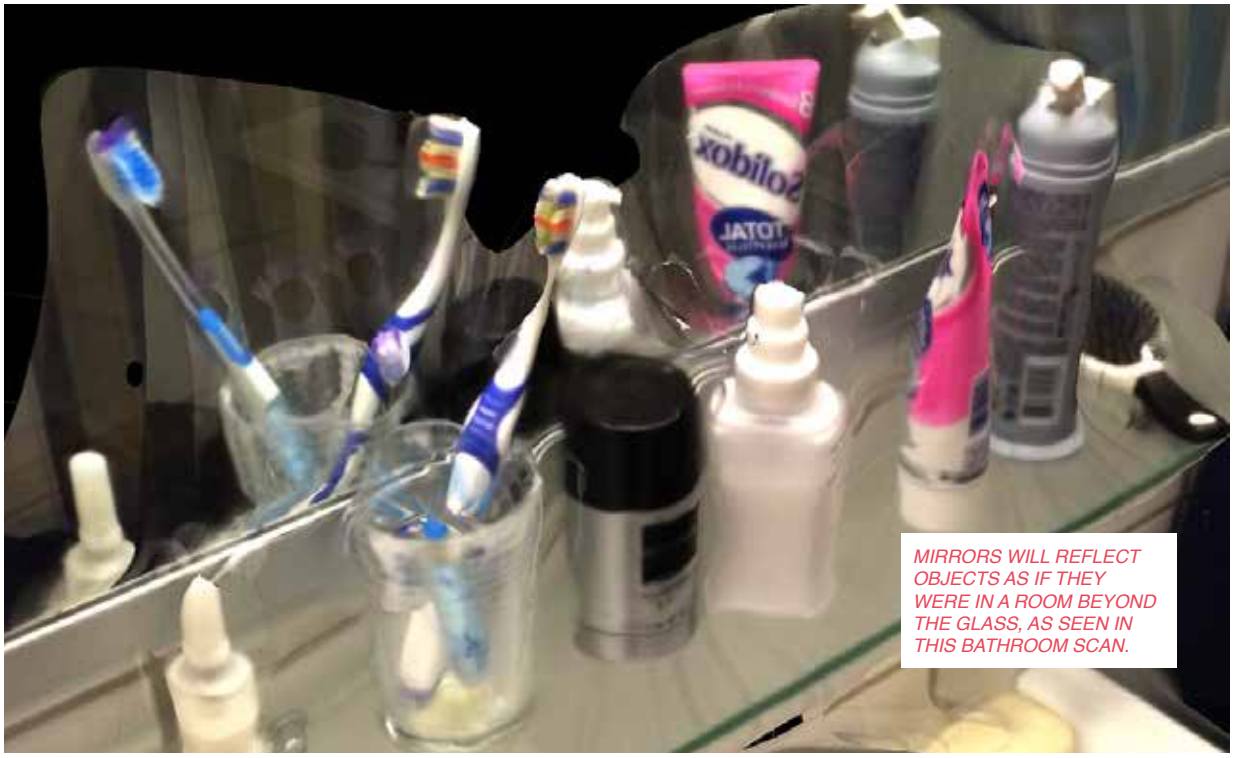
IN PHOTOGRAMMETRY, NOTHING IS EVER REALLY FLAT, AS THIS SCAN OF A TILED FLOOR SHOWS.



STRONG LIGHT SOURCES WILL OCCASIONALLY WARP SHAPES, AS SEEN IN THIS SCAN OF AN APARTMENT ENTRANCE.



TIGHTLY GROUPED OBJECTS WILL OFTEN BOND TOGETHER AS IF THEY WERE COVERED IN COBWEBS.



MIRRORS WILL REFLECT OBJECTS AS IF THEY WERE IN A ROOM BEYOND THE GLASS, AS SEEN IN THIS BATHROOM SCAN.

in memoriam

VIDEO RESOURCE: IN MEMORIAM https://vimeo.com/127396729

During my explorations into the imperfections of photogrammetry, a musician friend - Willas Rød - released an ambient remix of Andrew Lloyd Webber's "Pie Jesu". It had a sort of slowed down, off-pitch mood to it. I had shown him the strange, melted expression of the scans before, and we figured it might be a perfect match. I saw it as a good opportunity for doing an open cinematic exploration of photogrammetry. I wanted to see what it would feel like if one took the lo-fi quality of the 3D meshes and combined them with the traditional tools of cinema - lights, music and post-processing.

For the film, I used scans from a local church, as well as a few other scans that I had found interesting in my exploration. The church scans fit in with the soundtrack, as well as providing an interesting contrast to the digital, cutting-edge quality of 3D-scanning. I put them all into the animation software Blender, where I added lights and camera tracking. I also arranged the scans in impossible, dream-like configurations, to match the surreal quality of the soundtrack.

Evaluation

Although I had simply seen the film as a purely aesthetic exploration into what photogrammetry might look like in film form, it was not received as such. Viewers were finding it hard not to overinterpret the images, searching for a message where there was none, only a mood. In retrospect, I can understand why. It's very hard to remain objective when dealing with religion. Had I done another open cinematic exploration into photogrammetry, I would have completely omitted the church scans. Although, for the sake of the soundtrack I was supplied with, it seemed like a logical decision at the time.







reflection

Working with photogrammetry and three-dimensional imperfections was significantly more rewarding than digital media such as images or videos. Not just because it's taking place in three dimensions, but also because it is mostly unexplored territory.

Photogrammetry, as I found out, is an incredibly flexible tool. As a prolongation of my initial aesthetic exploration of digital glitches and flaws, I decided to apply my methodology on to the aesthetics of an imperfect scan.

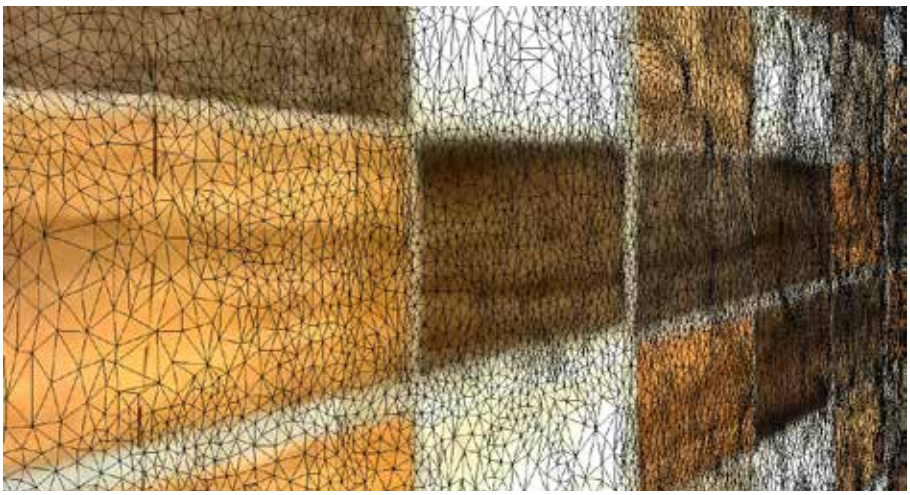
My approach was to take fewer photos, take photos while moving, take photos in poor lighting. Simply being sloppy combines the artefacts generated from every type of misuse, and is way more efficient in generating imperfect scans than being analytical and systematic, like my first experimentations with decreasing photo count et cetera. The paradox is that there is some skill involved in making imperfect scans. Be too sloppy, and the software won't return anything. Be too meticulous, and you'll get a nearly perfect scan, which, for the purposes of my diploma of digital imperfections, is not what we're looking for.

So, what is it about this warped, disintegrating aesthetic that makes it so fascinating?

It's a new kind of lo-fi. But where it separates itself from other types of lo-fi is that it in fact complicates shapes, while also simplifying them. Take for instance the way photogrammetry interprets flat surfaces. In the eyes of a photogrammetric 3D-scan, even the flattest of surfaces becomes a complex landscape with



OPPOSITE PAGE: *PHOTOGRAMMETRIC ABSTRACTION OF EVERYDAY LIFE.*
RIGHT: *VIEWING THE WIREFRAME OF THE MESH REVEALS THE ENOURMOUS COMPLEXITY EVEN IN FLAT SURFACES.*
BOTTOM: *ABSTRACTED SODA CABINET.*



tiny mountains and valleys. The algorithm has no concept of flatness. So even though a flat surface would make most sense to construct with a single polygon, photogrammetry uses thousands. This hang together with the fact that although shapes are abstracted and pulled apart, these scans are in no way low-resolution. They are the opposite of low-poly, and can contain over a million polygons each.

An attractive aspect of the scans is that they almost seem human in what they tend to focus on, and what is lost from the image. Because photogrammetry relies on clear landmarks to stitch images together, it struggles with featureless surfaces, and will often poke holes in them or omit them completely, as shown previously. This is similar to how our own human perception works. We tend to focus on features that stand out, rather than naked walls. Just like the scans, we disregard the unimportant.

Another key strength of the photogrammetry aesthetic is the way it melds photorealistic textures with abstract shapes. It's somewhere in the void between reality and fiction. Some objects remain well-defined and sharp, others drift out of focus. As interaction and installation designer Nick Stevens noted when shown the scans,

"It's got this kind of dreamlike aesthetic."
(Nick Stevens, personal communication, April 28, 2015)

Of course, the perception of what dreams look like will vary greatly from person to person, but this



photorealistic look bent towards the abstract reminded me of a famous quote by surrealist painter Zdzisław Beksiński:

"I wish to paint in such a manner as if I were photographing dreams." [38]

Having found an imperfect digital expression I was pleased with, the next step was to design something based on that aesthetic. To appropriate and use the broken scans to enrich an experience.
There have been appropriations of various types of digital lo-fi before. Pixel Pour 2.0[39] is just one example of a voxel sculpture, or pixel sculpture. The installation is located in New York and blends the physical and digital by placing unmistakably digital-looking water into a real world setting. There are also countless examples of pixel art being used in digital media, such as video games. When interviewed by Ars Technica magazine, artist Gary J. Lucken had this to say about the appeal of pixel art:

"I think it's all down to nostalgia. A lot of the people commissioning this type of art grew up playing 2D games so it's in their hearts, a love for pixels" [40]

As the photogrammetric imperfections I had found were a new expression, I couldn't count on nostalgic sentiment being a key strength. They are indeed strictly digital artefacts, but they are not old or retro. People





did not grow up with them. Adam Atomic - creator of *Canabalt* - however, made a statement on pixel art that I believe can be applied to all kinds of lo-fi expressions, and indeed, abstract expressions in general:

"I love that you can bring some of your own interpretation to a pixel art representation while it simultaneously communicates the purpose of the thing quite clearly." [40]

Abstraction opens up the possibility of interpretation. Although these photogrammetric shapes are concrete in that they have fully defined boundaries and volumes, they are clearly not truthful representations of reality. Instead of ending up in the uncanny valley, we forgive the scans for their inaccuracies because they are clearly not meant to look "right" in the first place.

***TOP**: THE PIXELLATED MAIN CHARACTER OF THE VIDEO GAME "CANABALT".*
***LEFT:** PIXEL POUR 2.0, A VOXEL SCULPTURE BY GARY J. LUCKEN.*
***OPPOSITE PAGE**: A LOW-POLY VERSION OF THE PANTON CHAIR, BY UNITED NUDE.*



part 3: designing for imperfection

After exploring how to generate imperfections, as well as discussing their aesthetic, it's time to see how the findings may be applied in a design context. To design an experience that may be enriched by an imperfect aesthetic.

In this chapter, I use my explorations into the aesthetics of imperfect photogrammetry, and design an experience around them. By drawing parallels to the history of photography, I design a new product category for the fully immersive 3D photo albums of the future - particularly relevant for future smartphones with virtual reality capabilities, such as the Samsung Gear VR.

THE MEMORY MACHINE



the scanner as an everyday object

Having found an imperfect aesthetic which appealed to me, it was time to figure out how it could be used to enrich a design.

As mentioned before, one of the reasons I chose to focus on 123D Catch and photogrammetry was its accessibility. It's a free app that everyone could potentially be carrying around in their pockets, and so it's worth considering how the 3D-capture device could function as an everyday object. Just ten years ago, the prospect of having a cell phone function as a 3D-scanner would seem like a far-fetched pipe dream.[41] It is a huge paradigm shift, or at least it should be. That makes it all the more frustrating to see Autodesk continue to market their incredibly accessible 3D-scanning app to the same user segment who might be 3D-scanning regardless of whether or not there was a free app available. Photogrammetry in itself is not new, but the fact that we are carrying it in our pockets is. It's this fact that I wanted to take advantage of when designing with 3D-capturing and its in inherent imperfections in mind. How the masses might embrace it, rather than just the niche user segment of 3D-print enthusiasts. Autodesk markets its app as a means to an end, and that end is to 3D-print the object. Unfortunately, the vast majority of users are not interested in 3D-printing.

To figure out how 3D capturing might appeal to the general public, it may help to look to analogue media for inspiration. Photography is not only a great inspiration when it comes to aestheticising imperfections, but may also give hints to what consumers might want from this newly accessible technology. The history of photography may also be seen as analogous to the potential development of 3D-capturing because this new technology, when all is said and done, is really just photography with an added dimension.

We can compare the paradigm shift of more accessible 3D-capture devices with the paradigm shift of the late 1800's, when Kodak started releasing the first cameras geared towards consumers. They offered a simple system for consumers to have their photos developed without the need for expertise in the field of film development.

> ***"…the Kodak was a simple box camera that came loaded with a 100-exposure roll of film. When the roll was finished, the entire machine was sent back to the factory in Rochester, where it was reloaded and returned to the customer while the first roll was being processed"*** [42]

What had previously only been accessible to a niche group of professional photographers had now found its way into the hands of the masses.[42] It was taken from the world of scientific exploration and carefully staged portraits into the everyday lives of consumers.[43] People immediately started documenting their daily doings. Friends, family and leisure activities found their way into family photo albums, where the photos would - either intentionally or not - form continuous narratives. Today the camera has become a ubiquitous object embedded in almost every device, from laptops to

RIGHT: *THE SMART PHONE OF THE 1800S: THE KODAK NO 1 WAS THE FIRST AMATEUR CAMERA.*
BOTTOM: *CHARACTERISTICALLY ROUND PHOTOS FROM THE KODAK NO 1, DOCUMENTING THE EVERYDAY LIFE OF THE 19TH CENTURY.*



tablets to the phones we carry in our pockets. We snap photos of special occasions such as parties, weddings and holidays, but also of the mundanity of everyday life. Most of us take hundreds, if not thousands, of photos every year. In a study from 2011, National Geographic concluded that the average American took 255 photos a year, and that number was expected to rise to 322 by 2015.[44] But why? Why are we so obsessed over documenting every little thing that happens in our lives? Photographer Monica Shulman gave an eloquent explanation:

"Because it makes me feel something. Moments are fleeting, time passes quickly before your eyes and landscapes are constantly changing. I think that what makes a photograph successful is subjective, but for me, the most important element is that it makes you feel something. What is it about a moment that moves you enough to capture it? A wave will never crash against the shore in the same way, my kids will only have one birthday celebration a year, and the light might never touch a person's face like that





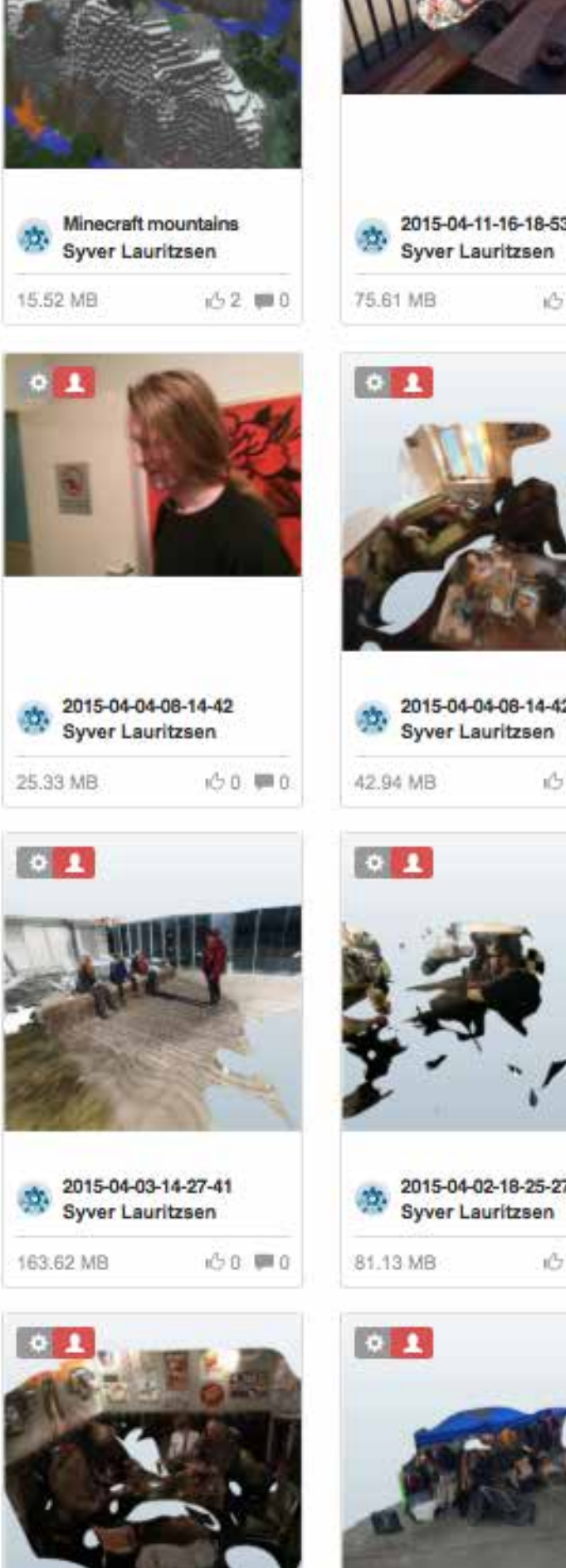
again, and the camera is there to document and preserve that moment so that it can live and move you forever. Beauty and art are everywhere.

[…] To hold on to memories

There are days you wish you could hold on to, and with your camera, you can. I'm as interested in capturing our mundane routines as I am in capturing holidays and special events. . . . Taking pictures helps you to hang on to those memories a little longer. Hardly anyone (except me, it seems) makes photo albums anymore but remember how you felt and how your smile spread across your face when you would hold those prints in your hand? We're looking at pictures on our screens more than ever but the feeling of wanting to hold on to memories is still the same." [45]

Having captured more than 200 scans over the past few months, I began to consider the collection as a whole. I found myself looking at old scans not for academic reasons, but rather for the sake of revisiting old memories, much in the same way people flick through an old photo album. Although it had started out as an analytical exploration into the technicalities of 3D-capturing, the collection of scans had become a chronicle of my own personal life.

I started to wonder if these broken 3D-scans might be used as a documentation of everyday life. How does the characteristic appearance change the experience of everyday situations? May the scan carry a greater emotional impact than a photo? Of course, to see if the scan had any real value compared to the photograph, it was necessary to compare the two.



RIGHT: *A CLOSE-UP OF 123D'S WEB USER INTERFACE, FEATURING A FEW OF THE SCANS TAKEN DURING MY DIPLOMA.*

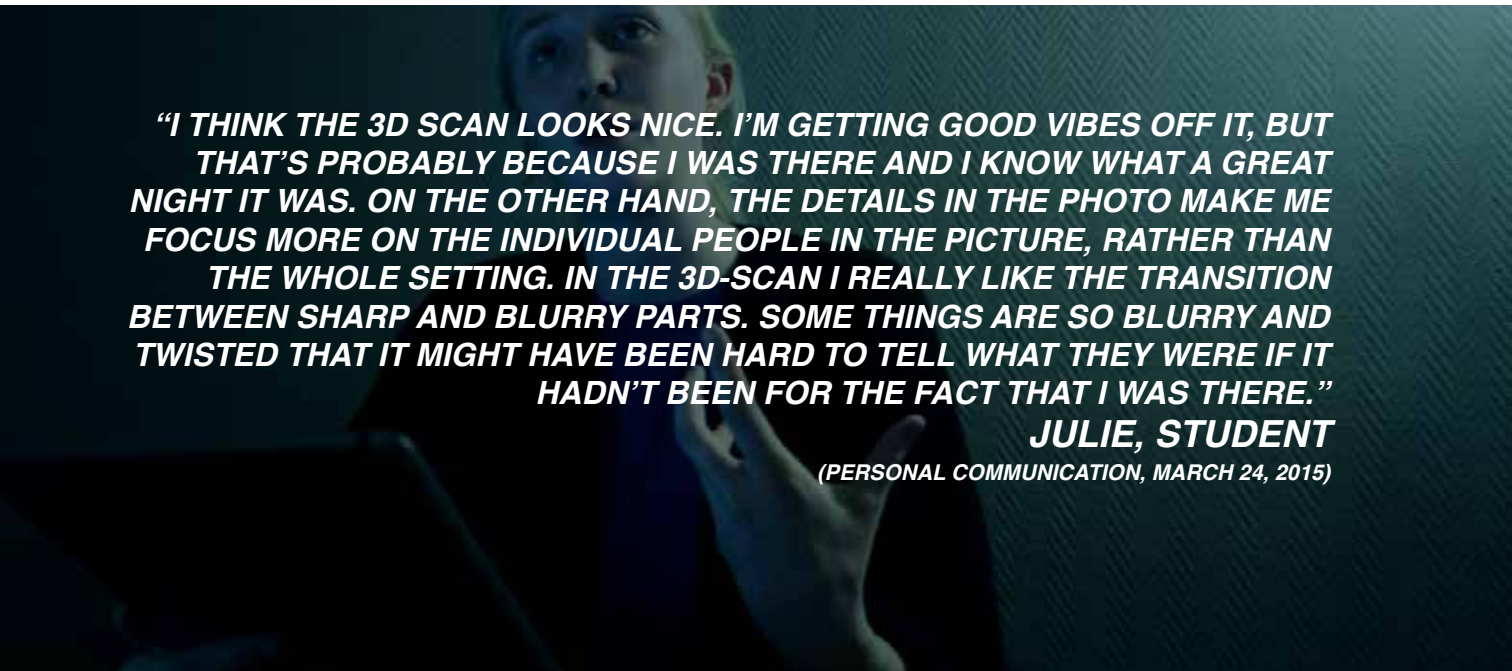
memory aesthetics

After establishing that an accessible smartphone-based 3D capture device may function well as a tool for storing memories, it was time to figure out how the strange new expression of the scans would fit into the mix. May they serve as an analogy to how memories are perceived? How have memories been depicted in art and popular culture? Are there similarities to the imperfections of the 3D-scans?

Interviews

User involvement is key to understanding needs in a design process. To test the feasibility of having 3D-scans function as a documentation of everyday life, I decided to conduct a few interviews where I showed the subjects a photograph as well as an imperfect 3D-scan of the same moment in time. The interviewees were all shown photos and scans of situations they were part of themselves. This way they could compare the two mediums side-by-side, drawing comparisons and analysing the differences. They were also given the opportunity to rotate the 3D-model and view it from different sides, and they could zoom in and pan around in the photograph. After getting over the initial fascination for the pure novelty of the 3D-scan, they gave some thoughts on what impressions they were left with.

Although I never informed the subjects about my intentions behind interviewing them, their comparisons to a large degree corresponded with my own ideas around the 3D-scans. I simply asked them to speak



"I THINK THE 3D SCAN LOOKS NICE. I'M GETTING GOOD VIBES OFF IT, BUT THAT'S PROBABLY BECAUSE I WAS THERE AND I KNOW WHAT A GREAT NIGHT IT WAS. ON THE OTHER HAND, THE DETAILS IN THE PHOTO MAKE ME FOCUS MORE ON THE INDIVIDUAL PEOPLE IN THE PICTURE, RATHER THAN THE WHOLE SETTING. IN THE 3D-SCAN I REALLY LIKE THE TRANSITION BETWEEN SHARP AND BLURRY PARTS. SOME THINGS ARE SO BLURRY AND TWISTED THAT IT MIGHT HAVE BEEN HARD TO TELL WHAT THEY WERE IF IT HADN'T BEEN FOR THE FACT THAT I WAS THERE."

JULIE, STUDENT

(PERSONAL COMMUNICATION, MARCH 24, 2015)

freely about how they felt about their respective 3D scans compared to the photos.

The main takeaway from Julie's conversation was her thoughts on the value of the abstraction, and how that value is specific to her, because she herself was in the situation in question. When looking at the photo, she zoomed into look at the funny expressions people have when photographed mid-sentence. She noted that although it was a pleasant evening, the people in the photo didn't look happy at that very moment in time. The 3D-scan, on the other hand, gave her pleasant associations, because rather than focusing on the minute, unimportant details of the photograph, she focused on the general mood of the evening. Its overall vibe. She also pointed out that due to the strange, twisted nature of the scans, she wasn't sure if anyone else would be able to appreciate it in the same way she did.

Thomas almost seemed upset when he started discussing the scan. He was upset because although it was a situation he was part of, he didn't feel like it was *his*. He had seen me on the night in question with my camera, and so he knew where the scan was taken from. He said he wished it had been taken from his point of view. However, he quickly came to the conclusion that the expression itself looked like someone's memory. When asked why, he drew comparisons with sci-fi films such as "Eternal Sunshine of the Spotless Mind". Thomas's reaction reminded me of Heidegger's hammer.[18] The brokenness of the scans had provoked in him a strong emotional reaction.

To the third interview subject, Einar, the main value of the scan was its pure weirdness and brokenness. He simply appreciated it for its novel character, compared to the boringly perfect photo. The loss of detail in the scan didn't bother him. He said the most important parts - the essence of the situation - remained.

It seemed from my interviews that the scans not being perfect was not a problem. As Julie hinted at, they may even holder a greater value than photos as a keepsake, because of how they reduce unnecessary details, leaving us with only the bare essence of whichever situation they were taken in. Photos, on the other hand, present us with every single detail, which is great in most cases, but if our intention is to communicate the feeling of a memory, fleeting and intangible, the abstraction of the scan might serve us better.

BELOW: *SIDE-BY-SIDE COMPARISON OF JULIE'S PARTY IN PHOTO AND 3D-SCAN FORMATS.*



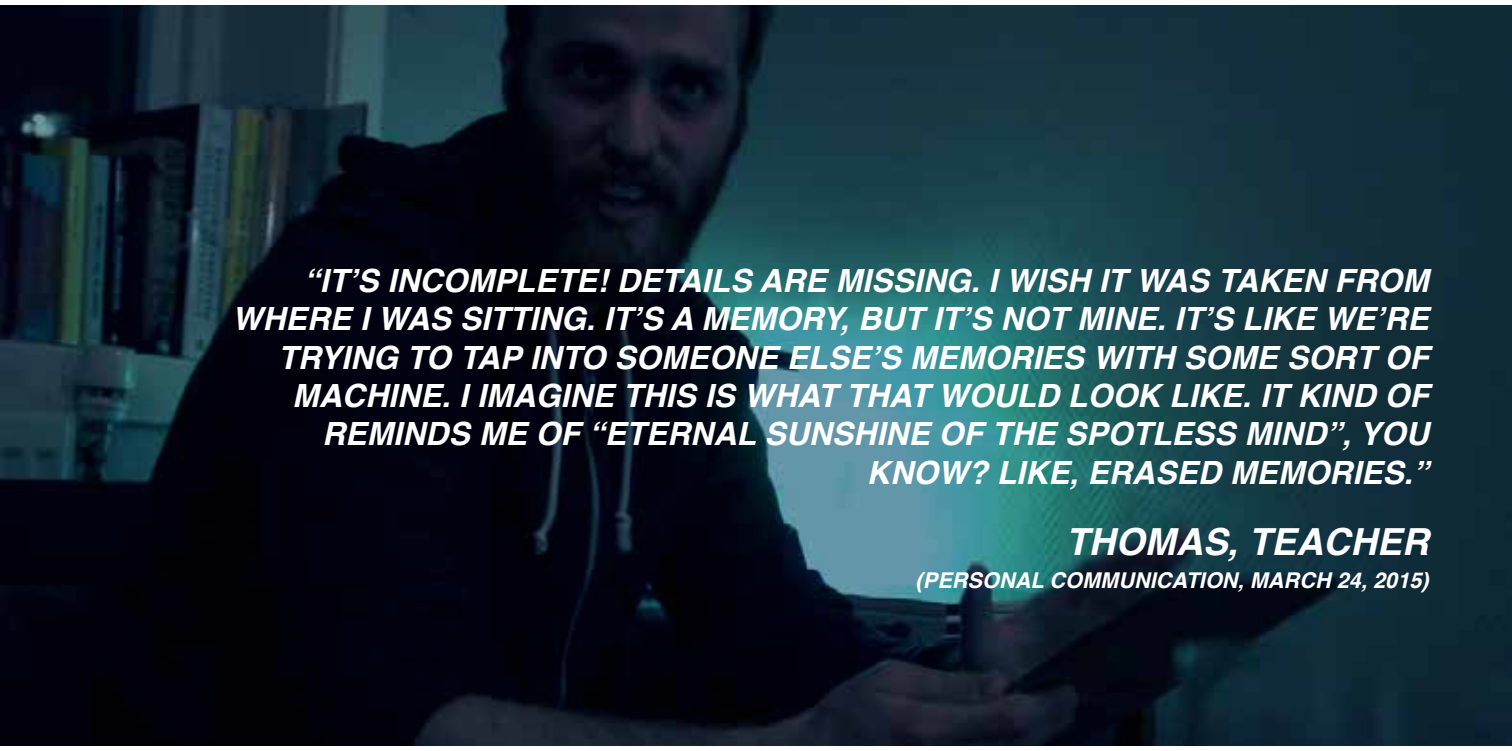




"I JUST LIKE HOW BROKEN IT LOOKS. FORMS MELT TOGETHER. SOME OBJECTS ARE OMITTED, OTHERS ARE NOT. UNEXPECTED SHAPES APPEAR OUT OF NOWHERE. IT'S A LOVELY KIND OF CHAOS. THE PHOTO JUST LOOKS BORING. THIS IS NOVEL AND DIFFERENT."

EINAR, MUSICIAN

(PERSONAL COMMUNICATION, MARCH 26, 2015)



"IT'S INCOMPLETE! DETAILS ARE MISSING. I WISH IT WAS TAKEN FROM WHERE I WAS SITTING. IT'S A MEMORY, BUT IT'S NOT MINE. IT'S LIKE WE'RE TRYING TO TAP INTO SOMEONE ELSE'S MEMORIES WITH SOME SORT OF MACHINE. I IMAGINE THIS IS WHAT THAT WOULD LOOK LIKE. IT KIND OF REMINDS ME OF "ETERNAL SUNSHINE OF THE SPOTLESS MIND", YOU KNOW? LIKE, ERASED MEMORIES."

THOMAS, TEACHER

(PERSONAL COMMUNICATION, MARCH 24, 2015)

Depiction of Memory in Arts and Culture

Memories are pervasive. One cannot possibly hope to find the true expression of such an intangible and fleeting concept. One may however see how others have gone about communicating them, to see how this may correspond to the imperfect scans.

In *Memento*, Leonard Shelby suffers from severe short term memory loss.[46] The film follows him as he struggles to cope with his amnesia in the pursuit of his wife's killer. *Blade Runner* tells us a story of a future where humanoid androids - replicants - live their lives not even knowing they're not human.[47] They have fake memories to ensure they are kept unaware of their own true nature. *Eternal Sunshine of the Spotless Mind* is a story about a couple - Joel and Clementine - who both decide to have the memories of one another erased.[48] As Joel undergoes the procedure, he re-encounters the happier memories of the relationship and struggles to keep them from perishing.

Although the concept of memory is frequently used as a plot device in movies - whether it be flashbacks or a central plot - , it is rarely depicted any differently from the rest of the film. At most, it is given a different colour filter, such as sepia or black and white. Sometimes clever editing is used, such as in *Memento* where the whole film is shown to us in reverse, thus leaving the viewer with the same disorientation as the protagonist. As far as my research shows, the only film which makes a fully-fledged attempt at trying to make tangible and visual the fleeting concept of memory - or at least fading ones - is *Eternal Sunshine of the Spotless Mind*. The film had been mentioned during the interviews regarding the aesthetics of the imperfect scans.

Much of the film plays out in the sleeping protagonist's mind, as he struggles to hang on to memories of happier love with his ex-girlfriend. In it, the concept of a fading memory is depicted using a pitch black environment, with little "hot spots" of memory fragments riddled throughout. Dream imagery is mixed with real footage to communicate the unreality of memory. Facial features disappear or are twisted in monstrous ways. The handheld camera and camera-mounted spot-light give the memory scenes a dreamy, surreal quality. Since these scenes play out while the character is sleeping, one could assume that in addition to being a depiction of memory, it is also a depiction of dreams. Although it is generally agreed that dreams and memories are connected, the exact nature of this relationship is convoluted and debated.[49]

It is equally difficult to find actual visual depictions of memory in the arts. If a given art piece deals with the concept of memory, it is usually in a metaphorical or analogous sense. There are, however, quite a few artists who deal with dream imagery. One of the more famous ones is of course Salvador Dali. He would sometimes refer to his paintings as "hand-painted dream photography".[50] Reading through several analyses of one of his most famous paintings, *The Persistence of Memory*, it becomes clear that he never explicitly stated what his paintings were about. The painting in question features multiple melting clocks - a recurring symbol in his paintings - which he himself attributed



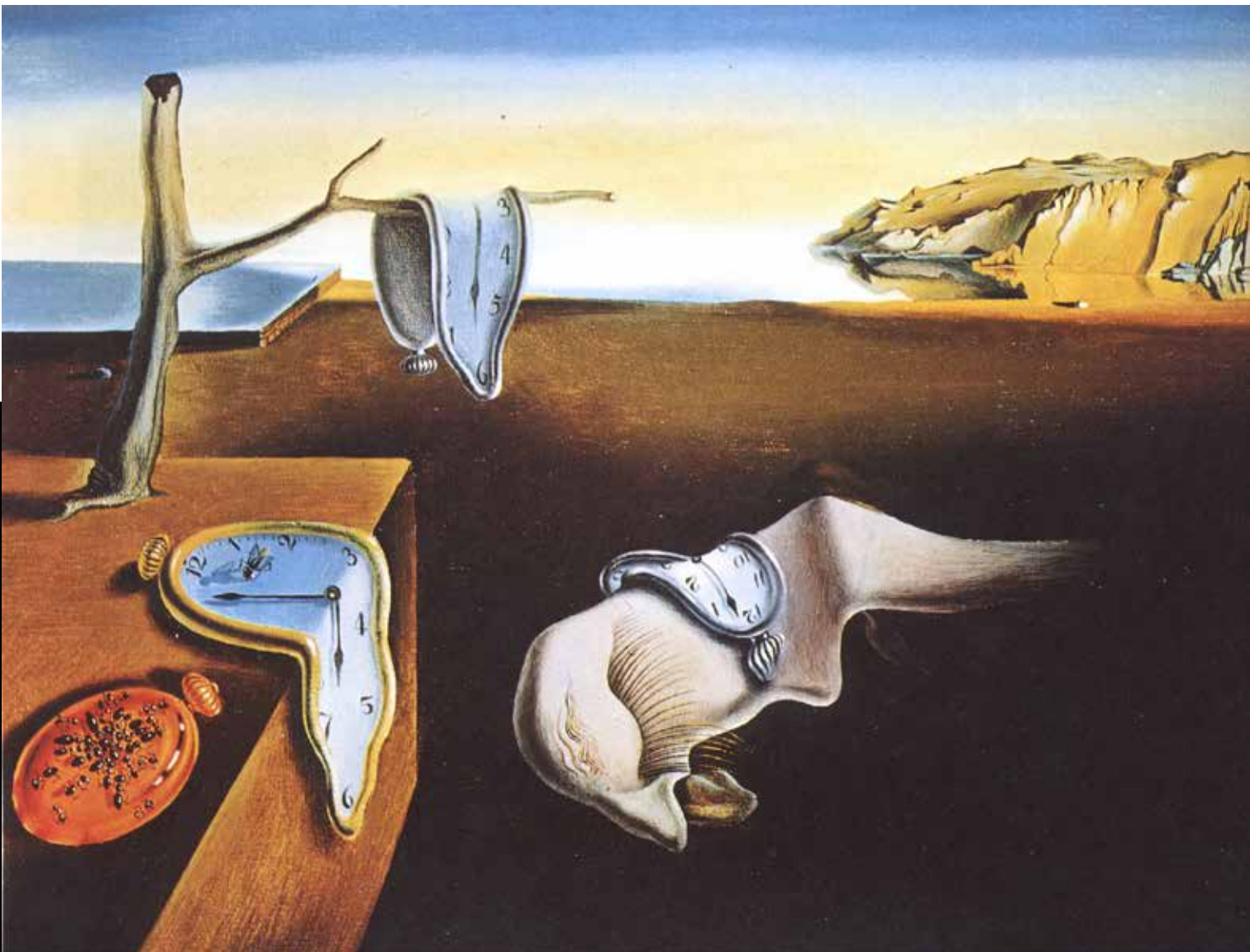
to the sight of a melting Camembert cheese on a hot summers day. He leaves us to speculate what their true meaning is. Could their melting aesthetic - reminiscent of the expression of the imperfect scans - be how he envisioned memories to look like?

"Dali would often make up ridiculous explanations for his paintings to purposely mislead people. The Camembert is an example of just that. By doing this Dali […] opened the doors for discussion of multiple interpretations of his art" [50]

As Thomas had noted in the interviews, the broken scan had reminded him of *Eternal Sunshine of the Spotless Mind*. Rewatching it, it's easy to see what he meant. The abstraction of scanned human faces is reminiscent of the abstraction the human faces of the film go through. I had gotten other comments that the scans looked "dream-like". The way the scans often come out in disconnected fragments corresponds with a quote from an article in Scientific America, which discussed the relationship between dreams and memory:

"Most of our dreams just recombine fragments of waking life." [49]

OPPOSITE PAGE*: A FRAME FROM ETERNAL SUNSHINE OF THE SPOTLESS MIND.*
BELOW*: THE PERSISTENCE OF MEMORY, BY SALVADOR DALI.*



memory platform

How does one get the best experience of viewing the broken scans? What will provide the greatest emotional impact? Choosing the correct medium for displaying and viewing the scans is integral to a good user experience. Of course, the go-to platform these days is the app. This is also where Autodesk decided to focus their 3D-capture technology. I originally considered the possibility of making a 3D photo album for phones and tablets, until I realized what a great injustice that would be to the fact that these are 3D, and not 2D, photos. Along with the paradigm shift of accessible 3D-scanning, we are currently undergoing another technological revolution, within the field of virtual reality.[52] Incorporating a VR-headset would allow the user to get the full value of the scans being actual three-dimensional shapes, instead of flat images which belong on a flat screen.

Virtually *everyone* seems to be developing a VR-headset these days. Oculus Rift, Sony and Samsung (To name but a few) are all developing their own headsets. Although we have seen the virtual reality-trend rear its head before, many believe that it's here to stay this time. Developers all over the world are trying to figure out what this technology will be used for. As well as being more accommodating for three-dimensional shapes, the VR-headset offers *presence* - something which a screen cannot.

Presence, when discussing VR, is the feeling of *actually being there*. It's a hard concept to explain, or even understand without experiencing it for oneself.



OPPOSITE PAGE: A RETROESQUE VIRTUAL REALITY-CONCEPT RIGHT: THE SAME EQUIPMENT THAT SAMSUNG SPONSORED ME, USING THE GALAXY NOTE 4 SMARTPHONE AS A KEY COMPONENT.



Michael Abrash, part of the team working on Valve's VR headset, gave this description:

"Trying to describe presence is bound to come up short – you can only really understand it by experiencing it – but I'll give it a shot. Presence is when, even though you know you're in a demo room and there's nothing really there, you can't help reaching out to try to touch a cube; when you automatically duck your head to avoid a pipe dangling from the ceiling; when you feel uneasy because there's a huge block hanging over you; when you're unwilling to step off a ledge. It's taking off the head-mounted display and being disoriented to find the real world there. It's more than just looking at someplace interesting; it's flipping the switch that makes you believe, deep in your lizard brain, that you are someplace interesting. Presence is one of the most powerful experiences you can have outside reality, precisely because it operates by engaging you along many of the same channels as reality. For many people, presence is simply magic." [53]

If our aim is to give memories a greater emotional impact, surely presence may go a long way in doing so. Presenting 3D-scans in a VR-environment gives the user a greater sense of being back in that moment in time the scan was taken from. It's one step closer to the dream of being able to go back and actually relive cherished memories.

VR-headsets such as the Samsung Gear VR and Google Cardboard are extra relevant. They integrate the very same devices which are now capable of taking 3D-photos; Our phones. The constant increase in phone screen resolution may be blamed for the massive VR-wave we are currently facing. Screens have been getting drastically smaller and more packed with pixels over the past few years, which allows us to finally construct crisp VR headsets that are light enough to easily strap to our heads. It was only natural that companies started basing VR-headsets around phones, which already possess screens and processing power.

virtual memory browser (vmb)

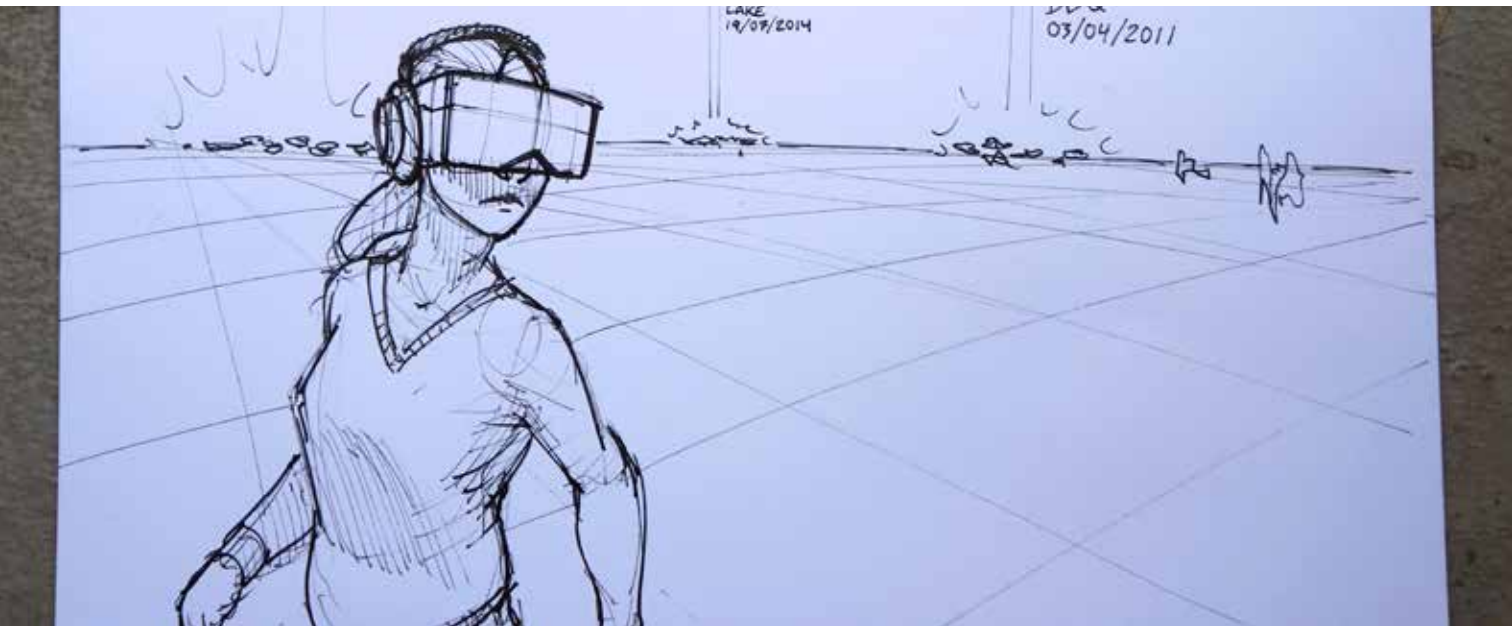
THIS PAGE: EARLY CONCEPT SKETCH
OPPOSITE PAGE: VMB BROWSING EXAMPLE. CLUSTERS OF MEMENTOS REPRESENT ALBUMS.

The idea of using 3D-scans in virtual environments can make way for dozens of different products and services. Many of which are already being looked into. The most looked into application is probably live 3D-scanning, using scanners such as the Microsoft Kinect to capture a live three-dimensional image of a person or object. This technology may be used for a number of applications. For instance, long distance business meetings will feel more visceral with the added dimension. Entire concerts could be captured in 3D, and people from around the world could witness it in a virtual setting, even walking up on stage and jamming with the band. Even Facebook is embracing virtual reality. In March of 2014, the company purchased Oculus Rift VR, and has already begun rolling out 360 degree video for the device.

3D capturing is also being more embraced, not just by Autodesk. Google's Project Tango is a research project which is currently developing phones and tablets with integrated 3D-cameras.[55] Apple has just purchased an Isreali startup specialising in smartphone camera technologies with depth sensing capabilities.[56] The world is embracing the world of VR and 3D, and all evidence suggests it's here to stay this time.

Design Concept

My design proposition is the Virtual Memory Browser (VMB). In short, it is a fully immersive, three-dimensional photo album. Its job is to bring users back to that point in time when the 3D photo, also known as memento, was taken. Users capture mementos using their phones, which are then placed into a three-



dimensional environment - their *Animus*, and may be sorted in a number of different ways. Chronologically, by event or by location. The word *animus* is taken from latin, and may be translated into spirit, or soul.[54] Users may share their animus with friends, much in the same way we share photo albums today.

It is meant to be used with future VR-headsets which integrate phones with 3D-capturing capabilities. Today's equivalent would be something like the Samsung Gear VR. The phone will be the tool for both capturing and viewing mementos.

It's impossible to say what type of 3D-photo technology will become most prevalent over the course of these next few years. Will it be the Kinect-type 3D-scanning capabilities of Google's Project Tango, or the mysterious camera technology Apple is developing? It is not unthinkable that photogrammetry will still be the way phones will capture moments. With faster processing power, the user could theoretically use the video function to capture a scene in a matter of seconds. This possibility of 3D from video was demonstrated in my experiments into photogrammetry.

The user will move about inside the simulation using only the headset. There is no joystick or other peripheral required. I believe external peripherals will only detract from the experience, and so they should be avoided. However, as this is a future-oriented design concept, I am not ruling out the possibility of new, more VR-friendly peripherals being developed. As of today, we have a very unintrusive peripheral - the Leap Motion Controller - which uses a forward-facing camera to capture hand gestures. However, through testing I found out that as of today it just doesn't function well enough to compliment the experience.

Users can customize what their Animus looks like. They can add different types of lighting, ambience and ambient soundtracks to suit their own tastes. Even the mementos themselves may be assigned audio, either from the environment the memento was taken from, or a custom soundtrack.

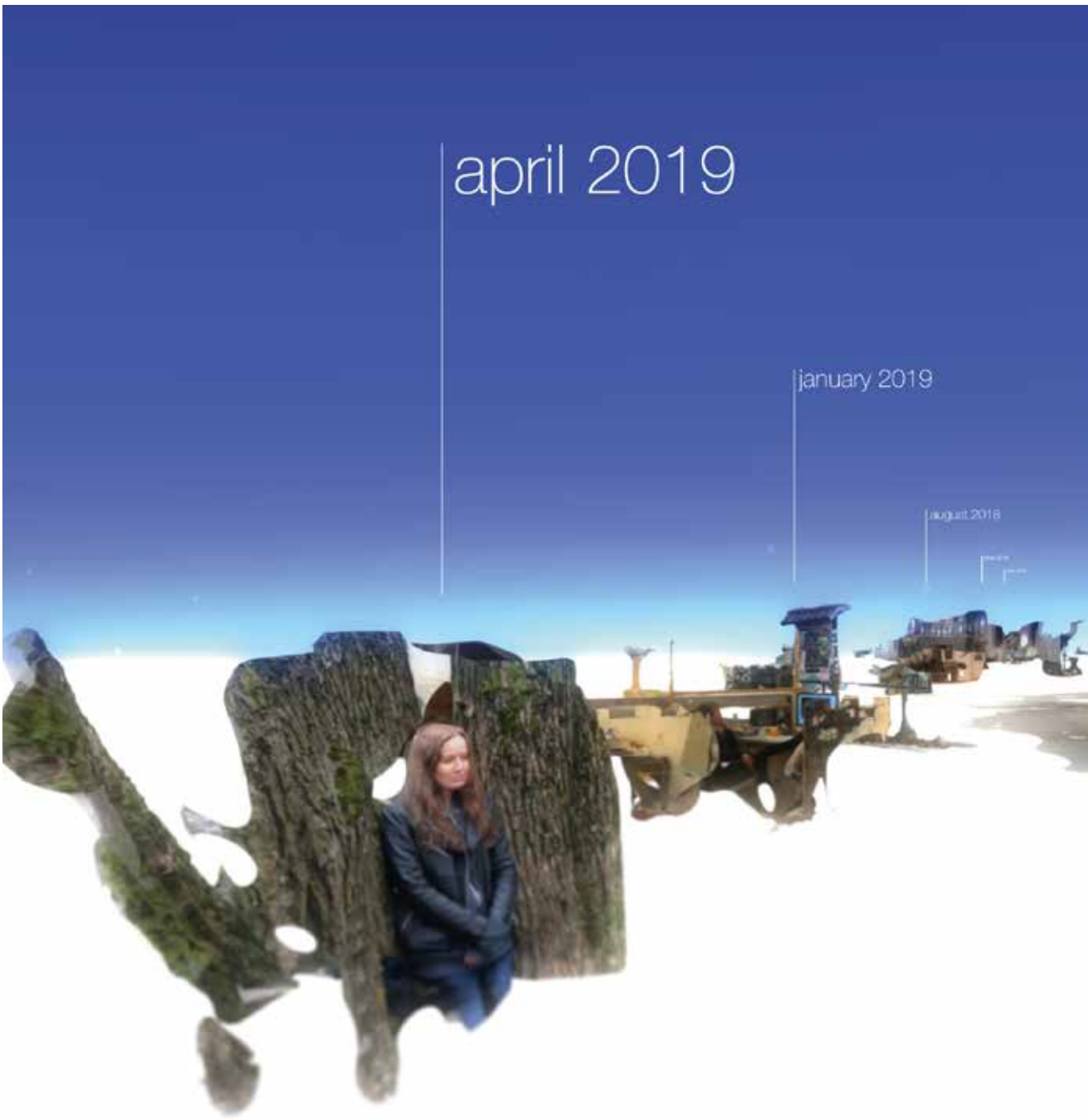
The Virtual Memory Browser product category is intended for those users who use their smartphones to capture and share photos today.

The Importance of The Prototype

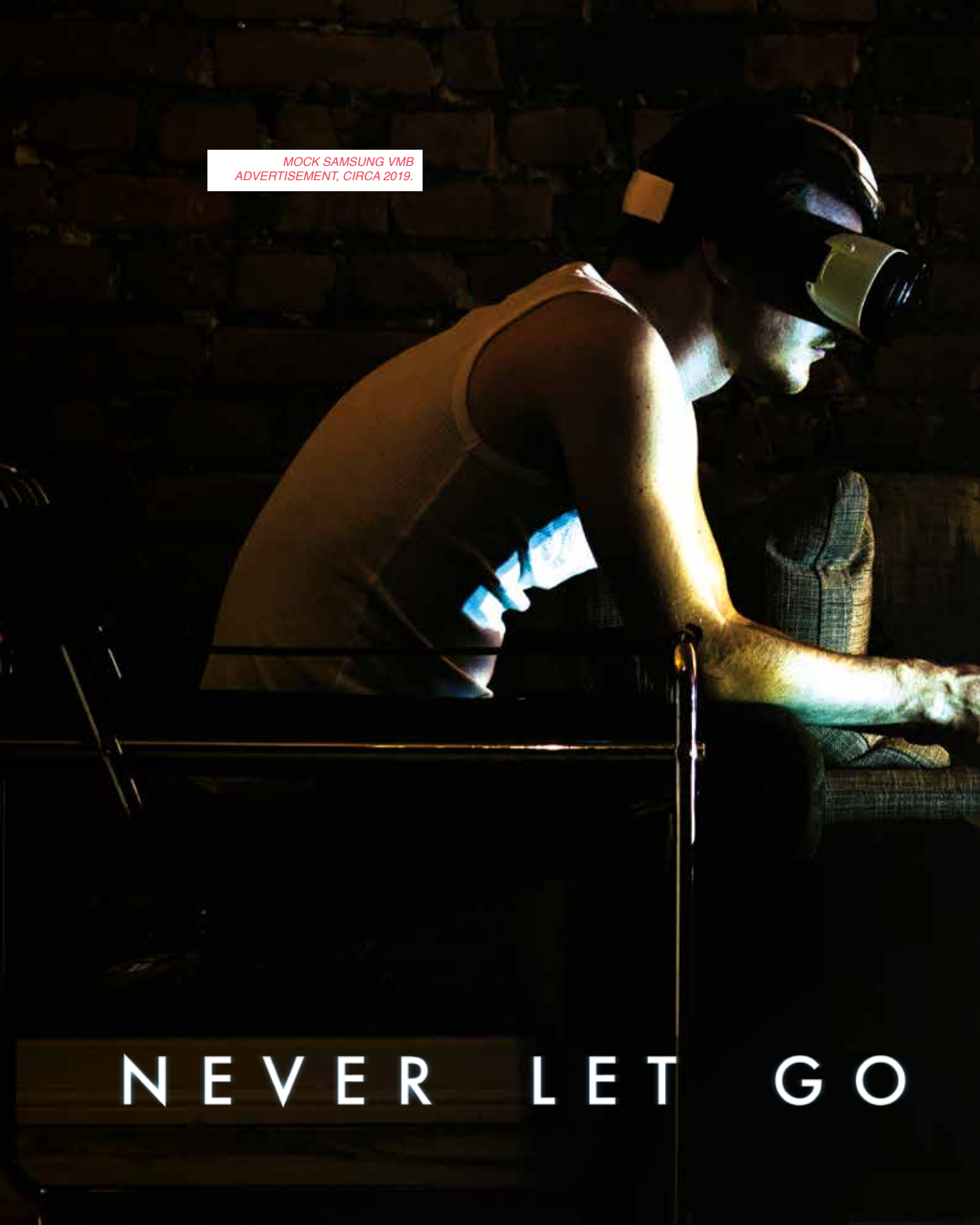
To demonstrate the validity of the concept, I decided to focus on creating a working prototype, rather than designing user interfaces, developing sharing mechanisms and deciding on business strategies. My main objective was instead to demonstrate how this new way of exploring memories may give a greater emotional impact than the traditional photograph. That, as well as a way of navigating an environment without peripherals, is where the innovation of the concept lies.

I wanted to create a prototype that would function well in an exhibition setting, to give as many people as possible a beautiful, engaging experience that would let them get a taste of what the photo album of the future might feel like. An experience that has value in and of itself. This means that the prototype will operate under slightly different design principles than the overarching concept. I dubbed this prototype *The Memory Machine.*




april 2019
january 2019
august 2018





MOCK SAMSUNG VMB ADVERTISEMENT, CIRCA 2019.



* Only compatible with the Samsung Galaxy X11, requires a GEAR VR7 HMD. Should not be used by children under the age of 7, pregnant women, or those suffering from depression, anxiety or epilepsy. Please reminisce responsibly.

the memory machine

VIDEO RESOURCE: THE MEMORY MACHINE https://vimeo.com/127403512

My explorations and subsequent research into 3D-scanning and virtual reality eventually lead me to my final, tangible deliverable. A prototype for a Virtual Memory Browser, focusing on providing users with an emotional and engaging way of exploring imperfect 3D-scans in a virtual space. The Memory Machine is a prototype intended to give users a taste of what it might be like to use a VMB.

Design Goals

For the Memory Machine, the main design goals were these: Design an experience fit for an exhibition setting, where the user can put on a VR-headset and enter an animus - a virtual environment in which 3D-scans are placed.

Since the design is for an open exhibition setting, users should be able to come and go as they please. There should be no definitive "beginning" or "end" of the experience.

There will be no extra peripherals to the experience besides the headset, as that would distract from the experience. Secondly, I wish to distance the project from the usual video game realm that virtual reality concepts usually operate in. Using traditional peripherals could make the user see it as just another video game, rather than an emotional experience.

Speaking of emotion, it is at the very centre of the experience. The main goal of the prototype is to explore what sort of emotional impact experiencing imperfect 3D-scans in a virtual reality setting may have



***OPPOSITE PAGE**: USER TESTING WITH THE OCULUS RIFT DK1*
***RIGHT:** DEVELOPMENT SHOT.*



on a user.

Lastly, and this should go without saying: The experience should be beautiful and engaging, making users actually want to interact with the prototype, and get excited about the prospect of a future VMB.

The Memory Machine

The Memory Machine, although developed with an Oculus Rift headset, is programmed to be flexible enough to allow easy switching of virtual reality headsets. It was only tested with the Oculus Rift because that is what I had available at the time, but using other headsets is as close to a plug-and-play operation as one can get. The experience was created using the Unity 5 game engine.

Although one may imagine different ways of sorting mementos in a real-life version of a VMB, they are randomly placed in the Memory Machine. This is to give users a reason to engage with the experience. Their own curiosity about what comes next is the main drive behind using the machine. Secondly, detaching mementos from their original context and presenting them without description leaves the users to interpret their context themselves. The whole experience is procedurally generated as it unfolds. This means that no two uses will ever be the same. New constellations of mementos will be formed with every use, giving every user their own story to tell from the experience.

The experience has no goals - there is no way to "win" or "lose". If the player reaches the end of the "playing field" (Which would take considerable effort) he or she is dropped back into the centre. The simulation is forgiving in that there are no "wrong" choices to make, which might frustrate a potential user.

The Memory Machine is populated by mementos - objects or items that serves to remind one of a person, past event, et cetera. There are two reasons why I chose to use my own mementos for the simulation. The first is that I already had a "memory bank" of over 200 mementos sitting around, waiting to be used. The second was that these were, indeed, real. If I were to base the mementos off someone else's life, chances are it would be difficult to get an honest impression. Even if I followed them around for days, my presence would have them act differently from them being alone. This gives the Memory Machine a high degree of honesty. Nothing is staged. As later user testing would show, users appreciated this fact.

The user controls the interaction using light head movement. One could imagine being propelled from under ones feet - that is what the logic of the controls are based on. Look down to go forward, look up to go backwards, and tilt your head from side to side to move from side to side. Turning is, as one would expect, done by turning. The user may turn his or her head and look slightly downward to travel anywhere he or she pleases. Some of the mementos have sound attached to them. These function both as a way of increasing immersion, but also to encourage users to explore, searching for the source. In close dialogue with a musician, I developed an ambient soundtrack to compliment the whole experience.

Now I would like to go in a bit more detail with regards to technicalities of how all these elements are made and the thought process behind them.

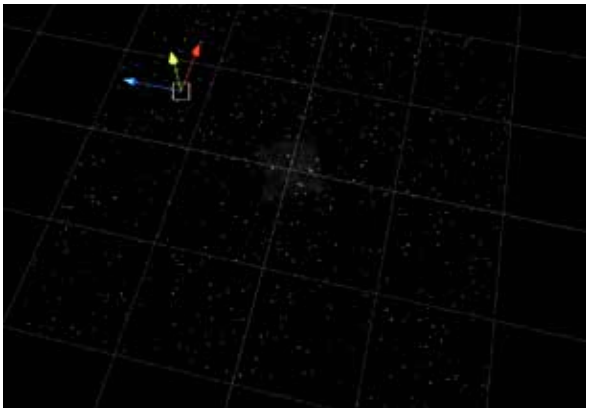
Flexibility

From the ground up, I programmed the Memory Machine to be as flexible as possible. The whole experience is easy to remix and adapt. From playing field size, to memento density to cosmetic details. This was important to the design process because as media artist Chris Milk noted in his TEDTalk *How virtual reality can create the ultimate empathy machine*:

> ***"Talking about virtual reality is like dancing about architecture."*** [57]

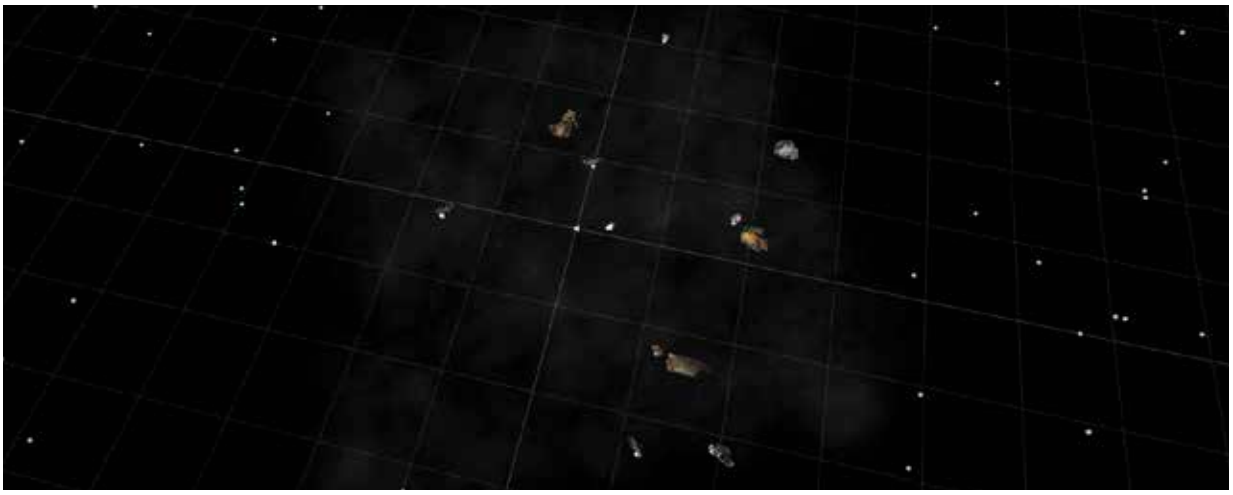
Meaning, to understand virtual reality, one has to experience it. It's incredibly difficult to accurately judge how well a design decision is going to work in a virtual reality-setting. The medium is so new, so different, that it was necessary to experience every design choice for myself before judging if it was a good call, especially considering it was my first foray into the world of VR, or indeed, game engines at all. The flexibility inherent throughout the prototype allowed me to make drastic changes on the fly, allowing for a dynamic, hands-on design process with constant testing.

I used the Oculus Rift DK1 for developing the prototype, but the flexibility means that switching to a different headset should be a simple plug-and-play operation.



Procedural Generation

To give users a reason to explore the environment they were dropped into, I decided not to make clearly-labelled clusters of mementos, as was the idea with a potential real-life VMB. Instead, I wanted to make both the placement and the content of each memento randomly generated as the user engaged with the prototype. Appealing to the user's curiosity, rewarding exploration rather than presenting them with every memento in an easy-to-grasp way, instantly spoiling every element of surprise. This way, every new use would present a different story. Every user would interpret a new narrative. The idea was simple, the execution was challenging. One of the main issues had to do with computer strain - I wanted the user to be able to explore a vast expanse littered with mementos. However, loading 500 high-density 3D meshes at the same time is bound to crash even the most powerful of

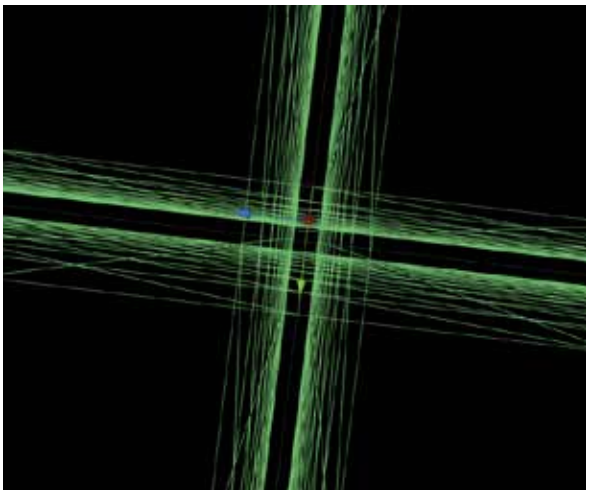


computers.
After trying and failing a few times, I finally found a solution built from the ground up by myself that worked. When the simulation is first initiated, a simple function sprinkles "nodes" in random locations across the entire playing field. For most testing, between 500 and 1000 nodes would be distributed. Each one of these nodes represents the location of a potential memento. When the user enters within a certain radius of a node, a random memento is loaded into its location. This trigger radius is always further away than the user is able to see, to avoid mementos suddenly popping into view.

You Can't Go Wrong

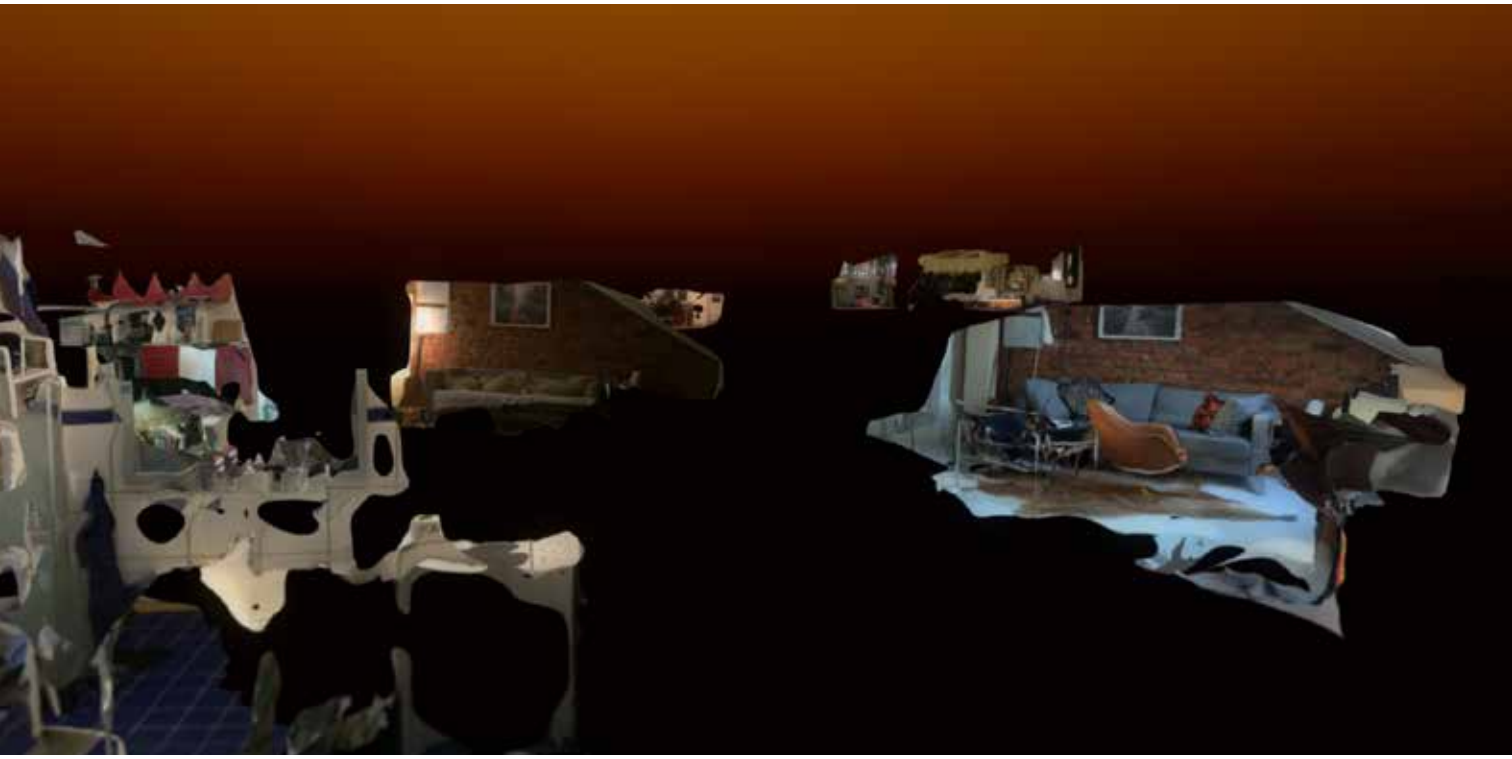
As mentioned, the experience is designed to make it impossible for the player to do anything "wrong", frustrating and discouraging them. This is accomplished by having four invisible walls generated at each of the edges of the playing field when the simulation is initiated. If the player reaches and touches one of these walls (Which still takes a good 5-10 minutes of walking in a straight line and is quite rare) he or she is dropped back into the centre of the playing field. The barren nature of the animuses I designed make this drop-in almost unnoticeable.

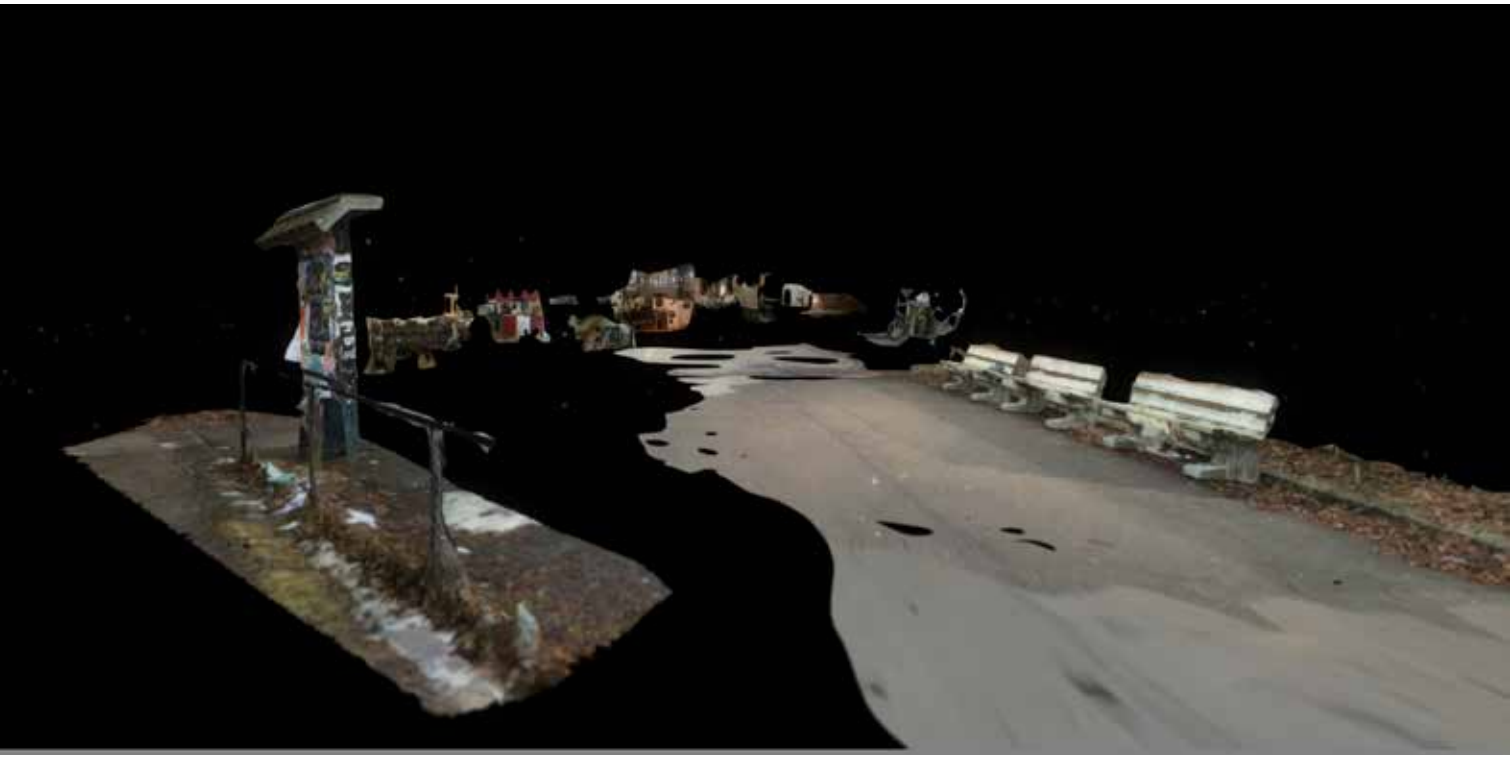
OPPOSITE PAGE, TOP: *1000 NODES DISTRIBUTED ACROSS THE PLAYING FIELD*
OPPOSITE PAGE, BOTTOM*: NODES TURN INTO MEMENTOS AS THE PLAYER APPROACHES THEM*
BELOW*: FOUR INVISIBLE WALLS ARE GENERATED WHEN THE PROTOTYPE IS INITIATED.*



The Animus

Animus is the name I gave to any given person's simulation environment in a VMB. It is latin for spirit, or soul. In a functional, real-world scenario, this would be customisable by its owner. A user could reflect their personality or mood in the way they customised their animus. The animus in the Memory Machine was developed through dozens of iterations, ending up with two vastly different moods. One was dark and mysterious, the other one was bright and ethereal. These diametrically opposed moods were chosen because it allowed me to see what both ends of the spectrum felt like. They also allowed me to test the two vastly different moods with users, to get their input on what sort of emotional impact each of them had.
In the dark mood, the only form of illumination is a bright, slightly blueish light that follows the user. Everything else is pitch black, with hints of smoke on the horizon to help orient the user and add to the atmosphere. This sole point of illumination makes mementos appear from the darkness only a few meters away from the user. Never knowing what will emerge from the pitch black environment puts the user on edge, and gives a feeling of entering someone's nightmare. The extreme darkness gives an almost strangling sense of isolation, although the faint smoke somewhat counteracts this and helps give the user a hint of what lies beyond the radius of the illumination. The scene is accompanied by a dark, brooding ambient soundtrack.
The bright mood is the exact opposite. The user can see a good 100 meters ahead. Mementos dot the horizon like little islands and make it easy for the viewer to orient him -or herself. As mementos recede into the distance, they are gradually blurred out until disappearing into the whiteness. A "bloom"-effect is added to the camera, which lets the brightness of the environment leak over the contours of objects. This gives a feeling of almost being blinded by the bright ambient lighting. Early testers likened the environment with their preconception of what a heaven may look like. A comforting, heartfelt soundtrack accentuates the mood.
One element the two moods have in common is that they both have mechanisms for obscuring mementos from sight long before the user reaches them. This allows them to actually be generated well out of viewing range, avoiding pop-in.





















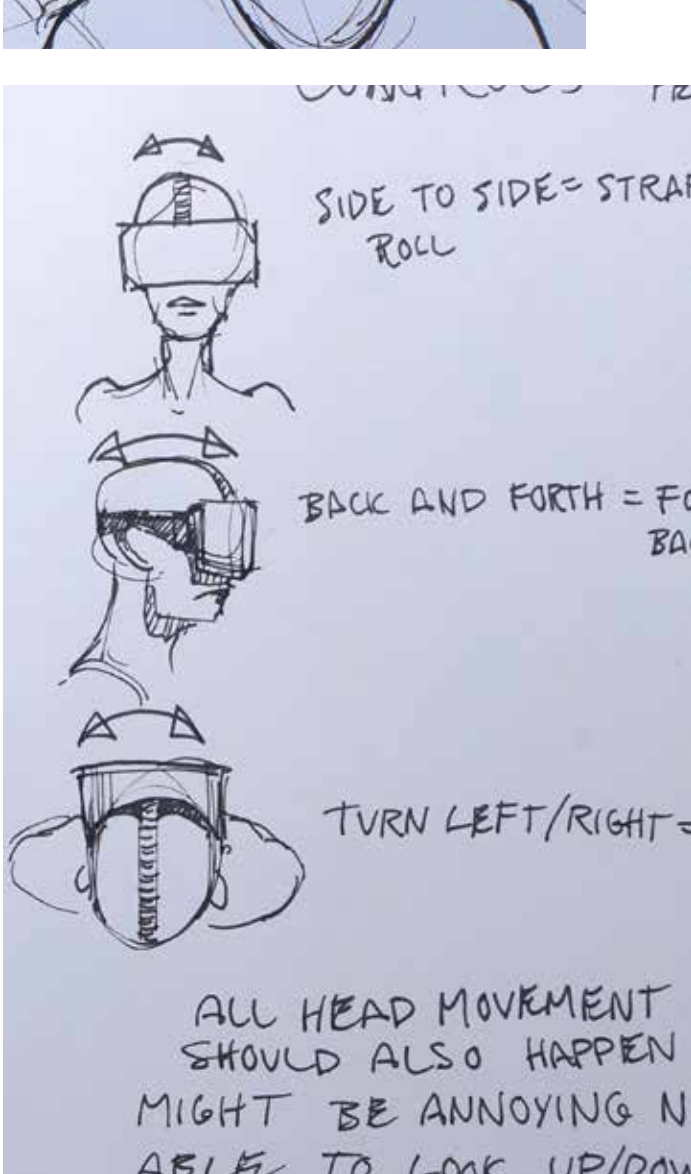




Transparent User Interaction

I wanted to design a control system so intuitive that the user would not even know he or she was using it. As mentioned, avoiding extra peripherals was key to ensuring a smooth, uninterrupted experience. It was also a way of distancing the prototype from a video game. In addition, a real-world VMB is intended for use with smart-phone integrated head mounted displays such as the Samsung Gear VR. Being able to control the experience without extra peripherals means the user doesn't need to drag along extra equipment to use the VMB. It's meant to be a mobile, easy to use and readily available experience, not something requiring complex setup.

The user moves forward by looking down, backwards by looking up, and from side to side by tilting their head from side to side. Other than that they are free to turn and explore in any direction they like. Although I had originally thought that moving by using head movements would make for an annoying experience, the controls work surprisingly well. This may be in part due to how fluid they feel. The simplest way of designing such a control scheme would be for me to program a rigid function that would simply move the user faster according to the tilt of their head. Instead, the user is tied to an invisible sphere which rolls around on the ground according to input from the head mounted display. The fact that "real" physical forces are acting in on user movement results in a smooth and "floaty" experience. Acceleration and deceleration both feel natural. The loose movement enhances the feeling of floating around in a dream world. One could of course imagine that more functional, rigid control systems would be used for a real-life solution, but the



fluidity of the one I designed compliments the mood of the experience.

Mementos

There are a few issues that need to be sorted out before photogrammetric scans are ready to be inserted into the simulation. Most importantly, their fidelity needs to be heavily reduced. Straight from 123D Catch, they typically consist of 600k-1,2m polygons. Just a few scans as heavy as these will bring even the most powerful of computers to their knees. Therefore, this number needs to be reduced to 30k-80k, which is still a fairly detailed mesh.

After bringing the scans into Unity, they need to be assigned hitboxes that the user can collide with. This prevents the user from being able to pass straight through the mementos. Also, because of the unique control system, it makes it easier for the user to stop at any given memento simply by crashing into it.

Audio

In addition to the animus's ambient soundtrack, some of the mementos have audio clips associated with them. In a real-world scenario, the user of the VMB will be able to assign these audio clips themselves. These can be recordings from the environment the memento was taken from, or other custom audio clips.

In the Memory Machine, the audio clips have a heavily exaggerated doppler effect associated with them. This means that the audio will pitch up when the user is moving towards the source, and down when he or she moves away. This serves two purposes. The first is that if the user decides to pursue the source of an audio clip, they will be given hints telling them if they are getting closer or moving further away. The second reason is an aesthetic one; The extreme doppler effect helps give the audio of the experience a surreal, dreamlike quality.



evaluation

After completing the first iteration of the prototype, I wanted to show it to as many people as possible to see what they had to say about it and how it could be improved.

Samsung

The first and most obvious choice was of course Samsung. Their Gear VR already incorporates a smart phone and the company is therefore highly relevant for a future VMB-solution. I presented Samsung with the concept, and they immediately took a liking to it, seeing the future potential of such a VMB. They understood my decision to focus on the emotional aspects of the design rather than the more functional ones, and decided to sponsor me with a Samsung Gear VR along with a Galaxy Note 4, to see if it would be possible to port the experience over to their platform. They could see the prototype possibly being used as a demo scene for internal and external use. This is easier said than done - the Gear VR uses only the processing power of the phone itself, rather than an entire computer. As I started to familiarise myself with their HMD (Head-mounted display), it quickly became apparent that optimising the experience to work on a Gear VR would be too time consuming within the scope of my diploma - not to mention for someone with little experience in programming and software optimisation. So I decided to get in touch with someone who might be able to make a more educated guess as to whether or not this was achievable with today's equipment.

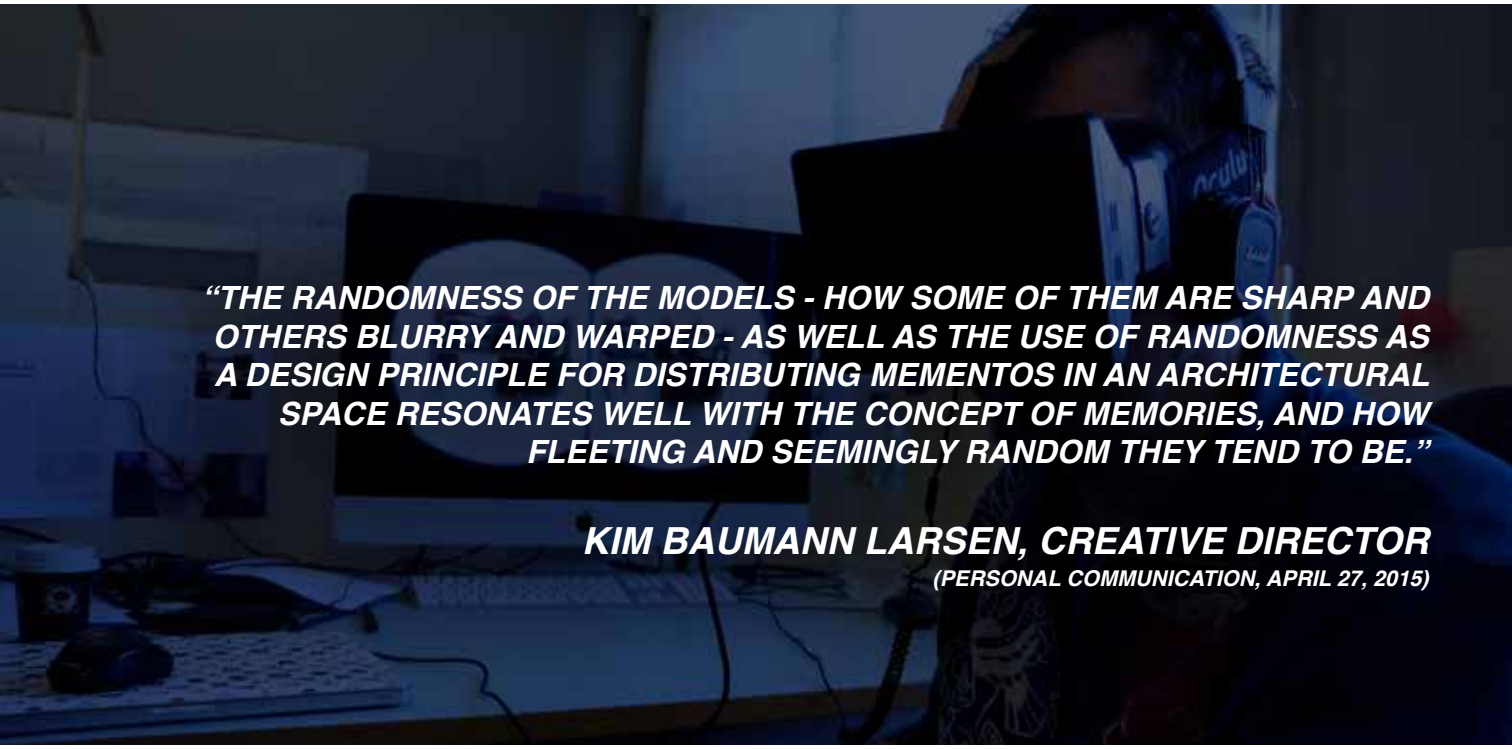
Kim Baumann Larsen

A licensed architect, Kim has over 20 years of experience in production design and visualization, and is a leading Norwegian VR-developer. I figured he might be able to give a better idea of how plausible it would be to run the prototype on a Gear VR, as well as give general input on the experience.

Although it was hard for him to give a definitive answer, he figured that with a few weeks of optimisation work, it should be possible to run the experience on a phone-based HMD. However, we both agreed that spending weeks optimising would not be the best use of the remainder of the diploma. He did however note that porting the experience over to a Gear VR would be a massive improvement simply for the fact that it is wireless. The rigid wire of the Oculus Rift DK1 detracts from the experience because it makes the user feel committed to only moving in one direction.



LEFT: *SAMSUNG LOGO.*
OPPOSITE PAGE, TOP*: KIM BAUMANN LARSEN TESTING THE PROTOTYPE.*



"THE RANDOMNESS OF THE MODELS - HOW SOME OF THEM ARE SHARP AND OTHERS BLURRY AND WARPED - AS WELL AS THE USE OF RANDOMNESS AS A DESIGN PRINCIPLE FOR DISTRIBUTING MEMENTOS IN AN ARCHITECTURAL SPACE RESONATES WELL WITH THE CONCEPT OF MEMORIES, AND HOW FLEETING AND SEEMINGLY RANDOM THEY TEND TO BE."

KIM BAUMANN LARSEN, CREATIVE DIRECTOR
(PERSONAL COMMUNICATION, APRIL 27, 2015)

As to the experience of the prototype, he was quite surprised at how well the control system worked. As myself, he had had a preconception that using one's head and neck to move around in a simulation would be frustrating and unintuitive.
He thought the abstraction of the mementos helped enrich the experience, as their contrast between sharp and blurry was a good analogue to the concept of memory. (Kim Baumann Larsen. Personal communication, April 27, 2015)
A few weeks after our meeting, Kim got back to me with information that he had contacted a talented 3D-modeller to have a look at the scans, who had concurred that porting the experience over to the Gear VR should be possible.

Nick Stevens
Installation designer Nick Stevens had a chance to try out the prototype and give his thoughts on the experience. Similarly to Kim, he was surprised at how intuitive the controls felt, and even said they fit in with the concept I was trying to convey. That the loose, floaty controls fit in with the dreamlike aesthetic of the rest of the prototype. Although the control system is not as tight as one would expect, Nick stated that he found enjoyment in this - that it was "chill" to relax and just float around. (Nick Stevens. Personal communication, April 28, 2015)

User tests
Of course, it was essential to test the prototype with non-designers as well. This was done informally throughout the development cycle, but a more formal user test was also conducted at the conclusion of the first iteration. The most prominent descriptions of the experience were "Fun", "Relaxing" and "Exciting". Following are a few key findings
An 8-year old girl was given ten minutes to play with the prototype. Out of everyone who tried it, she was the one who mastered the controls the quickest. She navigated around the animus effortlessly almost immediately after equipping the HMD. Perhaps this is due to children not having as strong preconceptions as adults of how one moves about in the real world. As a result, they are more receptive to vastly different methods for getting from A to B. It was difficult getting



***LEFT**: ROBIN, 8, GIVES THE PROTOTYPE A WHIRL.*
***BOTTOM**: RONNY AND TUVA FROM THE NORWEGIAN RADIO STATION P3 TRY OUT THE MEMORY MACHINE.*

her to quit playing with the prototype, as she found it highly engaging.

The most valuable feedback came in the form of comments on the control system. Several testers reported that they felt like backwards movement was too fast, while forwards movement was too slow. This was countered in following iterations on the prototype.

When asked about the imperfections of the mementos, all of the testers reported that they thought it was an intentional design decision. That I had treated the scans to somehow look imperfect. They said it was complimentary to the experience. The child said she thought the images looked "burnt".

"Fun" was a word that was repeated again and again during testing. One comment was that it was tied to the sense of the animus being infinite (Although in reality, it is not) and so the tester felt like he could keep on exploring indefinitely. Another tester said she found it engaging to hunt down the sources of audio clips she could hear in the distance. A third tester found it engaging because she was kept at the very edge of her seat during her explorations into the dark mood. That it was a very thrilling experience never knowing what might emerge from the darkness.

There were split opinions on which mood the testers liked the best. Although the dark one was more exciting, the bright mood was more pleasant.

One tester noted how she would love to share her potential animus with friends.

Nick Stevens' note about how comfortable it was to just



float along was repeated in the user tests. The tester sat still for a good twenty seconds, watching the mementos fly by. She commented on this as she was using the prototype. The same tester gave a good indication of the "presence" of the prototype, when she reached out and tried to touch a few of the mementos, commenting that she felt like she should be able to feel them in her hand.

Personal Reflection

Overall, I was pleased with the evaluations I had received from other users. It's easy to become blind to the effectiveness of one's own design, so a second opinion was crucial to evaluate the successfulness of the prototype. I was especially surprised at the positive remarks I got on the control system. The physics-enabled way of navigation corresponded to the users' preconceptions of walking around in a dream world. As previously established, dreams and memories are closely linked, so the users getting dream associations is a positive outcome. One tester gave a particularly encouraging remark: Without me having explained to him what the prototype was supposed to be, he remarked:

> ***"I get the feeling I'm walking around inside your memory"***
> ***(Ronny Brede Aase. Personal communication, May 3, 2015)***

Even without any sort of explanation or context, the user had reasoned that he felt he was navigating my own personal memory, which was exactly the feeling I had hoped to communicate.

The comments the users gave me on the navigational system were implemented into the next iteration on the prototype.

The users felt very receptive to the imperfect expression of the scans. In conversation, they explained that they prefer the imperfect scans over the perfect ones. This could have to do with the better scans falling into the uncanny valley. There is something sinister about perfectly rendered scans - especially the ones of humans - standing perfectly still. They are like creepy manikins, poised to strike. Also, the consistency of the imperfections made users assume that they were the result of careful modelling on my part, rather than the natural imperfections of the capturing technology.

Although photogrammetric imperfections are at the centre of this prototype in particular, a real VMB may use a different set of technologies, as mentioned. The imperfections of this given technology might not be the exact same as the ones on display in the Memory Machine. It is impossible to say exactly what they might look like, but one thing is for certain - they will not be perfect. Although 3D image capture technology geared at consumers is undergoing rapid development, it is likely several decades away from being able to capture the perfect scan - a 360 degree view of any given person or object, captured in a split second. Until we have that, there will always be imperfections. I believe one of the reasons no one (That I know of) has attempted to design something like a Virtual Memory Browser before, is because they are afraid that the current imperfections of the technology might ruin the experience for users. Similar concepts have instead been reserved for science fiction. Until now. I believe that through the Memory Machine, I have shown that by taking advantage of the presence inherent in VR experiences, users will appreciate - or in a worst-case-scenario, ignore - the brokenness of the medium.

The random placement of the mementos was interesting from a narrative point of view. I was pleased to see the users actively search for meaning in the random constellations of mementos they were presented with. As they were unaware of the fact that the whole experience was randomly generated every time, they thought someone had placed every memento for a reason, for them to discover.

Although a real-life VMB might use a different technology for capturing scans, photogrammetry works quite well for the purposes of conveying a sense of memory. Not only does it give the photograph a third physical dimension, but it is also gives the dimension of time, since the technology isn't instant. It gives an average. This average is perhaps why early user testing revealed that the *mood* of the image is more apparent than its details. Lastly, the finished mesh will have different levels of focus - reflecting what the user (Maybe unconsciously) was focusing on in that given situation. What they *wanted* to remember.





AN EXAMPLE OF THE RANDOM MEMENTO CONSTELLATIONS THAT ARE GENERATED. IN THIS CASE, FRAGMENTS OF A KITCHEN ARE PLACED INTO A PARK SETTING.

second iteration

The user testing gave me valuable feedback with regards to the mood of my animus. Although users found the bright mood more "pleasant", the dark mood kept them at the edge of their seats, and seemed to provoke more of an emotional response, which was the objective of the design. However, coupled with the smoke effects and the sinister ambient soundtrack, I believe it became too stereotypical of a horror-experience. I decided to base the next iteration on the dark mood for the excitement it brought to the table, but make certain tweaks in the lighting and environment, as well as develop a new soundtrack in close cooperation with a musician, to give the animus more of a unique mood. The audio tracks of the mementos were also iterated on. They were all designed to fit together in the same chord structure, so while moving around in the experience, the user would also be generating a unique soundtrack in real time.

For added depth, a dust mote effect was developed. It has a blueish, almost magical tint. The smoke effect was drastically toned down and tweaked to go along with the new mood. The specks of dust, besides possessing an ethereal eeriness, help communicate to the user which way he or she is currently moving, as well as provide as great sense of depth to the image. Aesthetically, I think the dust motes help communicate an environment which has been eternally frozen in time. I have also gotten comments that they contribute to the dreamlike expression.

The user feedback on the control system was also taken



into consideration, and it was tweaked accordingly.
The illumination was drastically tweaked. To give the scenes more sense of movement, the light following the player was animated as if it were dangling from the ceiling. It was also made colder to fit in with the rest of the environment.

The Road Ahead

Although this concludes my work with the Memory Machine in an academic setting, I intend to keep working on it. There are a few things I still would like to implement before calling it finished:
First of all, I would like to add significantly more mementos. Ideally hundreds. Due to the long-winded road from scan to memento, the Memory Machine doesn't quite contain as many as I'd like it to, and the user will usually see the same memento several times if the prototype is used long enough.
Although the randomness means the experience will change for every use, I would like it to only be semi-random. To program certain mementos to be more likely to show up next to one another, for instance. Human memory - although unexpected memories may show up from time to time - is not completely random. Memories are tied together in infinitely complicated ways, and it would be nice to at least partially reflect that in the Memory Machine.
The control system may of course be perpetually iterated on. For instance, it would be nice to have variable, automatic speed settings, depending on the user's distance to mementos.
Generative environments: Users, although engaged for one use, should have a reason to come back and have another go. By implementing gradually evolving environments, I will provide just that.
Of course, after finishing the Memory Machine itself, it would be interesting to develop more functional VMB prototypes, to demonstrate other aspects of the concept besides its potential emotional impact.















part 4: reflections & outlook

In this final chapter of the report, I present my findings and conclusions, not only in regards to the value of imperfections of digital design, but also to the future of VR, photogrammetry and 3D image capturing.
I also try to give an objective evaluation of my own process. What went well? What went wrong? What would I have done differently if I could do it again?

digital imperfections

***BOTTOM**: APPROPRIATION OF BOTH PIXELLATION AND CHROMATIC ABBERRATIONS IN THE 2015 VIDEO GAME "HOTLINE MIAMI 2: WRONG NUMBER"*

So at the conclusion of my diploma, what have I learned about digital imperfections, and their role in design?

The paradoxical side of working with imperfection is that the more one thinks about it and tries to define it, the less sure one becomes of what it really is. Questions arise, rather than answers. To limit philosophical paradoxes, I have tried to force myself to think of imperfection as a flaw, or blemish. But even if that is how one defines imperfections, dilemmas arise. If an imperfection is appropriated and aestheticised, may it still be considered imperfection? I am thinking of course of the analogue imperfections which are being appropriated into digital media. Chromatic aberrations, Instagram filters, light leaks, lens distortions. The list goes on. Hardly anyone would look at these today and think "Hey, this image is flawed!", although the case may have been different in the time before photographers learned to completely avoid these blemishes, if they so chose to.

As a general rule, it seems any given medium must be completely mastered technologically before its imperfections are accepted by the general public. We are just now beginning to see the imperfections of the early digital era being appropriated as common aesthetic expressions. Lo-poly and pixel art effects are both artifacts of the early days of the digital era, stretching all the way back into the seventies, but lasting well into the nineties. They were a necessary consequence of the (By modern standards) ridiculously low processing





***LEFT**: PIXEL ART THEN AND NOW: AN ANCIENT MOSAIC FROM A SYNAGOGUE IN HUQOQ, MASHED UP WITH A CHARACTER FROM HOTLINE MIAMI*
BOTTOM: A THEORETICAL MODEL OF HOW IMPERFECTIONS - NOT JUST DIGITAL ONES, GRADUALLY EVOLVE INTO GO-TO EXPRESSIONS.

power and screen resolution of the time, and may surely be considered imperfections of low performance. As time would show, these artefacts gradually disappeared as computers became more powerful. Screens were packed with pixels until we could no longer tell them apart. The same happened to polygons. Our technology has surpassed what was available then by light years. And yet, game developers, designers and artists are embracing the artefacts like never before. We hardly even consider them "retro" any longer, due to the amount of appropriation going on. They are just another visual expression, virtually free from nostalgic sentiment and retro associations. Perhaps there is some truth and beauty to them. They are so simple that they may be assigned a timeless quality. In fact, perhaps they are not a result of the early limitations of digital media at all? Look at ancient mosaics. Aren't these a type of historical pixel art? The same can probably not be said for datamoshing artefacts, a more newly appropriated digital imperfection. The artefacts are so particular to a very certain type of imperfection, that I have trouble crediting them as any more than nostalgic sentiment from the late nineties-early naughts. It is too specific, and therefore not timeless.

Limitation - Flaw - Glitch

Pixellation is a matter of hardware limitations. The "natural", digital artefacts of datamoshing are flaws. The artefacts generated by databending a jpeg are glitches. Three degrees of imperfection, with the scale starting at a passive low quality, and ending at an active and intentional destruction of digital media. My own work into the Memory Machine exists somewhere in the centre of this scale. The technology of photogrammetry may produce near-perfect results if used correctly, as demonstrated with *Digital Dolly*. However, by subjecting the technology to intentionally poor usage, the imperfections inherent in photogrammetry are magnified. Note, imperfections of photogrammetry, not just 123D Catch. Having briefly looked at a few different software alternatives, it became apparent that these imperfections are not exclusive to Autodesk's app.

Imperfections of The Memory Machine

According to the model I developed to try an make sense of the gentrification of digital flaws, the imperfections of the Memory Machine fit right into the "appropriation" phase. Although photogrammetry on our phones is a brand new phenomenon, photogrammetry as a whole has been mastered. Professional 3D-capture equipment



is fully capable of producing perfect - boringly perfect - scans. That might explain some of the appeal of the imperfect scans. It's fresh and novel compared with the perfection that is usually presented. Still, that is likely only a view held by those who are already into 3D-scanning, like myself. Those already well familiar with perfect scans.

So what could explain the "regular" users' attraction to the expression of the Memory Machine? I believe it is due to the fact that the entire experience was designed around the aesthetic, rather than the other way around as we are used to. So although the imperfections fit with the concept in this particular case, I cannot recommend consciously inserting digital flaws into designs just for the sake of having them there.

To sum up my conclusion around using digital imperfections in design in a few words: Although digital imperfections are no doubt more honest to the material of digital media than the current analogue ones we are seeing, the digital realm is simply too young. The media has not been well enough mastered for most people to start cherishing its characteristic artefacts as nostalgic keepsakes. Which makes it an excellent opportunity for designers to expand on, with its freshness and novelty.

VR and 3D image capture

It seems like every other week, a new game-changing innovation is introduced into the field of virtual reality and 3D image capture. They seem to be two of the most rapidly evolving technologies of today. Just over the course of my diploma, Facebook unveiled 360 degree video, the Microsoft Hololens was announced and Samsung released a new HMD, to name but a few recent innovations. The world of 3D-capture and image viewing is rapidly approaching the consumer market. We as designers have the huge job and honour of figuring out what these technologies will be used for, what consumers will want. I believe that by drawing on historical parallels, such as photography, one may at the very least make a well-educated guess.

"For a designer, or any builder of technology, looking at history enables 'thinking outside the box'. No matter how novel an invention is, it carries a legacy. Any technology has to connect with a world that includes old technologies, existing business models and economic structures, and laws and regulations written a year or a century ago, as well as with people, who have certain values, attitudes, practices, and uses for technologies. If a designer knows the history of a technology, such as in domestic photography, he or she has a better chance of being creative and innovative." [43]

It is my opinion that Autodesk has grossly misjudged what the average consumer will want out of a portable, free 3D-scanner. The average consumer is not interested in capturing perfect models for 3D-printing, but rather capturing everyday life with an added dimension.

Through my research, I have also come to the conclusion that some VR-developers, similarly to Autodesk, are misjudging where their technology may carry the most impact. Through the presence of VR, we can involve the user on a previously unprecedented emotional level. That is where the magic of virtual reality lies. Not in performance, precision or functionality, but in designing emotionally engaging experiences. At least for a few more years to come. With greater precision and tools for navigating, perhaps one day virtual reality will be good for more pragmatic purposes.

In the Memory Machine, the floating, somewhat unprecise control system compliments the experience. But that may only be due to the dreamlike nature of the prototype. Finding ways of comfortably navigating three-dimensional spaces will be a major challenge for everyone hoping to design similar experiences in the years to come.

With future smart phones having both 3D image capturing devices as well as virtual reality functionality integrated in them, I believe it is only natural that the two technologies are joined together. Drawing parallels to historical movements, it became plausible that the way to attract the most consumers would be something along the lines of a Virtual Memory Browser. Millions of people own smartphones. Millions of people use them to capture memories.

reflection

My design contributions have been an open exploration within digital imperfection, a future-oriented speculative design concept, and a functional prototype of 3D virtual reality image browser, which facilitates new, emotional user experiences.
To wrap up this report, I would like to take a moment to comment on my own work - both my process as a whole, as well as the finished, tangible result that is the Memory Machine.

The Process
Retrospectively, there are a few things I would have changed, had I gone through the process of the diploma again. First of all, it would have been kept more specific. I would have found a concrete problem to solve, following a traditional design development, instead of opting for an open exploration.
Although the exploration naturally lead to the Virtual Memory Browser, it was difficult trying to tackle both the VMB and Digital Imperfections at the same time. Towards the end of the diploma, I found my own fascination for the Memory Machine outweighing my fascination for the flaws I set out to explore. It would have been interesting to see what the result would be if the outset had been the VMB, disregarding all digital imperfections. Of course, that line of thought is problematic, since one naturally lead to the other. My main design contribution is enhanced user experiences in virtual environments on mobile media. This contribution has to some degree been validated through my collaboration with Samsung.
Although I am pleased with the end result, the road there was long and arduous. Prior to this diploma, I had never worked with VR, animation or game programming, so these were all skills I needed to acquire over the course of the semester. By pushing my own boundaries as a designer, I feel like my skills have grown tremendously throughout the diploma.

The Memory Machine
I am proud to put the Memory Machine into my portfolio, and am looking forward to letting more users experience it at exhibitions. There is great potential for further development, and I aim to release it online for people all across the world to try out. It is a speculative, future-oriented design concept, pertinent to the current technological trends. I hope that with the Memory Machine, I can show users that their science fiction fantasies are closer to being science fact. Ten years ago, a Virtual Memory Browser on a mobile device would be unthinkable in the real world. Now, with the disruptive technologies of the smartphone, the photograph evolves to encompass both a third physical dimension, as well as time, allowing brand new emotional experiences.

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image sources

NOTE: ALL IMAGES NOT LISTED HERE ARE MY OWN.

THE MUUTO RAW FURNITURE SERIES USES THE
IMPERFECTIONS OF HAND-CARVED WOOD AS AN
AESTHETIC EXPRESSION.
HTTP://STATIC.WEBSHOPAPP.COM/SHOPS/009368/FILES/002644096/MUUTO-RAW-GREEN.JPG

EARLY MOVIE MAGIC FROM GEORGE MÉLIÈS'
"A TRIP TO THE MOON"
A TRIP TO THE MOON (FILM)

EACH RAG CHAIR FROM DROOG DESIGN.IS UNIQUE.
HTTP://WWW.DROOG.COM/WEBSHOP/FURNITURE/RAG-CHAIR/

JACKSON POLLOCK SPLASHING PAINT IN HIS STUDIO
HTTP://YALEBOOKS.FILES.WORDPRESS.COM/2012/01/PAUL-JACKSON-POLLOCK.JPG

AN EXAMPLE OF A SPROCKET HOLE
EXPOSURE, COMPLETE WITH TYPICAL TOY CAMERA ARTEFACTS SUCH AS LIGHT LEAKS.
HTTP://WWW.LOMOGRAPHY.COM.BR/MAGAZINE/165223-PANORAMA-RAMA-SPINNING-OUR-WAY-THROUGH-WEST-HOLLYWOOD

FRAME FROM JAMES MILLER'S SHORT FILM "ROMANCE OF THE LIGHT"
HTTPS://VIMEO.COM/36623403

FROM GEORGES MÉLIÈS' FILM "THE MAN WITH THE RUBBER HEAD"
THE MAN WITH THE RUBBER HEAD (FILM)

"THE ART CRITIC" BY DADAIST RAOUL
HAUSMANN IS POKING FUN AT THE ELITIST ESTABLISHMENT, IN THIS CASE AN ART CRITIC.
HTTP://WWW.TATE.ORG.UK/ART/ARTWORKS/HAUSMANN-THE-ART-CRITIC-T01918

A FRAME FROM LEN LYE'S SHORT FILM
"A COLOUR BOX"
HTTPS://WWW.YOUTUBE.COM/WATCH?V=-DKSMBDMDUU

SCREENSHOT FROM JODI'S QUAKE MOD
"UNTITLED GAME"
HTTP://WWW.UNTITLED-GAME.ORG/UG12.HTML

FRAME FROM THE KANYE WEST MUSIC VIDEO "WELCOME TO
HEARTBREAK"
HTTPS://WWW.YOUTUBE.COM/WATCH?V=WMH0E8KIZTE

SCREENSHOT FROM THE 1990 DOS GAME

“SKI OR DIE”
HTTP://WWW.MOBYGAMES.COM/GAME/DOS/SKI-OR-DIE/SCREENSHOTS/GAMESHOTID,2391/

A WOVEN RUG.
HTTP://WWW.NILIMARUGS.COM/CLASSIC-HOME-JUTE-BERBER-OCEAN-BREEZE-BRAIDED-RUG-3007450.HTML

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HTTPS://WWW.ETSY.COM/LISTING/200449730/CONTEMPORARY-WHITE-ABSTRACT-ACRYLIC

I-FRAMES CONTAIN INFORMATION ON COLOUR, WHILE P-FRAMES ONLY DICTATE WHICH WAY THOSE COLOURS WILL MOVE..
2001: A SPACE ODDYSSEY (FILM)

THE 23RD COPY OF A VHS-TAPE. VIRTUALLY ALL TRACES OF THE ORIGINAL DATA HAVE BEEN LOST.
HTTPS://WWW.YOUTUBE.COM/WATCH?V=MES3CHENVYI&SPFRELOAD=10

POSTER FOR “POLTERGEIST”
HTTP://WWW.FREEALLPICTURES.COM/WP-CONTENT/UPLOADS/2015/04/POLTERGEIST-MOVIE-WALLPAPERS.JPG

THE PIXELLATED MAIN CHARACTER OF THE VIDEO GAME “CANABALT”.
HTTP://REVISTACACTUS.COM/WP-CONTENT/UPLOADS/2013/06/CANABALT.JPG

PIXEL POUR 2.0, A VOXEL SCULPTURE BY GARY J. LUCKEN.
HTTP://WWW.FRESHNESSMAG.COM/2011/01/11/PIXEL-POUR-2-0-MERCER-STREET-IN-SOHO-NEW-YORK/

A LOW-POLY VERSION OF THE PANTON CHAIR, BY UNITED NUDE.
HTTP://WWW.UNITEDNUDE.COM/OBJECTS

THE SMART PHONE OF THE 1800S: THE KODAK NO 1 WAS THE FIRST AMATEUR CAMERA.
HTTP://WWW.EASTMANHOUSE.ORG/EXHIBITIONS/CURRENT.PHP

CHARACTERISTICALLY ROUND PHOTOS FROM THE KODAK NO 1, DOCUMENTING THE EVERYDAY LIFE OF THE 19TH CENTURY.
HTTPS://WWW.FLICKR.COM/PHOTOS/NATIONALMEDIAMUSEUM/SETS/72157606845434332/

A FRAME FROM ETERNAL SUNSHINE OF THE SPOTLESS MIND.
ETERNAL SUNSHINE OF THE SPOTLESS MIND (FILM)

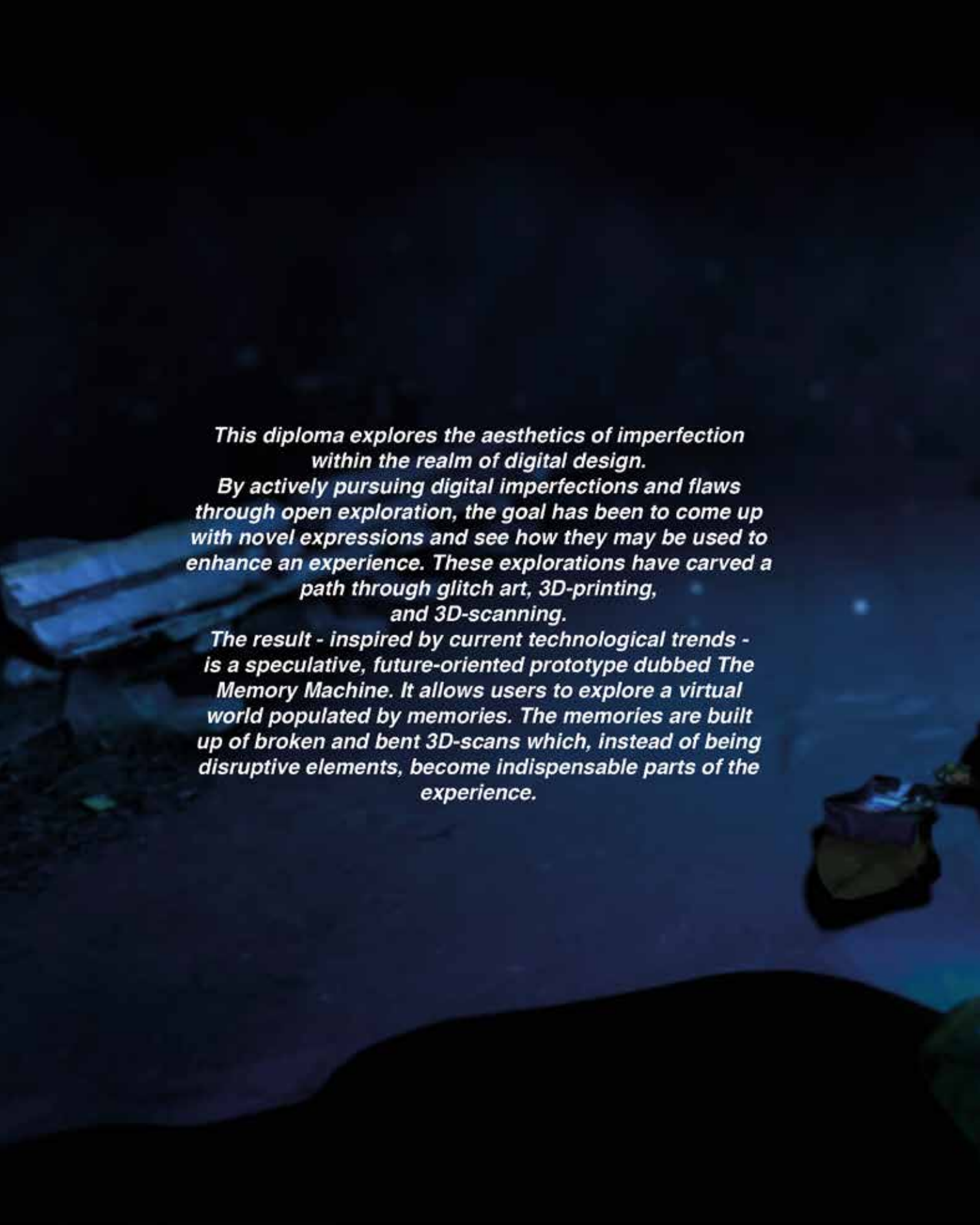
THE PERSISTENCE OF MEMORY, BY SALVADOR DALI.
SALVADOR DALI - PERSISTENCE OF MEMORY (PAINTING)

A RETROESQUE VIRTUAL REALITY-CONCEPT
HTTP://ARSTECHNICA.COM/GAMING/2013/01/HOW-FAST-DOES-VIRTUAL-REALITY-HAVE-TO-BE-TO-LOOK-LIKE-ACTUAL-REALITY/

THE SAMSUNG GEAR VR HEADSET USES THE GALAXY NOTE 4 SMARTPHONE AS A KEY COMPONENT.
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APPROPRIATION OF BOTH PIXELLATION AND CHROMATIC ABBERRATIONS IN THE 2015 VIDEO GAME "HOTLINE MIAMI 2: WRONG NUMBER"
HTTP://WWW.FORBES.COM/SITES/GAMES/2015/03/13/HOTLINE-MIAMI-2-REVIEW-CLOCKWORK-MAYHEM/

PIXEL ART THEN AND NOW: AN ANCIENT MOSAIC FROM A SYNAGOGUE IN HUQOQ, MASHED UP WITH A CHARACTER FROM HOTLINE MIAMI
HTTP://ASORBLOG.ORG/WP-CONTENT/UPLOADS/2012/07/J-HEILPERN-3.JPG AND HTTP://WWW.GIANTBOMB.COM/PROFILE/BITTERALMOND/BLOG/HOTLINE-MIAMI-IS-A-MASTERPIECE-PART-2/97208/



This diploma explores the aesthetics of imperfection within the realm of digital design.
By actively pursuing digital imperfections and flaws through open exploration, the goal has been to come up with novel expressions and see how they may be used to enhance an experience. These explorations have carved a path through glitch art, 3D-printing, and 3D-scanning.
The result - inspired by current technological trends - is a speculative, future-oriented prototype dubbed The Memory Machine. It allows users to explore a virtual world populated by memories. The memories are built up of broken and bent 3D-scans which, instead of being disruptive elements, become indispensable parts of the experience.