Flashlight drawing game with a neural network A.I.

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Abstract

Public spaces invite people to spend some of their time there, offering a space with particular architecture or aesthetic. However, they are usually limited in what they offer, and thus these spaces are not always used to their full potential. Since a significant part of the enjoyment of these spaces comes from the felt presence of other people also enjoying the public space, adding new reasons for the enjoyment of the space would add to the overall enjoyment of the space. A way to add to these public spaces is by having interactive installations that act as interactive playgrounds for people to enjoy in the space. The ideation, design, realisation, and testing of such an installation has been reported in the following report. The final product prototype is a game experience where users draw objects they are instructed to on a virtual canvas on a laptop screen using the flashlight on their smartphones. The user's intended drawn objects are predicted by a neural network artificial intelligence in an anticipative way. The neural network builds intelligence on doodled drawings by a process of training before it is instructed to predict other doodled drawings. This prototype serves to test the installation's game experience that would normally be suited to a public space. The testing of this prototype resulted in the game experience being considered as entertaining, fun, and captivating, which are essential requirements for an interactive installation that is placed in a public space. This prototype does not fully prove that the installation would be successful in a public space, as it has not been tested in such context. For that reason, further testing would be required for future implementations. However, it proves that the concept for the interactive installation would be suitable for a public space and for the variety of users that could potentially use it.

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Chapter 1: Introduction

1.1. Problem introduction

The streets of many cities are transited by hundreds or even thousands of people every day. A significant amount of public spaces that are passed are never seen as potential places where interactions could occur, and thus they seem meaningless to those that transit them daily. People are usually too busy getting from one place to another that they forget about what surrounds them throughout their day. Interactive installations placed in public spaces are an effective way of changing this, as passersby are invited to spend some of their time in that space. These types of installations evoke a sense of curiosity in passersby, which then motivates them to engage with the installation or with each other. Other people that pass by will also notice the unordinary activities taking place and their curiosity leads them to either become a part of it or to observe. I have thus made the goal of my graduation project to attempt to change behaviour and elicit interaction in people that transit a public space, and as a result to add value to that space.
This company will help me with the whole process of the project, from ideation to prototyping; and provide me with the necessary equipment to do so.

1.2. Client task

For this project I will be developing an installation that is to be placed on the facade of the WireLab building in the Willem Wilminkplein in the city centre of Enschede. I will be working with the help of the company 100% FAT, developing a new interactive projection installation for that space. It will be based on the concept of a previous installation that was previously on display in that same space, and will be using the equipment that is already in place. The concept of the previous installation is a floor projection and a facade display that invites passersby to engage in playful physical movement interactions with each other and results in visual changes to the displayed contents of the projection and the display. To improve this concept of an interactive playground I must first look at how others have also managed to create such playgrounds. The next chapter will thus aim at exploring the different ways in which interactions have been brought about in public spaces by other existing installations, so that I can gain sufficient inspiration and contextual familiarity for the most relevant designing of my installation.

For my improvement of the previous installation I have come up with an interactive concept that will bring about more physical and social interactions between its users. The use of smartphone flashlights and bodily forms and gestures of passersby to interact with a media facade display, while they are being guided in interaction by what is displayed in a floor projection. The design

would consist of a large projection coming from the inside of the flat facade of the Medialab building that passersby would be able to see through its large glass window.
A floor projection that sources from the inside of the window facade will cover a large surface of the floor in front of the facade display, so as to establish the area that users can use to interact with the installation. This combination of displays will immerse users more into the experience and intuitiveness of the interactions with the installation. The design of interactions that will take place will be decided in the later stages of the development of this installation. The design of these will have to depend on the technologies that they involve, and thus the process of the design will be iterative and involve various prototype tests.
The testing will also involve its users in a way that a selection of users would be chosen to represent as closely as possible the installation's target group. The purpose of the installation will be to bring the people that transit the public space together for an entertaining and insightful activity where the audience will take the stage and be a part of the overall design of the installation. People that pass the space can either become observers or part takers in the experience that is offered.

The chosen technology to realise this installation would be a wide angle high resolution camera that is connected to running software that would be able to detect and trace the bright source points of the various flashlights. Also, using TSPS app software connected to the camera feed to track people and communicate this data to a client such as Processing or openFrameworks. If the tracking of flashlights cannot be done because of technical or contextual reasons, other technologies such as Kinect could be opted for the tracking of the user's hands. On the other hand, the issue could lie in the interacting device, so an alternative could be to use a laser pointer or a hand wearable that would be provided to users. However, this would prove to have a high cost for initial interaction; thus, it would be best not to make it device dependant, but to have software that uses the camera to for example track user's hands.

1.3. Research question and sub-questions

The following research question and sub questions have been formulated:

- What are the key considerations for designing an interactive installation for a public space?
- Sub-question: What different types of interactive systems have been installed in public spaces?
- Sub-question: What design values have to be taken into account when designing an installation for a public space?
- Sub-question: What is the target group for an installation in the public space of the Willem Wilminkplein in Enschede?

Chapter 2: State of the Art on ‘Interactive Playgrounds in Public Spaces’

2.1.1 Background research

Public spaces have for long been designed to foster interactivity and engagement between the people that they contain. However, in the last decade, continuous advancements in technology have given rise to the opportunity to further enhance the design of these spaces. Technologically functioning interactive installations have been made part of public spaces to fulfil various purposes, such as enabling people to experience new forms of interaction, evoking insights, and informing.

What different types of interactive systems have been installed in public spaces?

There are various interactive systems that have been designed to be best fitted in a certain public space. Interaction with such systems is driven by and the user experience is greatly influenced by contextual factors such as location, place, people, and technological infrastructure [1]. Therefore, the type of interactive system that is installed in a public space strongly depends on the consideration of such contextual factors. These types will be outlined and explained in the following paragraphs as background information of the research area ‘interactive installations in public spaces’.

Interactive public displays are designed as mediums to communicate new media, which then create a space where people can engage in interactive experiences [5]. In the design of such displays, social situations in that space need to be taken into account, together with the bodily gestures that would occur during the interaction with the installation that would be best suited for users in a public environment [4]. Should the interaction be passive, active, or both?

Projections on walls or buildings have long been used to create interactive experiences by exposing viewers to many forms of media or digital art. These might not provide the spectators with a direct way to interact with the projection itself, but they are provided with the opportunity to share a lived experience, that might lead them to choose to interact with each other on their feelings and opinions on such experience. In such cases, the projection systems would have to be designed considering the space of the public space, so as to make sure that the audience is able to properly observe and thus experience the projection.

Some interactive systems involve the interaction with users using mobile or wearable devices, such as their own smartphones, or devices specifically made for the installation. Designing such

systems requires the consideration of how users will interact with the installation or with each other with wearables on their bodies, and whether these interactions can be accommodated in the relative public space.

Other interactive systems make use of tangible user interfaces that facilitate the interaction with its users and between the users themselves. The makers of such systems would need to consider the specific end users' needs and limitations in order to design the most accessible tangible user interface possible[1]. As a whole, it can be argued that any of these interactive systems could always lead their users to share their experiences online, and thus very possibly engaging in many more interactions virtually.

The more specific type of interactive system my graduation project entails is a media facade. A media facade describes the concept of transforming the outer surface of a building into an architectural scale public screen by providing it with digital, light emitting elements or projections of various kinds [2]. According to this previously referenced academic article, media facades can be categorised according to the way create interaction with a public. Narrative media facades usually remain in a static state and simply communicate ambient or high-resolution information to an audience that has to be encoded by the recipient. Reactive media facades gather their content through the surrounding environment using placed sensors that will provide input data. And interactive media facades provide a direct or indirect interaction mechanism that allows users to access and manipulate displayed content [2].

What design values have to be taken into account when designing an installation for a public space?

For my installation, I will aim at making an interactive media facade, for which I must consider the way in which interaction is mediated between the various users in the public and the installation. Wiethof [2] states that there are three conditions in which users can be allowed to carry out a task (an interaction) that is imposed by an interactive media facade installation. These conditions are established to empower short-term playful engagement with the installation using mobile devices by multiple users playing simultaneously [2].
The article investigates the effectiveness of these conditions in providing the most positive user experience. The conditions were the following:

- Time-Multiplexing: The ownership of the interaction of the facade is exclusive to a single user at a time, each user getting 30 seconds for their turn.

- Space-Multiplexing: The displayed contents of the media facade are subdivided into a certain amount of separate segments, where a corresponding amount of users have the exclusive temporary ownership of these parts.
- Mayor-Mode: The exclusive ownership is given to the winner of a qualification game (such as rock-paper-scissors) that is played between the users on their own mobile devices

Based on various real life user tests, the article concludes that participants voted space-multiplexing to be the most effective, followed by time-multiplexing and mayor-mode.
Users argued that space-multiplexing provided a better compromise when compared to time-multiplexing, but that mayor-mode was considered too competitive in contrast to the other two turn-taking methods [2]. It would thus be most suitable to condition the interaction of a interactive media facade using space-multiplexing.

What must also be accounted for is the usability of the public space of interest and the social interactions that are already taking place within it, in order to best design an installation with the most suitable added interactions. According to Arroyo [3] engaging passersby of a public space in interaction with each other or with the installation can have its challenges. For example, an abundance of passersby in the public space can mean that the installation is less visible to them, since the space for interaction could be occupied by passersby that are not aware of it, and are thus obstructing the installation's affordance to interact. The article tested whether using sound and light as embedded interactions in a public installation are effective ways of overcoming this type of challenge. It concluded that sound is most effective in luring passersby to an installation in a public space with fewer people, whereas light is preferable in a space with many people [3].
Since an outdoor public space can vary between the two situations, it would be best to design an installation that combines both the use of sound and light.

An interactive public installation should also be designed to persuade passersby to stop and interact with it. What would thus be the best way to achieve this?
In general, a public space offers a lot of space where people can carry out many sorts of actions. Taking advantage of this space by using as much of it as possible as part of the installation would be a first approach at catching the attention of passersby. Having considered this, the installation should also be designed for short moments of play, where the cost for interaction should be kept at a suitable level, in order to be designing for everyday encounters and situations [7].

Another consideration would be the type of interaction that would best suit the context of the public space. When thinking of an interactive public installation, the concept of an interactive playground usually comes to mind. A place where people of any age can engage and interact as a result of a

curious exploration of an environment. In such a case, emergent play would be the type of interaction that takes place. Emergent play is “play that is not defined before-hand, but that evolves as a result of interaction” [8].
Emergent play cannot be designed, it can only be designed for, and thus an interactive installation that aims to incorporate it should opt for designing open-ended play[9].
This type of interaction would give users the power to initiate and mediate their playful activities and take it to any extent that they wish to, allowing for greater creativity, motivation, and engagement.
Another method in designing for playful persuasion would be to incite the curiosity of passersby or onlookers with certain principles or interactive mechanisms. For example, exposing them to novelties, complexities, uncertainties, and situations of conflict [10]. These principles would be most effective in triggering the users’ curiosity, and as a result they are seduced and captivated to interact with the installation.

What is the target group of this installation?

The target group of this installation are the people that transit the public space where it is to be placed. In the case of my graduation project this would be at the Willem Wilminkplein in the very centre of Enschede. Since the installation can only be active during the nighttime, only once the daylight is gone, the target group can be more specific to this night time period. By considering these facts, it can be presumed that the target group would consist of people of all ages that venture the space at night time. However, since is Enschede is a student city, it can be assumed that students are the demographic group that transits the public space the most at night.

Conclusion of background research:

Having discussed all findings, I can come to certain conclusions that will answer my research question. The key considerations when designing an interactive installation in a public space are the following:

- The installation must be designed with the close consideration of the contextual factors of the public space where the installation is to be placed.
- The design of these installations can be in the form of interactive public displays, projections on walls or buildings, device dependent interactive systems, or tangible interfaced systems.
- A single or a combination of these design forms can make up an interactive media facade
- When the interaction with an installation needs to be mediated between its various users, space-multiplexing proves to be the best condition for the highest user experience and satisfaction

- Using both sound and light as part of the design of an installation considerably helps the luring of passersby
- The cost of interaction for passersby should be kept at a level that is suitable for the everyday activities and situations that take place in the public space
- An installation in a public space could be designed to elicit emergent play, where the interactions involved are open-ended, and thus motivate the use and enjoyment of the installation
- Designing an installation that exposes its users to some kind of novelty, complexity, uncertainty, or conflict can incite curiosity in them, and they can thus be seduced and captivated by the installation

While I am aware that this background research literature review isn't completely exhaustive of my graduation project's field of research, it provides a starting point and covers most of the relevant possible approaches to the designing of an interactive public installation.

2.1.2. Problem analysis

The streets of many cities are transited by hundreds or even thousands of people every day. A significant amount of the spaces that are passed are never seen as potential places where interactions could occur, and thus they seem meaningless to those that transit them daily. People are usually too busy getting from one place to another that they forget about what surrounds them throughout their day. With my project I have made it my goal to attempt to change this or create a reason for reflexion and eventual change. I will be working in collaboration with the company 100% FAT (Fusion of Art and Technology) to create an interactive playground in a public space. The public space of interest is a part of the Willem Wilminkplein in the city centre of Enschede, where there is a large and flat facade that belongs to the WireLab company of digital creatives. This facade can be transformed into an interactive media facade, however, a state of the art research must first be conducted. In this research, a discussion of related works will help outline the limitations, and considerations to take into account when designing such an installation.

2.1.3. Definite research question and sub questions

How can an interactive installation be designed for a public space?

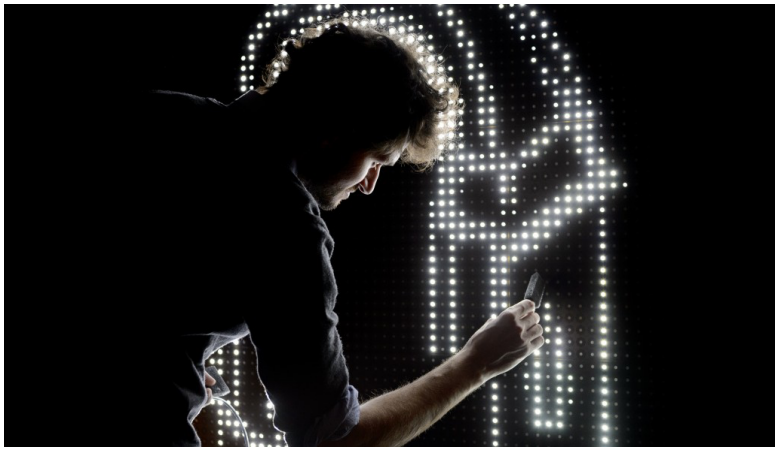
- How can the installation be entertaining and open-ended for people of all demographics to enjoy?

- How can the interaction with the installation captivate people passing the public space?

2.2. State of the art review of related works:

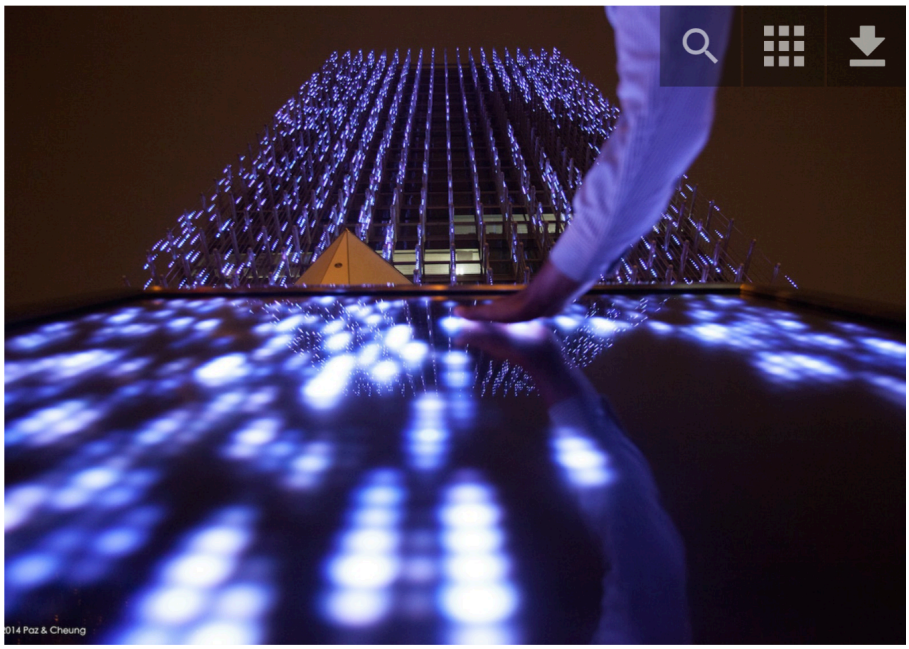
2.2.1. Interactive Media Facades:

Water Light graffiti (Fig. 1)



This installation aims at creating a material that is made up of thousands of LEDs that lights up when touched by water. Water touches a frame of LEDS that then creates an electrical bridge transporting the power needed to light up the LEDs [15]. These LEDs are connected to form a large wall surface so that anyone in a public space can 'graffiti' the wall of LEDs using either their fingers, sponges, paintbrushes, or even spray cans. The installation manages to bring people together by inviting them to explore this intriguing water and light combination. It challenges the thought that water and technology do not correspond with each other.

Affinity - Interactive Art Piece (Fig. 2)



It is an installation that gives the opportunity for people to feel free and explore new sensations. People are invited to use their hands on a large touch sensitive display that then translates these movements onto an even larger architectural building. The result is an experience of light, sound, and speed that is generated by people's own body movements. The displays have different modes that display various different forms of visualisations that can be interacted with, such as 'magic dust', 'rain', 'sand', 'aurora', 'stars' 'fireworks', 'ripple', 'light orchestra', etc [11].

LED Action Facade (Fig. 3)

The council of Madrid commissioned the LED action facade, the creation of an outdoor public art display that would get people to literally stop on the street [14]. This display invited passersby to take part in a collective experience that would range from a Tetris game controlled by the positioning of players in the space to catapulting a message towards the display so that it can be shared with the public. This installation brought the members of a community together and enabled various forms of engagement, it also gave a more meaningful use to the public space that is usually only transited by many people.

La Vitrine Culturelle (Fig. 4)

‘La vitrine culturelle’ is a cultural hub in Montreal that promotes the cultural offerings of the city. It has an interactive media facade that displays an entertaining and interactive light show for people that pass by. The interactive display of media incites curiosity in people and they are brought aware about the cultural potential of their area. Meanwhile, the interior of the building extends the experience with an installation that extends through three floors and is composed of long strip like displays that show information. This interior immerses people into a cultural atmosphere and encourages them to engage with each other. The outside media facade uses 35 000 low resolution LED bulbs to change its shapes and colours in reaction to the movements of passersby [13].

The creators are a company called Moment Factory, and their installation was awarded with the Grand Prix Creativite Montreal 2008.

2.2.2. Interactive Public Displays

Every Passing Moment (Fig. 5)

This screen was placed in the Liverpool Clayton square for the public to appreciate as the walk by. The interaction takes place passively when passersby have and active Bluetooth device, which the system detects, and depending on the user's path a red, blue, or yellow flower will be generated in one of the three possible virtual garden landscapes that are displayed in the public display. The system will remember each person's MAC ID and their seeded flower; if the 'growers' only pass by the square once their flower will slowly start to fade away. However, if people get closer to other people with a bluetooth connection within the square their flower will grow bigger. This installation creates and insight in people to reflect on their surrounding society and the scale of technology usage that it involves [12].

Face in the Snow (Fig. 6)

The UK company Knit developed and interactive shop window display that uses facial recognition to motivate engagement with passersby [16]. It evoked brand interaction by displaying falling snow to attract passers, then taking a photo of a person or a group that decides to stop and face the window display. The 'posers' are then shown a four digit code which they can choose enter in a mobile website, or they can send an SMS to allow for the photo to be viewed on the Facebook gallery of the promoted brand [16]. The facial recognition is used to trigger the taking of the photo and for the system to mediate the interactions and messages with the audience.

Chapter 3: Methods and Techniques

This chapter will outline and briefly describe the various methods and techniques that will be used throughout the various iterations of the design process of this graduation project.

3.1. Idea generation

Considering that the client does not have any definite ideas or requirements for the final product, ideas must be generated carrying out certain techniques.
One of the techniques carried out was active search, this involved the active search for information through web searches, magazines, and festival visits.
Another technique used was brainstorming. Having gotten enough knowledge on the subject, the state of the art, some initial requirements and constraints, and a target audience; a fruitful brainstorming session took place. This session involved using mind maps to branch out from an initial subject into many subtopics and then subsequent ideas from these.(ref)

3.2. Design Process for Creative Technology

During this project a design method is used based on the paper by A.H. Mader (ref) “A Design Process for Creative Technology”. This method is composed of four phases: Ideation, Specification, Realisation, and Evaluation. These are detailed further in the following chapters of this report.

3.3. Playtesting

Play-testing sessions are organised together with the client in order to test lo-fi and hi-fi prototypes of the installation. The main aspects that are tested are the interaction mechanisms of the installation, together with the equipment setup that is put into place at the public space of interest. This technique will allow to determine whether the physical design and elicited interactions of the installation would be the most suitable for the public space and the target audience that transits that space. (ref)

3.4. Levelled Data Flow Diagram

Interactive installations are systems that are commonly composed of several sub-systems. In order to describe how these systems work, a levelled data flow diagram is used to outline how data travels from system to system. This technique aids the understanding and conception of the complex system as a whole, by decomposing its various parts.(ref)

3.5. Time Sequence diagram

This diagram gives and overview of the various interactions of the system by showing how and in what order its different components operate with each other. It aims at giving a visual representation of object interactions organised in a time sequence, by outlining objects and classes associated with specific communication processes between the different components. (ref)

Chapter 4: Ideation

4.1. Idea generation

There are various methods and techniques possible to stimulate or guide creative thinking towards the generation of an idea. Some of the methods I undertook to begin ideating towards a project idea involved an active search for inspiration by visiting a few festivals themed around the combination of art, science, and technology. One of the festivals was STRP Biennale, taking place in Eindhoven throughout the entire month of April, it exhibited all kinds of interactive installations, performances, concerts, conferences, and even masterclasses. During my visit, I was able to experience many multi sensory interactive installations, I had talks with the scientists or artists behind these works regarding these experiences and the design specifications of these, and I attended an engaging performance on the topic of human relationships and partnerships. All these experiences inspired me to set a direction towards what kind of interactive installation I would be most motivated to conceptualise and design.

A couple of weeks after this visit, I attended another festival called FIBER Festival taking place in Amsterdam, this one focused more on audiovisual art and digital culture. Its program was composed of many talks, conferences, and discussion panels that would explore the impact technology has on culture, society, and nature. It also had night-time program composed of a varied range of audio and visual art performances. What inspired me the most throughout the visit of this festival were the conference talks by many emerging talents and renowned makers and thinkers. These talks often explored forward thinking topics, ideas, or developments in digital culture. Throughout these festivals I was exposed to many kinds of experiences, interactions, and insights that have furthered my interests within the fields of science, art, and technology. I was also introduced to certain technologies and experience designs I had never seen or explored previously, these closely corresponded with my pre-established interests.
Having a better understanding of the topics, ideas, and technologies that motivate me helped me set a good starting point for the explorative ideation process that follows this section of the report.

Some of the topics I kept in mind that fit within the theme of my graduation project are:

- Hybrid forms of architecture composed of materialised data streams at specific public locations.

- The movements of human bodies and nature colliding with digital aesthetics.
- Posthuman creativity, the training of neural networks to function as autonomous creative agents.
- Human to human touch or interaction as completion of the circuit of a machine that visualises this human-machine connection.
- The power of magnetism; collective human movement, sounds, and behaviours act as magnets to an installation that translates these into new sounds and visual light particle patterns.

4.2. Design questions for analysis of design problems

Moving on from the inspirational methods, I must also explore the possibilities for the design of my interactive installation. I will approach this by analysing important design problems through the definition of design questions and subquestions, these will provide a guideline for the most relevant commencement of the ideation.

- DQ1: How is a playground created within a public space?
    - What is a playground?
    - What elements of interaction compose a playground?
- DQ2: What type of interactive installation best suits the public space?
    - What interaction is the best suited to the public space?
    - How much space can the installation occupy in the public space?
    - How will the installation invite users to interact?
        - In what ways have other installations afforded interaction?
        - What kind of things make people stop while they transit public spaces?
        - In what ways are people transiting the public space?
        - Does the target user group have any limitations or requirements for interaction with an interactive public installation?
            - What are the demographics of the target user group for this installation?
            - What are the general physical and intellectual abilities of this target user group?
- DQ3: How will users interact with the installation?
    - What interaction mechanisms have been used by other interactive public installations?
    - What types of technologies have been used in public interactive installations?
    - Are any interaction mechanisms or technologies unsuitable for the public space and for the target user group?
- DQ4: What kind of experience should be designed for the public space?
- What is an experience?
- What experiences are regarded as most entertaining by the target user group?
- Should this experience provide the users with an insight?
- What kind of interactive experiences have been previously designed for public spaces?

4.3. Choice of ideas and public space of interest

During the first meeting with the client company, I was introduced to an interesting selection of different interactive installations that they had created for various public spaces. I was then proposed to choose one that I could work with to improve or to work along a similar concept for my graduation project. From this selection I chose to work to improve an installation situated at the Noordenhagen road of Enschede. I spent various nights visiting the installation as it was situated close to where I lived. During these visits I analysed its functionality, the equipment setup, and the amount of people that transited the space it was located in. Once, I was familiar with the way it worked, i proceeded to brainstorm ideas that could accommodate such space and equipment setup. Throughout this brainstorming session I made mind maps starting with the subject of interactive playgrounds in public spaces, branching out into many different possible ways to interact in a public space. However, many of these ideas had to be discarded because of the limitations of the equipment setup put in place. The main issue I had was with the positioning of the camera that was used by the installation to track people that transited the space. This camera overlooked the road from the top of the facade of a building, therefore people were tracked as blobs from an upwards vantage point. Because of its positioning, the possibilities for new ideas of interactions were limited, ruling out any ideas with a more direct interaction mechanism. This was problematic because my best ideas involved such interactions, so I therefore decided to discuss with my client for the possibility of switching installation to work with. This lead me to choose an installation that was no longer active but still had its equipment setup, placed on the window facade of the Wirelab office at the Willem Wilminkplein in the city centre of Enschede.

4.4. Chosen technology

The initially chosen technology will involve projections together with applications that use computer vision. This choice is due to the equipment that is in place at the public space of interest, which is provided by my client (100% FAT). The equipment that is in place is thus the equipment I am limited to work with, however, it is not too limiting as the amount of equipment is extensive. The technological equipment that is of most potential use is the following:

- A powerful projector that projects from the inside of the window facade of the Wirelab office
- A second powerful projector that projects onto the floor in front of this window facade
- An outdoor surveillance camera that is placed in the middle and above this window facade
- A powerful desktop computer that connects to the camera and projectors

4.5. Identification of stakeholders and target audience

This following paragraph will aim at analysing the different wishes and needs of the stakeholders of the interactive installation, so as to come up with a design that is most fitting to their interests.

4.5.1. Client - 100% FAT

The client, a company involved in creative applications of technology called 100% FAT, imposes the assignment that the interactive installation should be derived from the installations that they have already standing at certain public spaces. Thus, the client provides all the necessary equipment, materials, and expertise to facilitate the redesigning of one of their installations. From a large choice of installations they propose I work with the ones that are best situated in public spaces in the city centre of Enschede, which will allow for more creative and significant designs. Apart from these constraints the client has no further requirements, and allows me to fully decide on the idea for the installation.

4.5.2. Project supervisor - University of Twente

Since this graduation project is being supervised by an appointed university teacher, Dennis Reidsma, the project must be carried out under certain constraints and requirements. That the creation of this installation is of enough educational value to the student that is creating it and that the entirety of the project is finished within settled time slot. This forces the student to come up with a graduation project idea that is feasible in a relatively short period of time, and that the idea will motivate the student to make use and further develop the knowledge and the various sets of skills acquired throughout the Creative Technology program.

4.5.3. Target audience - The general public or community of Enschede

Since my installation will be placed in a public space, it can be assumed that the target audience for this installation will be people of all kinds of demographics. It can be argued that a public space can have a dominance of people of a specific demographic, however, the public spaces offered by my client are spaces used and transited daily by all kinds of people. The fact that my installation has such a broad target audience means that it has to be designed to fit various common requirements and interests. For example, the interaction mechanism and the experience of the installation needs to be simple enough and of easy access for the lower intellectuality and physical ability of younger and older people in contrast to the average middle aged person. Furthermore, the design of the experience of the installation should involve a topic or theme that is of interest to a large majority of this target audience, therefore, choosing a theme all people can understand and be a part of is most inviting to all.

4.6. Tinkering and ideation process

Having made a definite choice of hardware technology, public space, and conducted an analysis of stakeholders, I was ready to use these as a guide for the creative process. I began by proceeding to explore the options in terms of possible interactions that could occur between people and the installation in the public space. Since the only component in the equipment setup capable of sensing was the outdoor surveillance camera, I decided to research its potential and stumbled upon an ongoing field of research called “computer vision”. I discussed this field with my client, and was provided with some insights on its common use and capabilities. By recommendation of my client I began tinkering with a computer vision application called TSPS. This application is a cross-platform toolkit used for sensing people in spaces, it is open-source and can be used as a tool for creating interactive applications that are based on natural user interaction. It provides an interface that is simple and easy to control for the most intuitive tweaking of parameters of the application. It was developed in openFrameworks with the ultimate goal to make it easier for beginners to explore computer vision while also providing the more experienced with an easy framework to build off of. (https://www.tsps.cc/) This application uses blob detection, which is a computer vision method that aims at detecting certain regions of a digital image or video that differ in properties such as brightness or colour, compared to other surrounding regions. (https://en.wikipedia.org/wiki/Blob_detection) By changing and tweaking certain sensing parameters (such as the threshold, the max and min blob size, or the type of differencing) within the application, I was able to exclusively detect certain objects of choice that I would wave and move around in front of a webcam. I also tested the application with the surveillance camera, tracking people that would pass by the public space. The results from this were that the application is able to track objects or people, calculate the amount of time they spent inside the monitored space, and track each one with an ID. These sensing capabilities were rather limiting, so I was forced to think outside the box for new creative ways in which I could use them.

While ideating, I looked back at the various results of my previous brainstorming session, and kept in mind the various concluding insights I had gathered from my state of the art research. I decided to use the following three insights as a guidance to my ideating exploration:

- The cost of interaction for passersby should be kept at a level that is suitable for the everyday activities and situations that take place in the public space
- An installation in a public space could be designed to elicit emergent play, where the interactions involved are open-ended, and thus motivate the use and enjoyment of the installation
- Designing an installation that exposes its users to some kind of novelty, complexity, uncertainty, or conflict can incite curiosity in them, and they can thus be seduced and captivated by the installation

4.6.1. First Iteration Process

Considering the first insight, the user's cost of interaction with the installation in the public space of interest must be kept relatively low, since the space is mostly used for transit. The space is however part of a square that is intended for social use by the community, having several sitting places such as benches and a grass pit, it can be expected to have lots of potential users that would see the installation from a distance. Knowing this led me to a next insight on how it would be optimal if the interaction with the installation was visible and obvious from a distance, so as to incite the curiosity of people around the square. With this in mind, I came up with various ideas for interactions with the installation, the most compelling ones out of these were:

- Using a floor projection to guide people to move around the area that is monitored by the surveillance camera in order to have their body movements or displacement as interaction input
- Using music or sounds together with a floor projection to encourage people to dance and move around the camera's monitored area
- Using a starting screen projected on the window facade to instruct people that they must use the flashlight of their smartphone to interact with the installation by moving the flashlight around
- Using this starting screen to inform people that they must physically touch each other and connect in some kind of way in order for them to interact with the installation

These succinct ideas for interaction mechanisms were a good starting point, I believe it is most important to start with a decision on the interaction mechanism of the installation as this is a core component of the experience that is being designed. Moving on in this process, I decided to make a choice out of these ideas using all the insights gathered up to that point as criteria for this final decision.

- Is the cost for interaction relatively low?
- Does it encourage emergent and open-ended play?
- Does it expose its users to a novelty, complexity, uncertainty or conflict?
- Is the interaction mechanism visible from a distance for people that are also in the public space?

From this decision methodology, I settled for the interactive mechanism involving the movement of a user's smartphone flashlight. I was certain that this sort of interaction would best fulfil the criteria, especially since it would be a relatively novel way of interacting and evidently visible from a distance. On top of that, I believed that it would be easier and more straightforward to track a flashlight than to track people's bodies or movements.

4.6.2. Second Iteration Process

Having made the first and most important decision of my project idea, I moved on to the search for the second idea that would complete the installation's offered experience, the effect of the interaction. I began by brainstorming on the different possibilities that using a flashlight as interactive input could offer. The flashlight of a user would have to be tracked by a computer vision algorithm, and with this kind of tracking a few ideas came to mind:

- To use the slow or quick movements of the flashlight to dynamically alter an artistic composition displayed on the window facade
- To use these same random movements to trigger sounds or noises with which users could play around with or compose songs collectively
- To translate these movements to an x and y coordinated canvas as a painting tool where users would be able to draw
- To translate the movements to an x and y coordinated screen interface as a controllable mouse that users can operate to be able to navigate the interface

These were a choice of ideas that most appealed to me from the brainstorming, and also that seemed most feasible within the time frame for this project. In order to choose the most suitable idea, I decided to evaluate them according to the previously used criteria together with the close consideration of my stakeholder's interests and limitations as well as my own abilities to carry out such idea. From this evaluation I came to the decision that I would go for the idea of translating the flashlight movements to an x and y coordinated canvas as a painting tool for users to draw with. The main reasoning behind this decision is that such effect of the interaction is the most clear, simple, and straightforward compared to the other ideas for effects, and thus it is easily understandable by people of all kinds of demographics. In addition, this idea would allow for emergent and open-ended play, as users would be free to draw for as long as they wish and to come up with as many drawing games as they can think of. Such an effect would also be clearly visible to the people that are around the public space but that are not participating in the interaction, making the experience of the installation more apparent and alluring to them.

4.6.3. Third Iteration Process

Being close to a definite project idea, I decided to evaluate the generated idea as a whole. The idea up to this point consisted of users using the flashlight on their smartphones to intuitively draw in the air in order to control a painting brush to paint on a large projected canvas. This idea would allow people to freely draw with no limits or goals, giving them the power to create their own drawing games or to express themselves through drawings. This idea seemed very appealing to me because of the great amount of creative possibilities that it enables, however, it also posed some potential issues. First of all, giving so much free will and power to the users assumes that

these users are creative and driven enough to come up with creative applications and perform them in front of other people in the public space. However, this is most usually not the case, as people tend to be uncreative and can lack initiative when it comes down to doing things in public (ref). Having this issue means that there is a significant possibility that the installation does not get used as often as intended, and since the installation would mainly depend on participation to attract more participation, such issue is problematic. Secondly, there are certain ethical issues that could arise when allowing users to freely draw whatever they want. Users might decide to draw inappropriate content or messages, use the space for commercial advertising, or even express ideas or opinions that might conflict with other's. Because of these issues I decided to continue the creative iteration process in search of a final idea that would give a purpose to the interactive drawing on a public canvas. Accordingly, the best solution would be to come up with some kind of drawing game that would provide users with guidance and a framework to creatively draw.
After a bit of research through web searches and suggestions from friends, I stumbled upon a game recently developed by Google Creative Lab called "Quick, Draw!". This game runs through a web browser, and invites users to draw with the mouse of their computers. The game tells the user to draw a specific object within a 20 second time frame, and during the process of drawing a neural net attempts to guess what is being drawn. This game involves a subfield of computer science that evolved from studies in artificial intelligence called "Machine learning". This term specifies the phenomenon of giving computers the ability to learn without being explicitly programmed (https://en.wikipedia.org/wiki/Machine_learning). Being so intrigued by this game and its purpose to present this phenomenon to the world in an entertaining way, I decided that making such a game would be very interesting and novel when using a flashlight as an input to draw.

4.7. User requirements and general constraints

From the previous ideation process and analysis of stakeholders an outline on requirements and constraints is provided:

4.7.1. Requirements:

- The experience of the installation must be entertaining and challenging
- The game that forms the experience must be simple for use by people of all demographics
- The installation interaction must be engaging and encourage physical movement
- The interactions with the installation must be obvious and visible from a distance

4.7.2. Constraints:

- Has to be placed in the chosen public space in front of the Wirelab office window in the Willem Wilminkplein in the city centre of Enschede
- Has to use the hardware equipment that is set up at the location provided by Wirelab

4.8. Elaborated Project Idea

4.8.1. Description of elaborated project idea

The project idea will involve people that transit a public space to use the flashlight of their smartphones to play a drawing game where an neural network A.I. will attempt to guess what is being drawn. The flashlight of people's smartphones will be tracked with computer vision algorithms, and its movements will be translated to the drawing canvas of the game. The game will run with a doodle recognition algorithm that has been trained beforehand in order for it to recognise the objects that users will draw. The chosen technology to build the application that will run these algorithms will be OpenFrameworks. This is an open source C++ toolkit that is designed to assist creative processes by providing a simple and intuitive framework for experimentation (http://openframeworks.cc/about/)

The application will run on a desktop computer that will be connected to two projectors and an outdoor surveillance camera. The application will be using the camera for computer vision to track user's translations of flashlights. The doodle recognition algorithm running within the app will be using the saved flashlight translations as inputs to classify. The app will use the projectors to display the game interface where users will be given instructions, will be able to see what they draw and what the neural network A.I. says in response to what is drawn.

The idea for the experience of the installation is that people that transit the public space will see the projection screen that is inviting them to turn on their flashlights. The people will be curious to see how the flashlight will interact with the installation, and will turn it on while facing the projection. Once it is turned on, the users will see a countdown giving them time to prepare to play the game, but when the time is up, the game will instruct them to draw an object. The first few attempts at drawing with a flashlight could result unsuccessful, as the user might need to get used to the way the movements are translated into the game. However, the game will allow for various tries for within a session, so eventually the interaction mechanism will be understood and users will be able to draw with reasonable precision. While a user is drawing, the A.I. neural network will attempt to guess what is being drawn by displaying messages with those guesses. The user will feel a little overwhelmed at first because of the various guesses the A.I. will display, but this will motivate the user to continue drawing the instructed object in the clearest way possible. The A.I. will usually be able to guess what the user is trying to draw halfway through the drawing process, when this happens the user will be left with a feeling of awe. The user will feel as if the A.I. was able to read minds somehow, but the A.I. would have simply been trained properly to predict what people are drawing because by using its computer vision it has saved enough drawings of the object it was trying to guess. The end result of the experience is for users to gain an insight on the superior intelligence that machines can potentially have. The prediction that is done by the A.I. contradicts the common belief that such prediction can only be done by humans; the game makes users understand that this is not the case.

4.8.2. Game screens and interfaces mockups

An overview of the first screen and interface mockup is shown bellow.

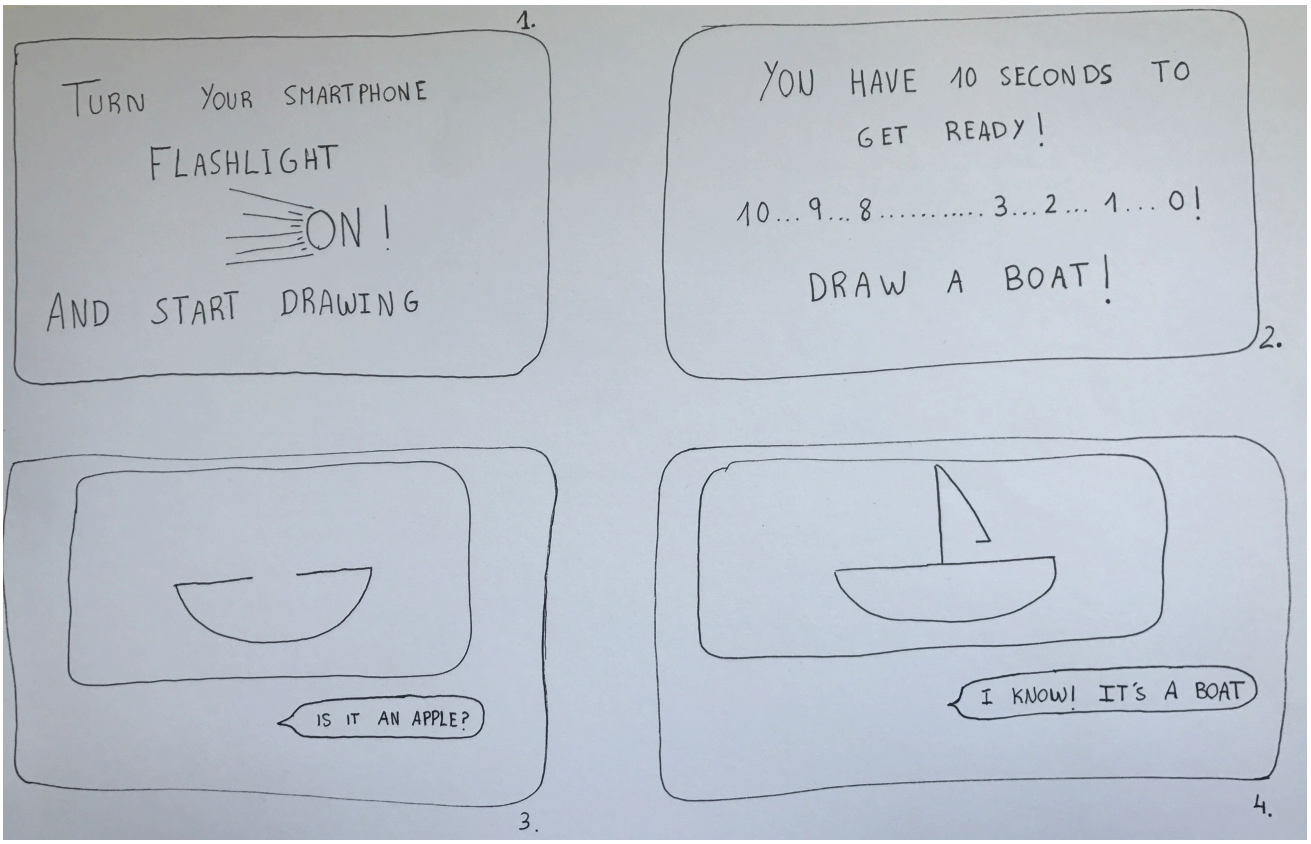


Fig 7.

1. In this first screen the game the interaction mechanism would be introduced to the user by means of a written message supported by an illustration or animation of a light turning on. It is important to communicate this through a visual cue so that it can be directly understood by people of all demographics.
2. In the second screen the user is given a countdown to be prepared to start the game, this lets the user know that it will be a fast paced game, under certain time constraints. The game then begins with an instruction to draw a specific object.
3. The screen shows an empty canvas where the user can start to draw the object that it was instructed. The neural net will start to try and guess what the user is drawing, by showing speech bubble messages of what it is guessing. Additionally, it could speak out these messages through speakers, using an automated voice to represent the fact that it is a machine speaking.
4. In the last screen, the neural net has guessed what the user was drawing, sometimes even before the user has finished drawing the object. After this screen the starting game screen (2.) is displayed again and the user plays the game a certain amount of times, so as to see how many drawings the user can draw successfully for the neural net guess them.

4.8.3. Illustrative sketch of installation setup

No physical prototypes were needed for the ideation of the physical design of the installation because the physical equipment necessary for it is already in place, however an illustrative sketch shows the placing of this equipment within the public space of interest.

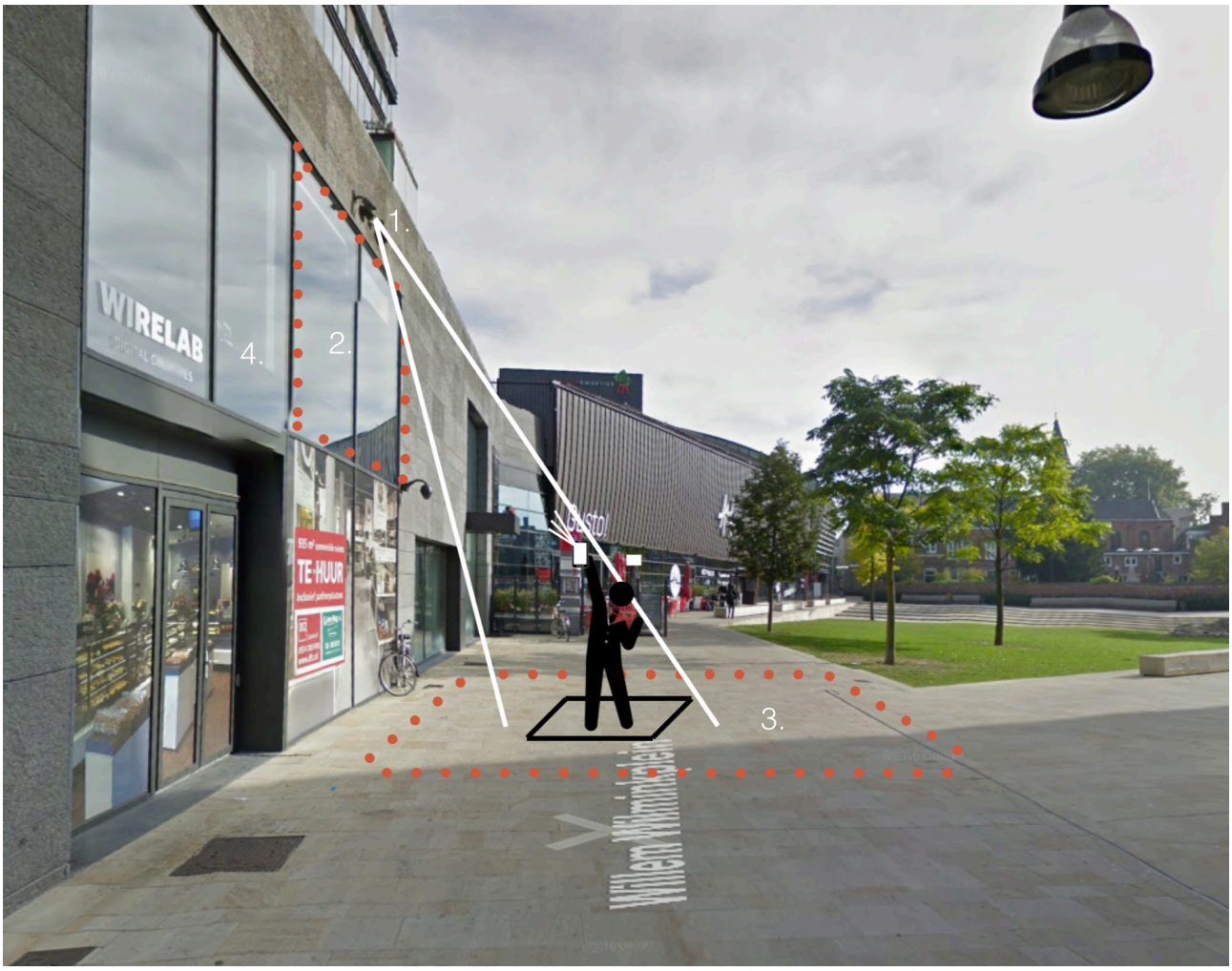


Fig. 8

1. This is where the outdoor surveillance camera is placed, this camera can monitor the illustrated space in front of the Wirelab office window (3.)
2. This is the Wirelab's office window where a projection screen will be deployed, and the game will be projected with a projector that is placed within the office.
3. This is the floor surface that users will be able to move around in, a floor projection will outline this space so that users can clearly be aware of the limits for interaction with the installation. The floor projection will be projected from a projector placed inside the office, it will be placed right next to the window, slanted downwards so the projection fills up the floor space that is monitored by the surveillance camera.
4. This is where the desktop computer will be placed, within the office, connected to both projectors and the surveillance camera.

Chapter 5: Specification

5.1. Narrative User Scenario

Richard, a 15 year old boy, is taking a walk with his friends around Enschede, when they come across a projection screen that is asking to turn on the flashlight of their smartphones.
Richard and his friends switch on the flashlights on their smartphones and point them towards the projection. The screen then asks for only one single flashlight to be pointed towards it, Richard asks his friends if they can turn theirs off so that he can play. Once this is done, the game begins a 10 second countdown for Richard to prepare himself to start playing the game. During this countdown Richard gets familiar with the interaction mechanism by using his smartphone flashlight to freely draw on the screen. Once the countdown is over, the game begins, and Richard is instructed to draw a a house. Another countdown begins, this time 25 seconds long, during which Richard moves his smartphone flashlight in the air to draw a house. While he is drawing the game starts to guess what is being drawn by means of visual messages on the screen and a voice that speaks in a machine like way. The game says things like: “Ah, is it a mountain?”, “Could it be a box?”, “Maybe it’s a trolley?”, etc. The game eventually guesses that Richard is drawing a house once he finishes drawing the triangular roof on top of the square house walls. Richard and his friends are a little surprised but not too impressed. The game continues, and instructs Richard to draw a sailing boat. Richard begins with drawing the hull, the game guesses by saying: “Is it a cup?”, “Maybe it’s a bucket?”. Richard continues and draws the pole that holds the sail, the game guesses right and says “Oh, I know, it’s a sailing boat”. This time Richard and his friends are more surprised, as he wasn’t even halfway done drawing it. Some say to one another: “How did it know?”, “I didn’t think it would be that smart!”. The game keeps on going, and Richard is instructed to draw a carrot. This one sounds easy to him, so he proceeds to draw it, meanwhile the game guesses what it could be. He eventually finishes drawing it as well as he can, but the game isn't able to guess it right and says “Sorry, I couldn’t guess it”. Richard now seems confused because to him it looks like a carrot and his friends support this thought. Either way he continues playing, and the game instructs him to draw a duck. He starts by drawing the face as an oval, the game gives a few guesses, he then draws the duck’s beak as a semi circular oval on one of the sides of the face. Right after he finishes drawing this, the game guesses right and says “Oh, I know, it’s a duck!”. This time Richard is in awe, and so are his friends, as they cannot believe that the game guessed it right. They discuss with each other how the drawing looks more like a coupe of stones or a pacifier rather than a duck or duck face. After this, the game ends and displays Richard’s results, by displaying an overview of all the drawings he drew and whether they were correctly guessed or not. Richard and his friends continue their walk with a new insight in mind.

5. 2. Levelled Data Flow Diagrams

Level 1: Interactive Installation

This diagram shows an overview of all the main components of the installation as well as their influences on each other.

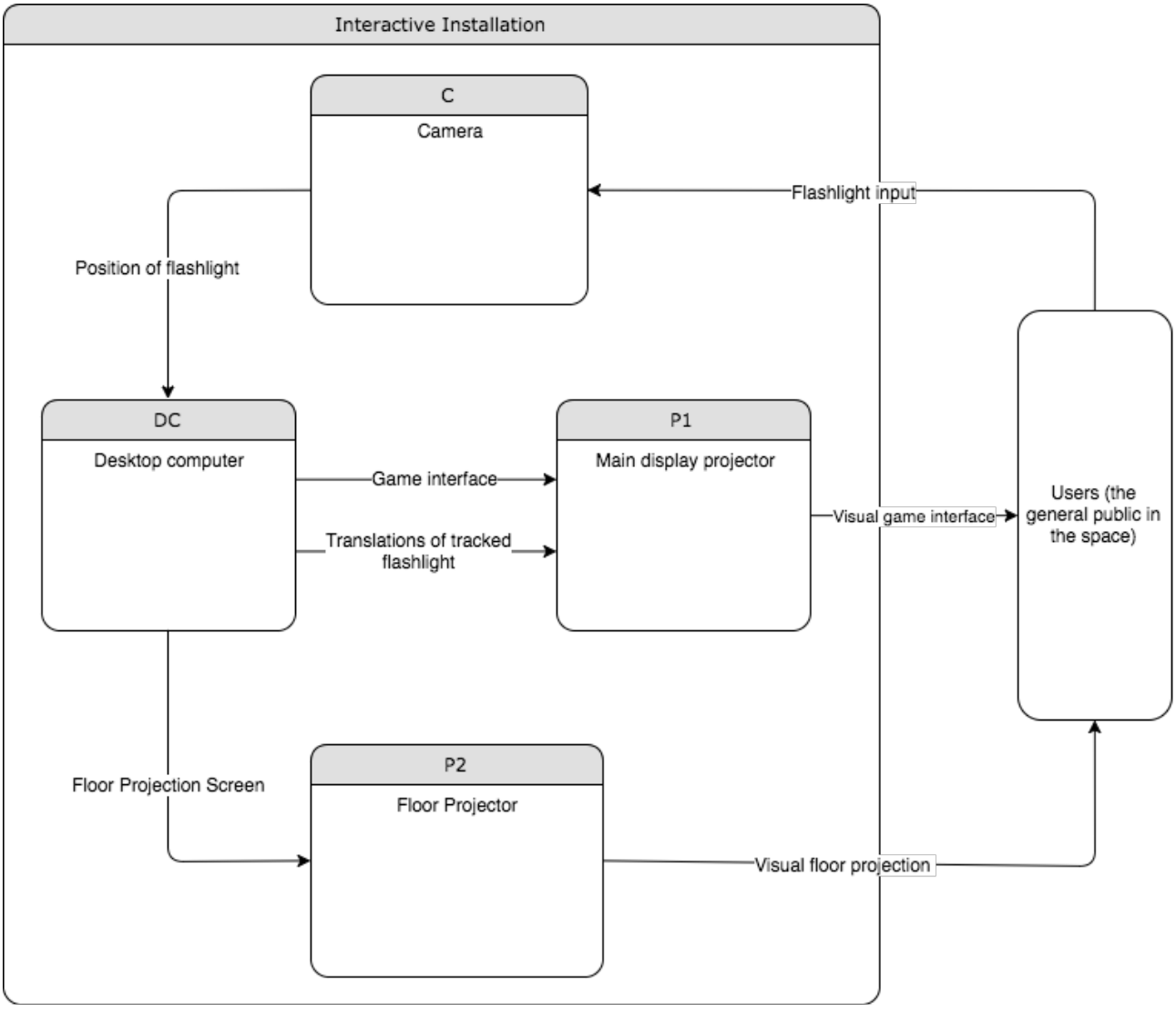


Fig. 9

Level 2: Desktop computer

This diagram shows a decomposition of all component elements and processes taking place within the desktop computer component

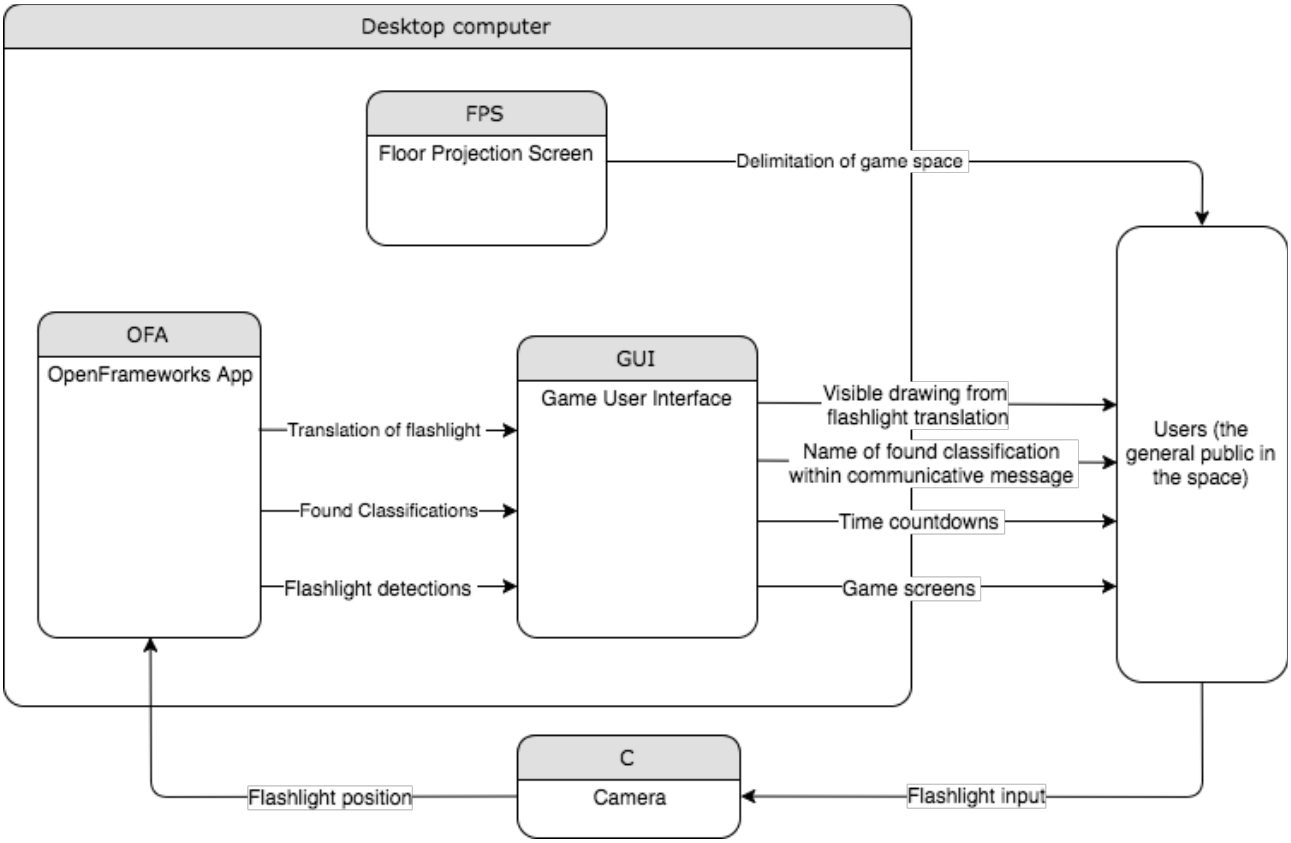


Fig. 10

Level 3: openFrameworks app

This diagram shows an overview of all classes within the openFrameworks application, with all the processes of communication that are carried out with each other

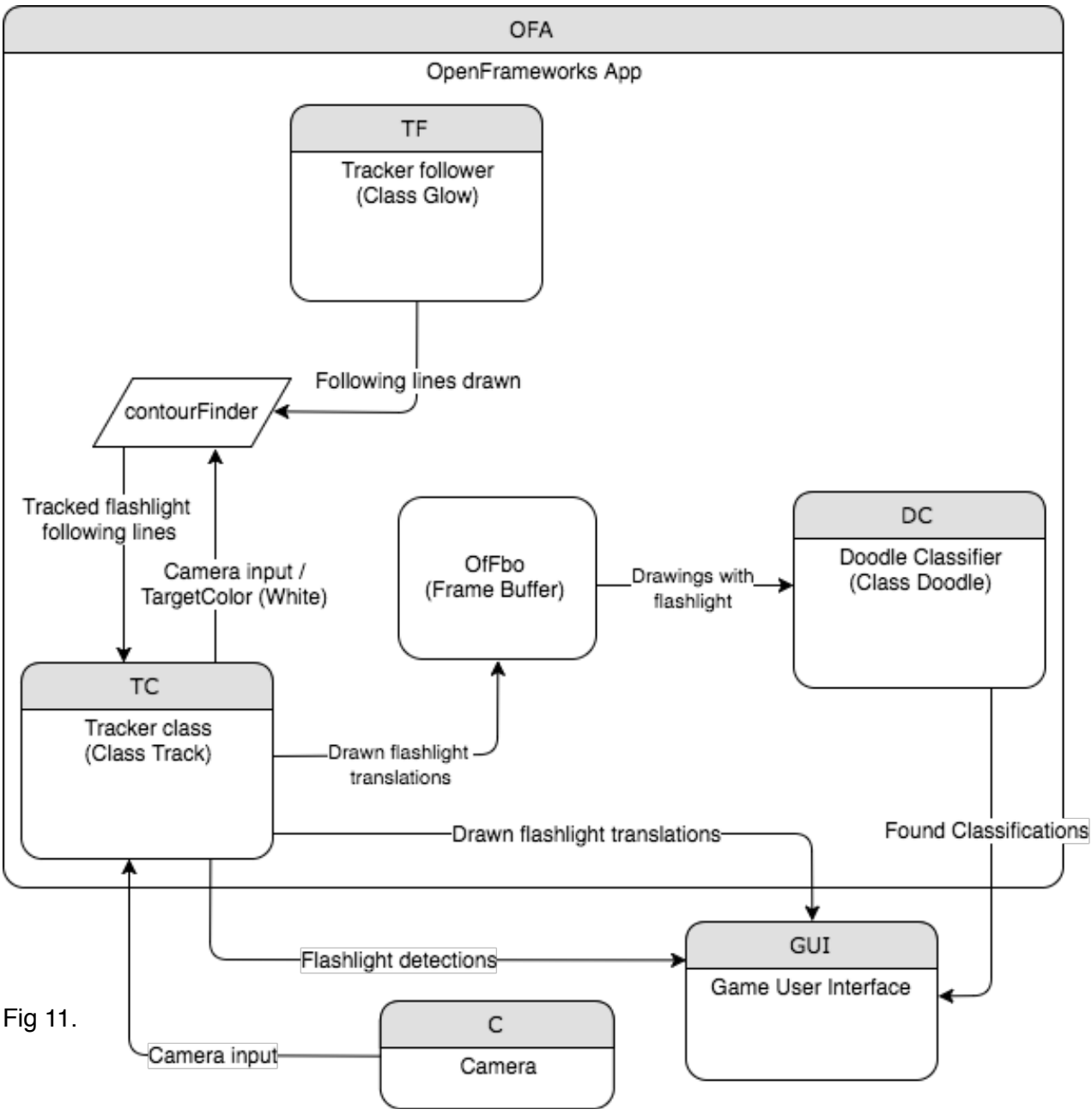
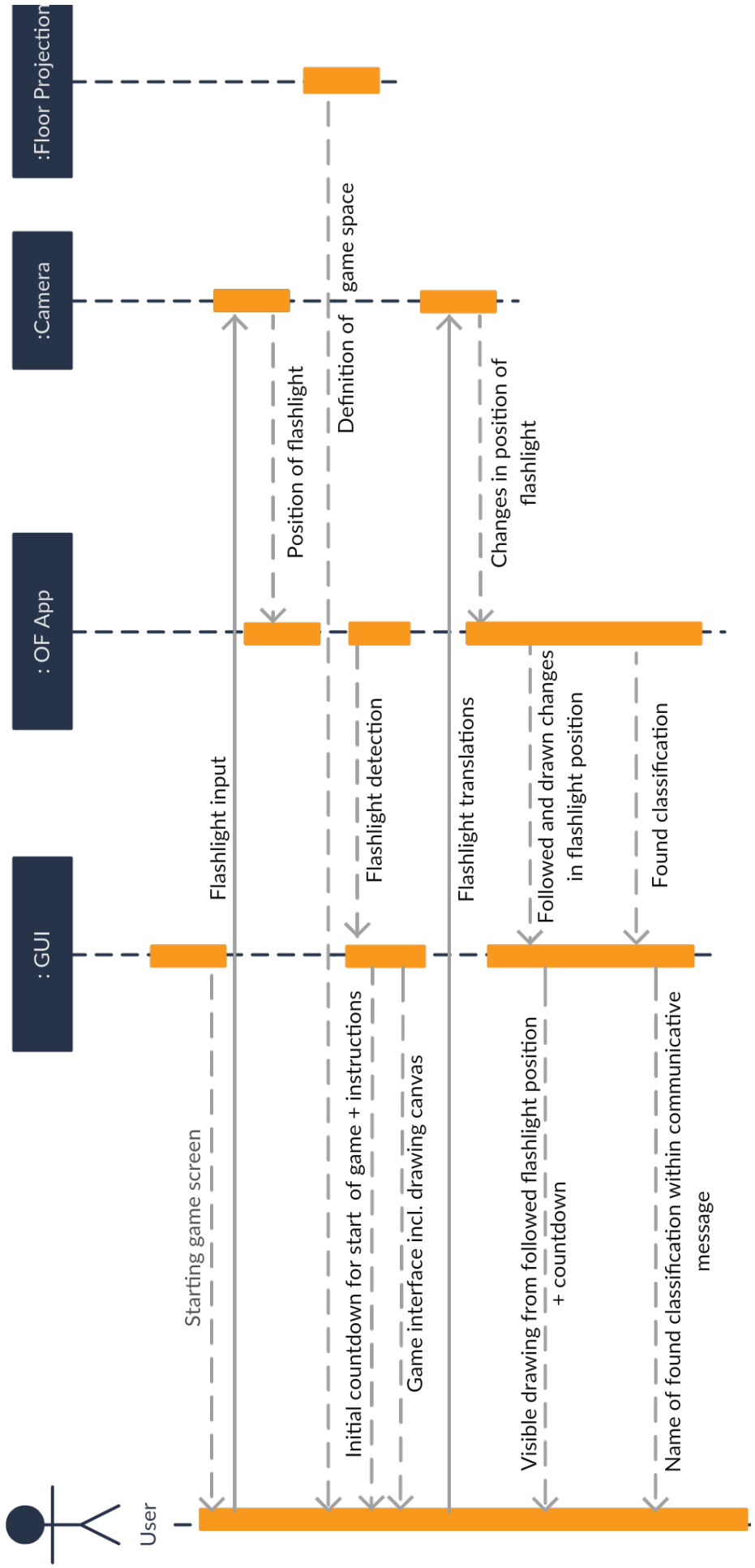


Fig 11.

5.3. Time Sequence Diagram

In the next page, a time sequence diagram shows the processes of interaction between the user and the components of the installation in an organised and systematic way. This sequence diagram illustrates similar processes to those of the level 2 data flow diagram.

Fig. 12


:Floor Projection
:Camera
: OF App
: GUI
User
Definition of game space
Position of flashlight
Changes in position of flashlight
Flashlight input
Flashlight detection
Flashlight translations
Followed and drawn changes in flashlight position
Found classification
Starting game screen
Initial countdown for start of game + instructions
Game interface incl. drawing canvas
Visible drawing from followed flashlight position + countdown
Name of found classification within communicative message

5.4. Experience specification

Although an exemplary experience with the installation has been given in the previous narrative user scenario, this experience will be further specified.
A first interaction with the installation is incited when passersby of a public space either notice the game's starting screen on the facade of a building, or see others already interacting with it using their smartphone's flashlights. In both cases, the passersby are instantly informed on how to initiate interaction with the installation, allowing for a quick start of the game. People that interact with it, are either aware of the goal of the game from having observed others play, or eventually find out by playing a first round. In both situations, users find out reasonably quickly; this allows for them to focus more on getting familiar with the interaction mechanism, to learn about its limitations and its most efficient use. Virtually drawing using a smartphone's flashlight imposes a learning curve that usually is overcome within a couple of tries, however, it depends on the user's adaptability and motor skills and can therefore take longer to overcome. To ensure that the experience of the interaction isn't affected by this learning curve, users are given the chance to freely draw during a 30 second countdown that is displayed after the installation detects a single flashlight being pointed at it for interaction. Once a user has begun to draw, he/she will notice that it is not easy to draw things in a very detailed way, and must thus adjust to this limitation by drawing in the most simplified way possible. In doing so, most users will draw things in similar ways, making it easier for the game's neural network to guess, those that deviate from the common drawings will further challenge the game's neural network. The resulting experience from drawing interactively thus depends on the user's interest and motivation to challenge the game's neural network. In drawing with such an interaction mechanism users are encouraged to move around the designated game space area in front of the game's display, which is delimited by a floor projection. Such encouragement improves the interactive experience because of the added challenge a user would face in drawing things while having to move around. The overall experience of the installation thus revolves around users enjoying to draw with such interaction mechanism, and challenging the game's neural network with drawings. Some users will get more enjoyment out of the interaction rather than the purpose of it, and vice versa.

Chapter 6: Realisation

6.1. Decomposition of components

6.1.1. First level decomposition of components

Camera

The camera that will be chosen for the installation will have to depend on the public space that is chosen for the placement of the interactive installation. The public space in front of the Wirelab building is large and extends in width and length for various meters, therefore the camera needed will need to be of good resolution to allow for precise tracking of the user's flashlight. The camera that is already setup on the facade of the Wirelab building is a surveillance camera equipped with infrared light for night time vision. It is placed approximately 5 meters above the floor in front of the Wirelab facade, so approximately 3.5 meters above people's chest height. To further validate the use of this camera a testing session will be organised at the Wirelab space in order to test whether it will fit for correct tracking of the user's flashlight. If this camera is not suitable, a new camera would have to be installed in the same place.

Main display projector

The main display projector is provided by my client 100% FAT, this projector will be powerful enough to beam over a projection screen of 5x3. This projection screen will be placed within the Wirelab building but will be visible from outside for passersby because it is placed in parallel to a large wall window of the office. An alternative to this setup would be to place the projector outside in the public space, however, deciding on placement for it would be challenging and if there is a case of bad weather the projector could not be used.

Floor projector

The floor projector is also provided by my client 100% FAT, the only possibility for placement of this projector would be within the office. It would have to be placed close to the office's wall window at a tilted angle of approximately 65 degrees so that the projection can hit the outside's floor correctly and properly outline the interactive installation's designated game space. There would be no alternative to this setup, and if it were not to work the floor projection component would have to be discarded from the installation.

Desktop computer

The desktop computer would also be provided by my client 100% FAT, it would have to be of enough processing power and have a good enough graphics card to run the application that would contain the installations's game. This application will be composed of various components that will be outlined in the following sections.

6.1.2. Second level decomposition of components

Floor Projection Screen

The floor projection screen will simply be composed of a large framing rectangle that will serve as the indicator of the designated game space. The rectangle will be unfilled and within it a series of animated arrows will point towards the two shorter sides of the designated space, so as to motivate users to move themselves along this space while drawing.

Game User Interface (GUI)

The game user interface will display the data and the user's current drawings that it continuously receives from the openFrameworks application.

openFrameworks application

The openFrameworks application will be composed of various classes that carry out the various in-app mechanisms necessary for the tracking of the user's flashlight, the following of this tracking, the drawing of the followed path, and the classification of the drawings made. These in-app components will be outlined and described in the following

6.1.3. Third level decomposition of components

Tracker class

The tracker class takes care of the tracking of user's smartphone's flashlight. It does this by receiving the camera's input pixels and locating the brightest grouping of white pixels within the feed by a process of thresholding the received pixels. Thresholding is the process of assigning each pixel of an image to either a false or a true class based on the pixel's value or location, which thus results in a binary image [17]. Having located the source of the grouping of brightest white pixels it then uses a countourFinder function to establish the contours of the grouping of white pixels, and from this contour it calculates its centroid to have an even more precise tracking of the source of these white pixels.

Tracker follower class

The tracker follower class follows the tracking of the whitest pixels, and draws the followed path by an interpolation of the tracked points. It also makes sure to only draw this path when the white pixels are detected, and to stop drawing when there are none.

ofFbo

A frame buffer object (FBO) is used to store the pixels created by the drawn paths. These pixels are then read to a grayscale image for a first round of thresholding using the contourFinder function.

Doodle classifier class

The doodle classifier class analyses the drawings made to classify them by comparison to previously saved drawings. The saved drawings make up the neural network's artificial intelligence, which are saved by a process of training that is carried out by a function within this doodle classifier class.

6.2. Realisation of components

Considering that the physical setup (composed of the first level components) of the installation is already in place at the public space of interest, the realisation of the second level components are the main focus of this phase. In particular, the openFrameworks application is the core component that determines whether the installation meets its functional requirements, for that reason the primary focus of this realisation process will be in developing this application. In developing such application, I had to realise each of its components (third level components) individually, and eventually link them so that they can communicate data to each other. Each of these components are classes that operate on the basis of certain openFrameworks addons that incorporate computer vision into the application. The realisation of these components and their relative addons will be described in the following paragraphs.

6.2.1. Tracker class

For the realisation of this component, I fist installed the openCV computer vision library that the ofxCv addon requires. Once this library was installed, I was able to run an example application that carries out the required functionality of this tracker class, which is to track a specific colour from a camera feed. Using this example, I further modified it so that it would only track the colour white at a certain intensity (the desired intensity would have to be set in accordance to the intended distance from the camera that the users are expected to have their flashlights). In the figure bellow the coutourFinder function displays a bounding box around the tracked white colour from the flashlight.

Fig. 13

6.2.2. Tracker follower class

For the realisation of this class, I used another ofxCv addon example that drew different coloured paths along the displacement of each tracked contour from a camera feed. I modified this example and implemented it into the aforementioned tracker class, so that it only follows and draws the path of a flashlight's contour box that is tracked by this class. This can be seen in the figure below

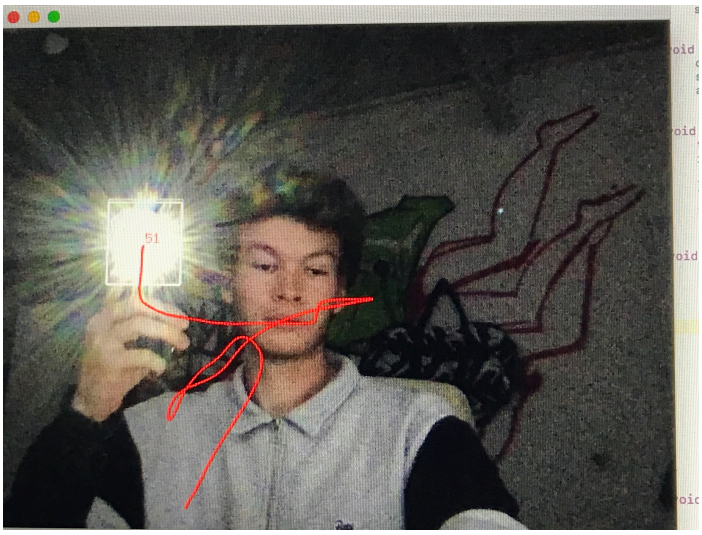


Fig. 14

6.2.3. Doodle classifier class

The realisation of this class was based on an existing openFrameworks application, found within a GitHub repository called ml4a (machine learning for artists) containing a collection of real-time interactive applications for working with machine learning. To run this example, I had to first download and include the ofxGrt addon, which also required that the GRT (gesture recognition toolkit) be installed. The installation of this toolkit proved to be challenging since it had to be done through the computer's terminal, and in the linking of this toolkit to the ofxGrt addon I occasionally encountered some difficulties. Once this addon was correctly included in the example, the addon ofxCcv had to also be included, which contains the core computer vision library that by using openCV can perform image classification. With both necessary addons included into the example it was finally ready for a test run. The important features of the application can be seen in figure 15 and 16, where figure 15 shows the control interface of the application, and figure 16 shows the two thresholding windows where inputed pixels are analysed. When running the application, the doodle classifier class uses the camera feed as input for the classification of images. I thus needed to modify part of the code so that the class receives an input of pixels of what is being drawn in the tracker class. I had to find a way to effectively communicate the pixels created by the tracker class to the doodle classifier class, which led me to find out about frame buffer objects (ofFbo). A frame buffer object is used to do off-screen rendering [18], and can thus be the optimal medium for such pixel communication between two classes.

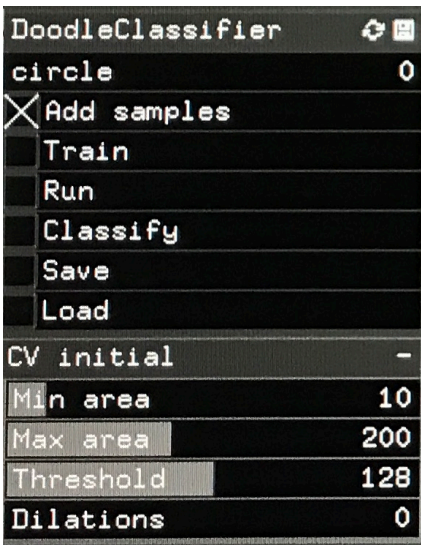


Fig. 15

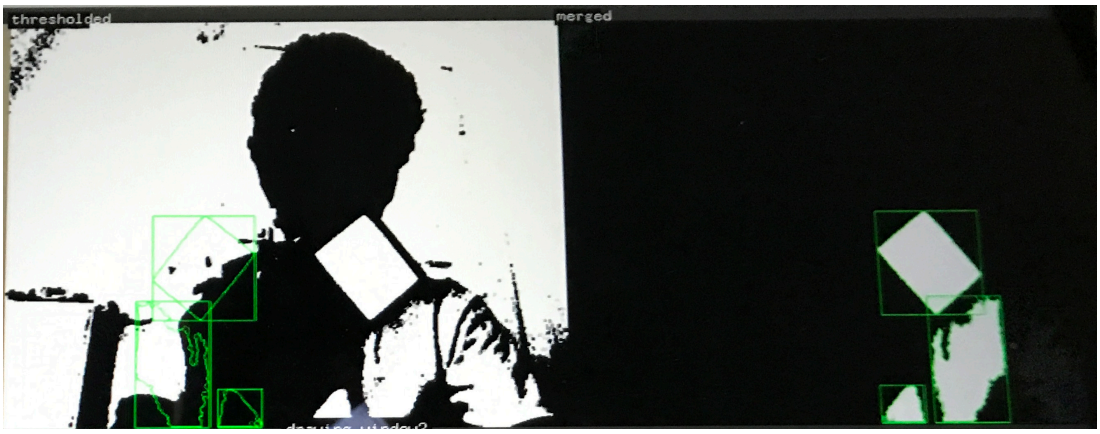


Fig. 16

To complete the realisation of the doodle classifier class, I created a frame buffer object that contains the tracker class' setup and draw functions, and then read this object to a pixels object so that it can be included in the doodle classifier class and used as new input for image classification. The result from this can be seen in figure 17 where the 'drawing window2' shows what has been drawn by the tracker class, and the 'thresholded' and 'merged' windows show the analysis of the pixels of this drawing window.

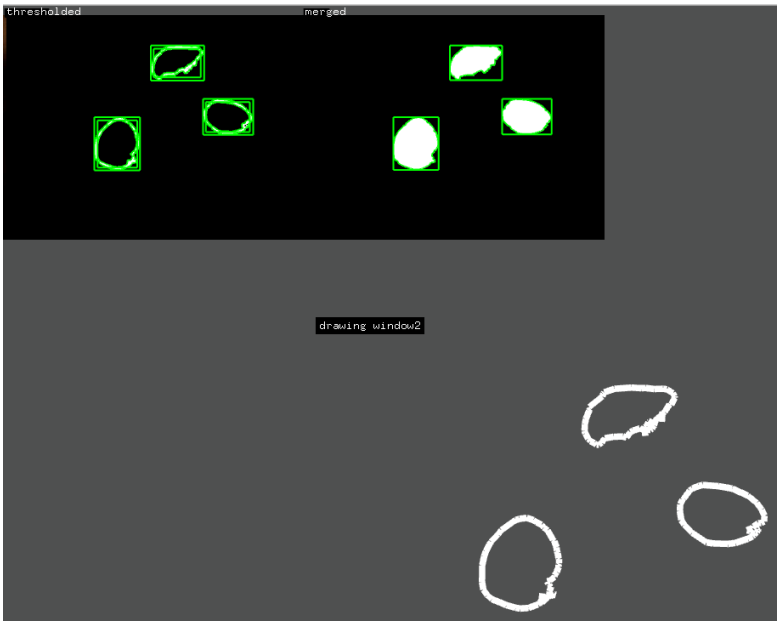


Fig. 17

6.2.4. Training of the neural network artificial intelligence

Now that the openFrameworks application has been built it, it is able to fulfil one of the installation's functional requirements, being able to interact with people by means of their smartphone's flashlight. However, the second functional requirement is for the game that composes the installation to be able to accurately predict what users are drawing by means of their interaction. Since this prediction is achieved using a neural network artificial intelligence, the neural network must first gain some intellect and learn through a training process. For this training process, at first the instance of object that is to be trained is drawn several times, then when the 'merged' window has analysed the pixels correctly, the class that will contain the trained samples is selected, and 'Add samples' is clicked on the control interface of the app. The added samples are then displayed on the app for further analysis by the person conducting the training, if these are considered suitable for training, 'Train' is clicked on the control interface to save the drawn instances into the neural network. This training process is then repeated several times with different drawing instances of the same object, so as to prepare the neural network for as many variations in the drawings of the object, since it must be prepared to predict drawings made by different people. Such a training must be conducted for each different object that the neural network would be required to predict. In the case of this application, the neural network was trained to predict drawings classified as 'circle', 'arrow', 'star', 'house', and 'shovel'.

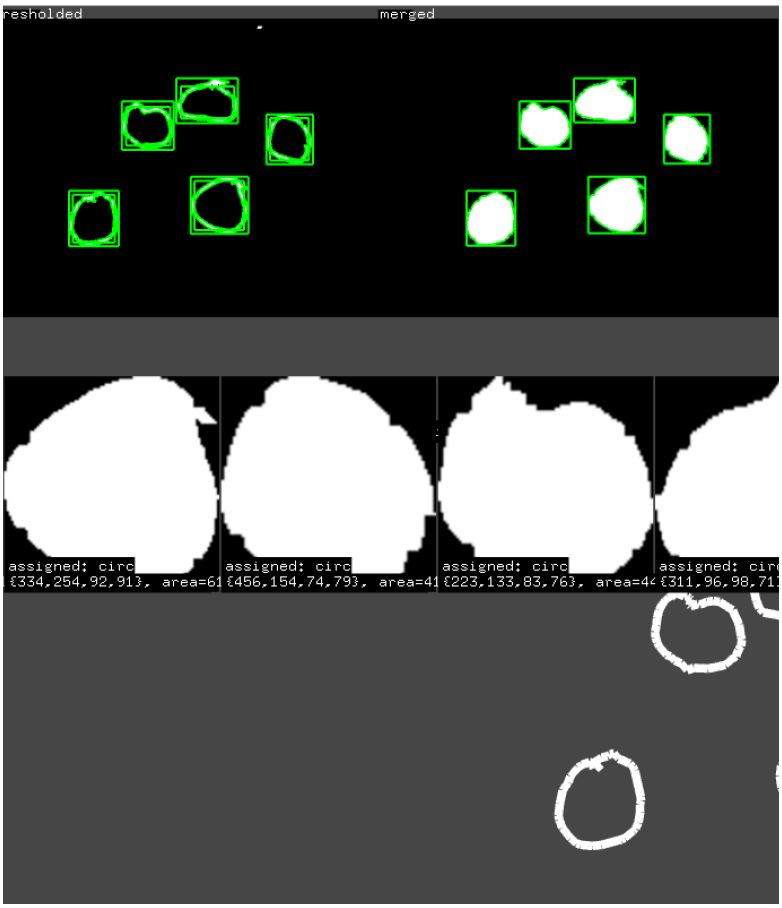


Fig. 18

6.2.5. Testing of the intelligence of the neural network

To test whether the neural network has been trained properly, it will be tested by making it perform predictions on various drawn instances of an object, as seen in figure 19. If it predicts all drawn instances of that object then it has been trained correctly and should be ready for more challenging predictions.

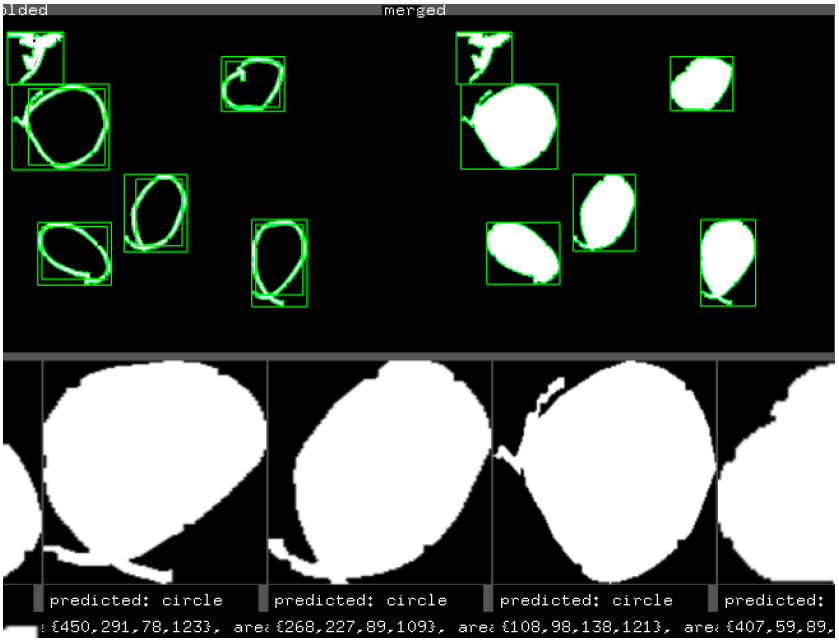


Fig. 19

Usually users will be instructed to only draw one object at a time and only one prediction is made as a result. However, even though it is outside of the scope of the installation's game, the neural network will be further tested by making it predict different objects that are drawn within the same canvas, as can be seen in figure 20. If it is able to correctly predict all the different previously trained objects, then it has been trained correctly for each object.

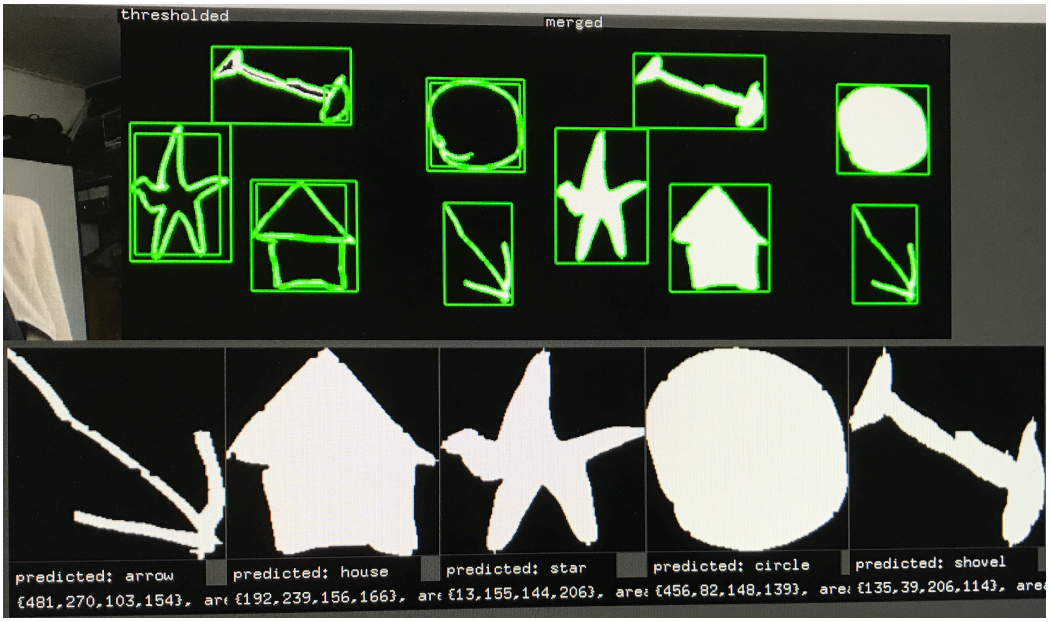


Fig. 20

In addition to this, further testing of the neural network can be done by having it predict objects that have been drawn in a much less recognisable manner, as can be seen in figure 21. Correct predictions of these “messier” drawings would prove that the neural network has been correctly trained with various drawing instances of all objects.

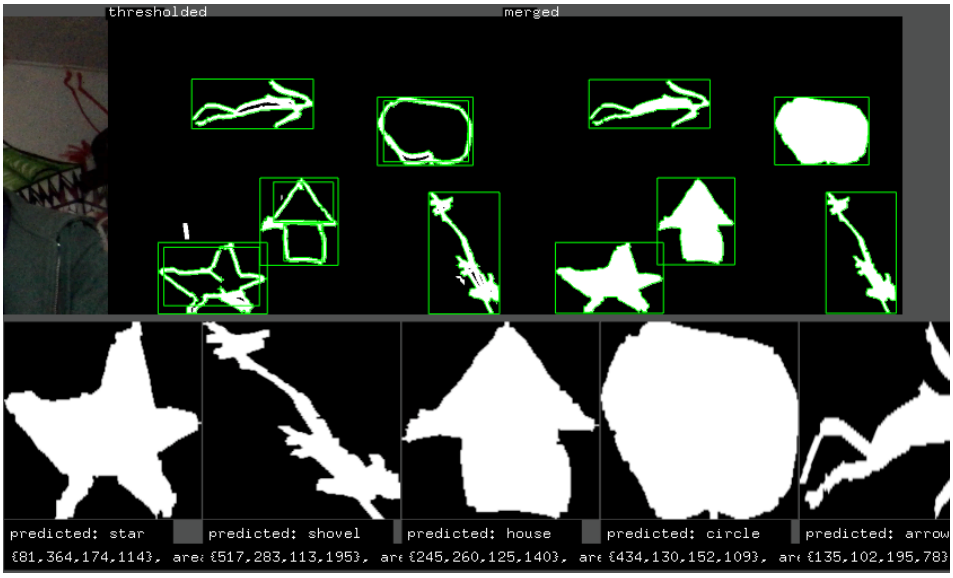


Fig. 21

Furthermore, this time staying within the scope of the installation’s game, the neural network’s intelligence can be tested by making it predict objects that are half drawn, as can be seen in figure 22. The correct prediction of objects that are half drawn proves that the neural network would be able to predict what users are drawing while they are in the process of doing so, much like in Google’s ‘Quick, Draw!’ game. By doing so, the neural network’s intelligence becomes more apparent to users, as it surprises them with such anticipative predictions that can even be considered difficult for humans to replicate.

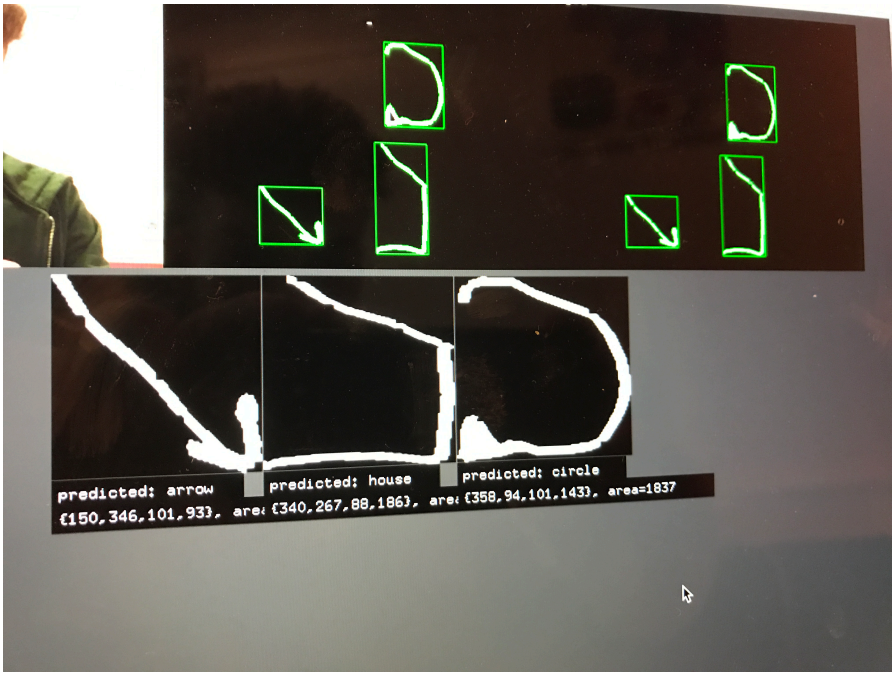


Fig. 22

As mentioned at the beginning of this section of realisation of components, this realisation process solely focused on the development of the openFrameworks application, therefore excluding the realisation of the game user interface and the floor projection screen. These components are however not trivial, but are essential in creating the desired user experience of the interactive installation within its context in a public space. Thus, possible suggestions for realisation of these components will be outlined and discussed in the later chapter of this report “Discussion and future work”.

Chapter 7: Evaluation

7.1. User Testing

“Wizard of Oz” user testing method:

This user testing method involves a so called “Wizard of Oz” methodology in which the application is not fully functional, therefore certain functionalities have to be carried out by active control of a moderator. Such a methodology aims at showing and testing the installation’s game experience with its end users, to obtain results about the user experience.

The openFrameworks application is run on a laptop, and uses the webcam it has to capture input from a flashlight. The game’s experience application is tested through in house testing with a selection of user testers. The laptop and the running application is thus deployed in different locations, namely spaces of choice to the user testers. The setup consists of the laptop being stably placed at slightly under chest height and approximately one meter away from the user tester. The laptop’s screen displays the drawing canvas where the user can draw using a smartphone flashlight.

User testing procedure:

1. The user testing moderator asks the user to turn on the flashlight on their smartphone, and instructs the user to always hold the smartphone parallel to the laptop’s screen, and that by switching on the flashlight the drawing starts and to stop drawing it must be turned off.
2. The user is instructed to draw a circle within the drawing canvas displayed.
3. The moderator then presses “Classify” on the hidden interface, and he informs the user tester that the app has predicted that it is a circle, and reveals the hidden interface to show the result.
4. The moderator then instructs the user to draw a star, and once done, he reveals the predicted result.
5. The moderator repeats this step three times with the instructions to draw a house, an arrow, and a shovel.
6. The user is then instructed to draw both an arrow and a shovel on the drawing canvas, the moderator reveals the application’s predicted results of both drawings.

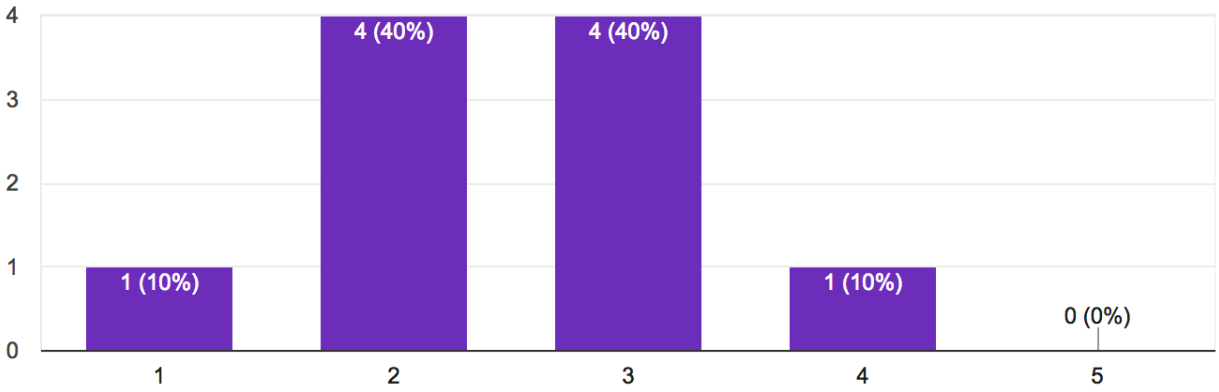
7. The moderator instructs the user to draw all the objects previously drawn within the single drawing canvas, and reveals the app's predictions to the user.
8. The user is instructed to half draw a circle, a house and a star within the drawing canvas; and then is shown the app's predictions on those half-drawn objects

After carrying out the procedure, the user is asked to fill in a short qualitative questionnaire composed of scaling, open, dichotomous, and multiple choice questions. The questionnaire can be found in Appendix A.

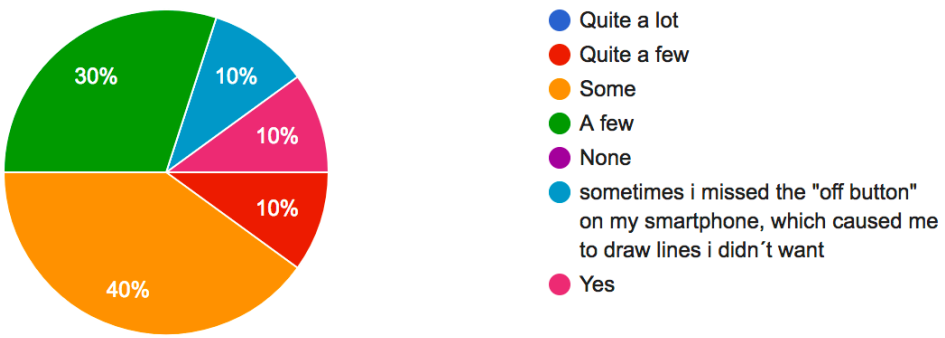
7.2. Analysis of user testing results

7.2.1. Graphical results regarding the user experience from using the interaction mechanism

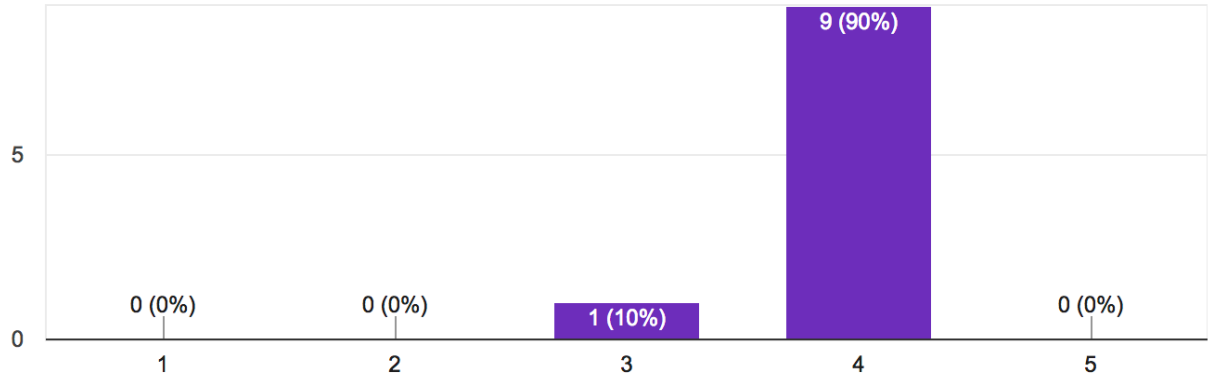
To what extent was it easy to draw using your smartphone's flashlight?



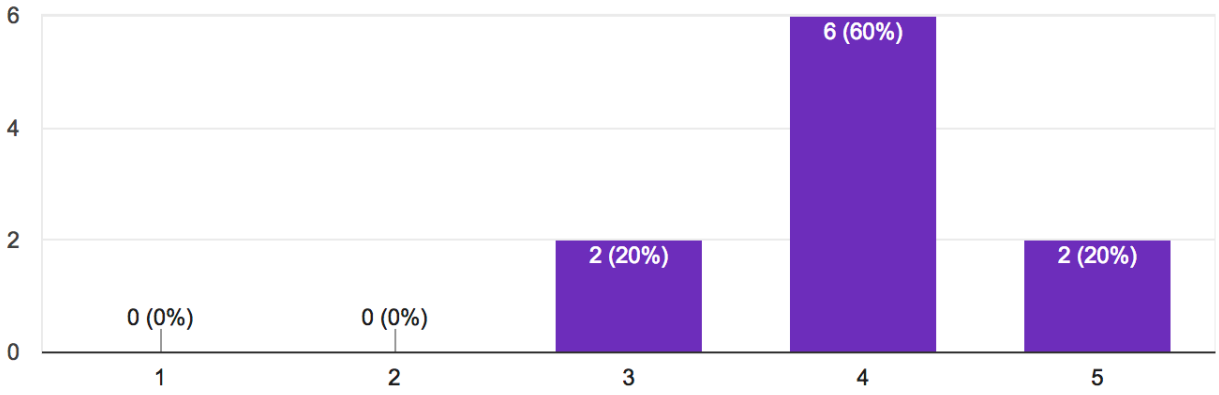
Did you experience any difficulties while drawing with a smartphone's flashlight?



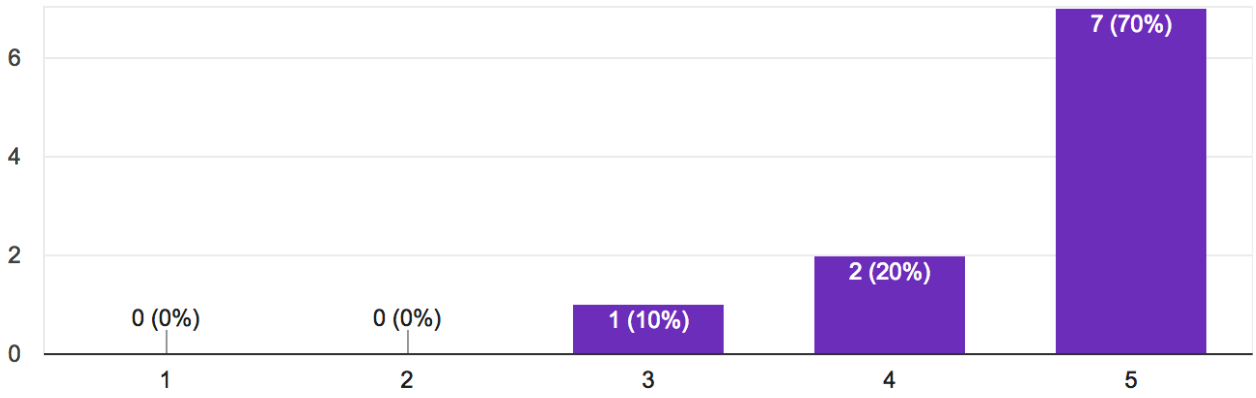
Were your movements with the smartphone's flashlight translated accurately onto the drawing canvas?



Was drawing with your smartphone’s flashlight intuitive?



To what extent did you feel that drawing with your smartphone's flashlight was fun?

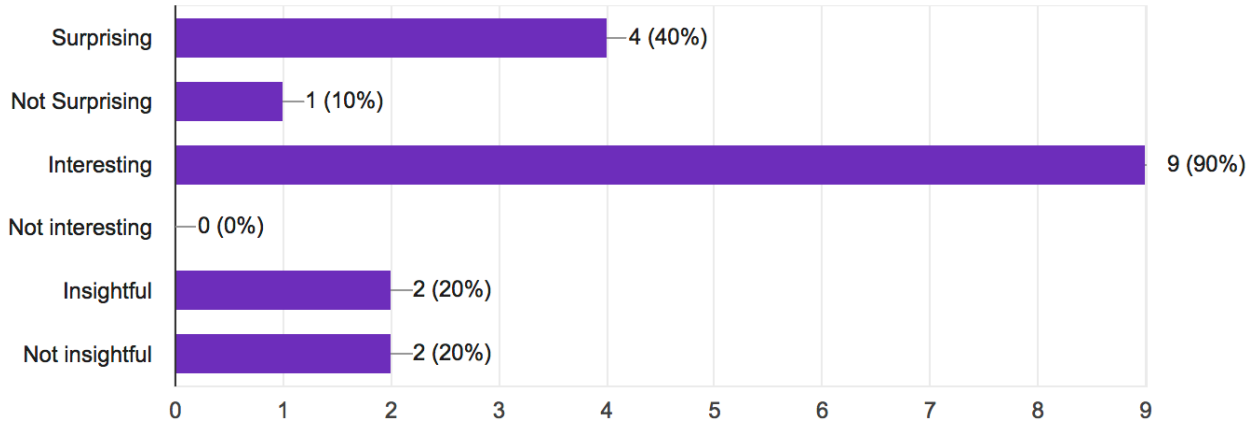


From these graphical results the following insights are reached:

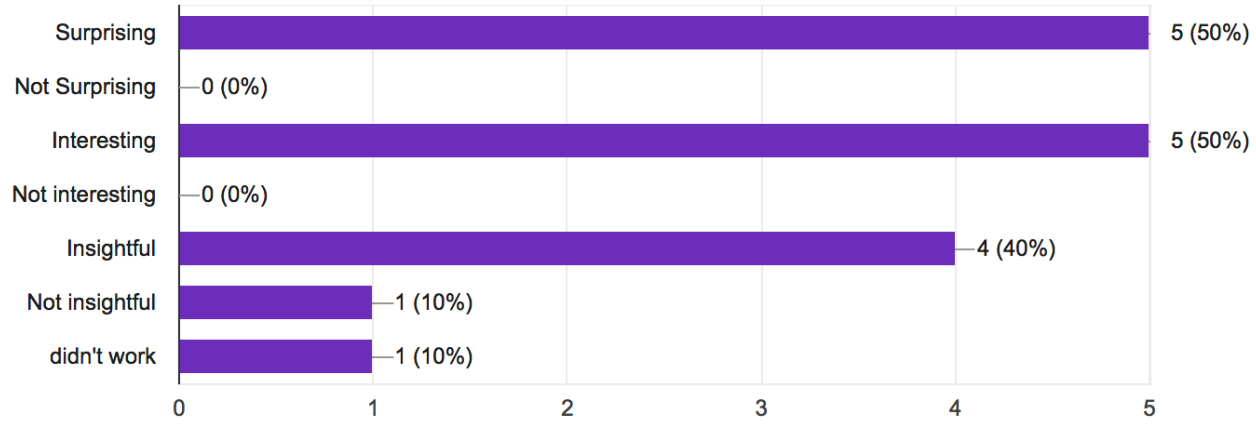
- It is not considered easy to draw using the interactive mechanism of drawing with a flashlight. However, it is considered doable as all user testers recognised that there is a learning curve to using it (which can be seen in the results in appendix B, table 1, question 4). It can be assumed that by admitting to having recognised a learning curve, users consider themselves capable of learning how to use the interactive mechanism to a functional extent.
- There are usually some difficulties experienced when drawing with such mechanism. Most users experienced ‘a few’ or ‘some’ difficulties, however, the variety of results indicates that the amount of difficulties experienced could depend on the user’s motor skills.
- The app translates the user’s movements almost completely correctly.
- Drawing with a flashlight can be considered almost intuitive.
- Most users found it fun to draw with a flashlight, but there are some cases where users didn’t find it particularly fun.

7.2.2. Graphical results regarding the user experience from receiving the neural network’s predictions

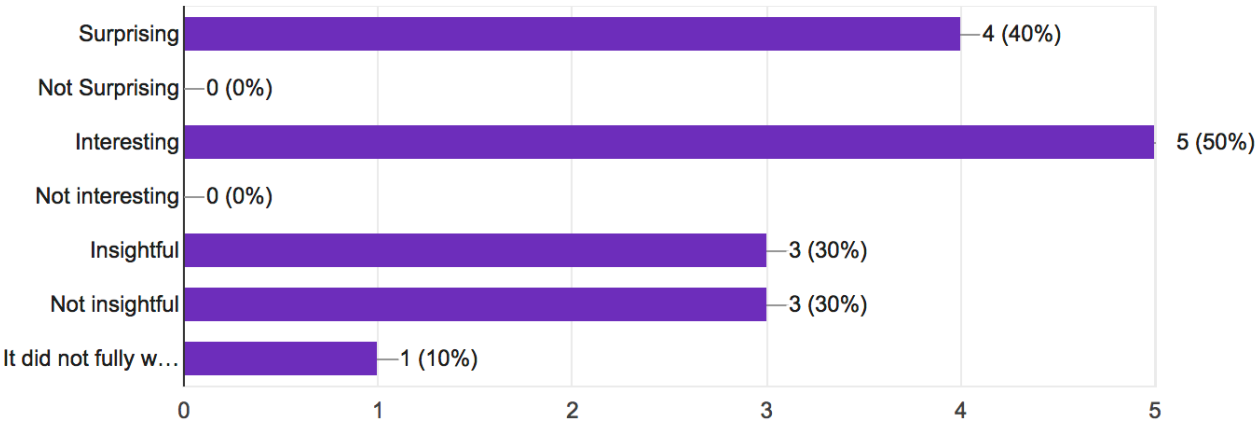
What was your first impression when you saw what the app had 'predicted' from the circle you drew at the beginning?



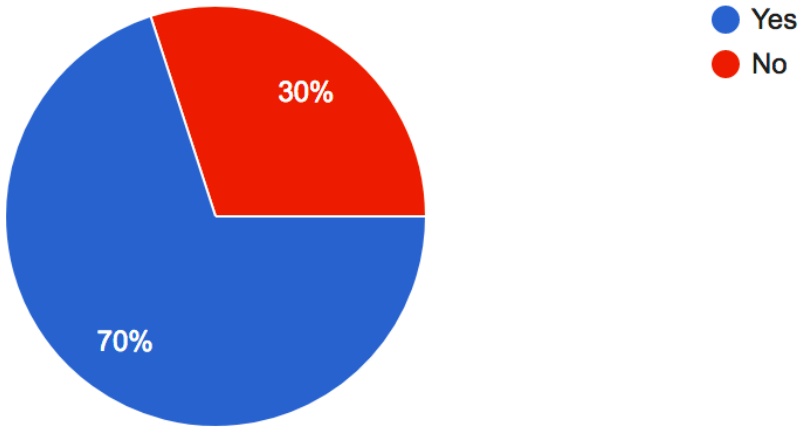
What was your first impression when you saw what the app had 'predicted' from all the objects drawn together within the drawing canvas?



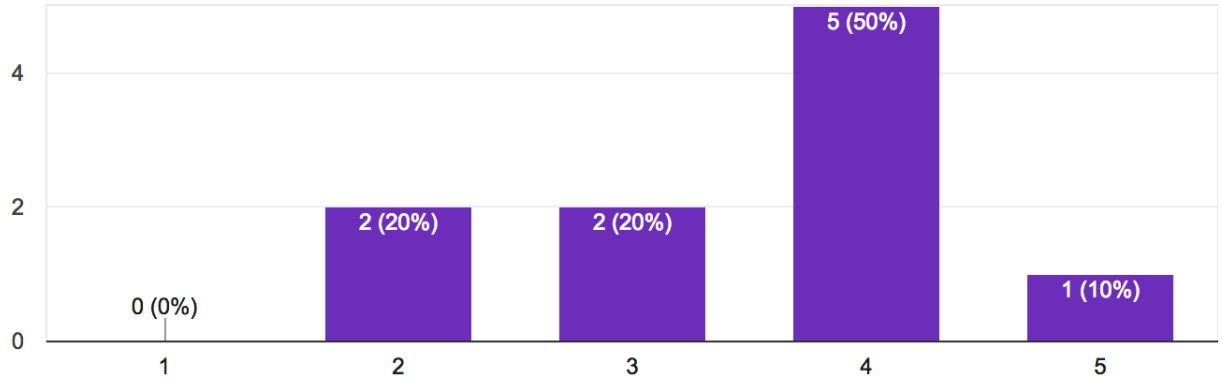
What was your first impression when you saw what the app had 'predicted' from the objects that were half drawn within the drawing canvas?



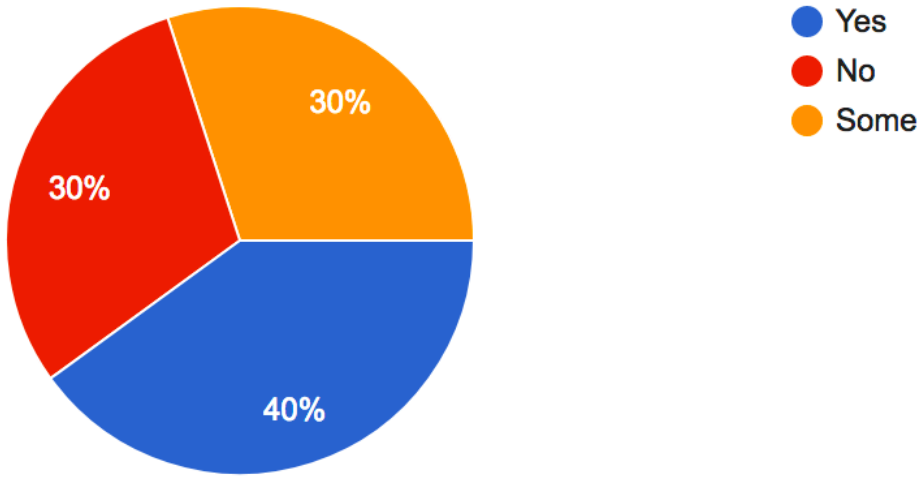
When you saw the app's predictions, did you wonder how they were reached?



To what extent were the app's predictions correct?



Were the half drawn objects predicted correctly?

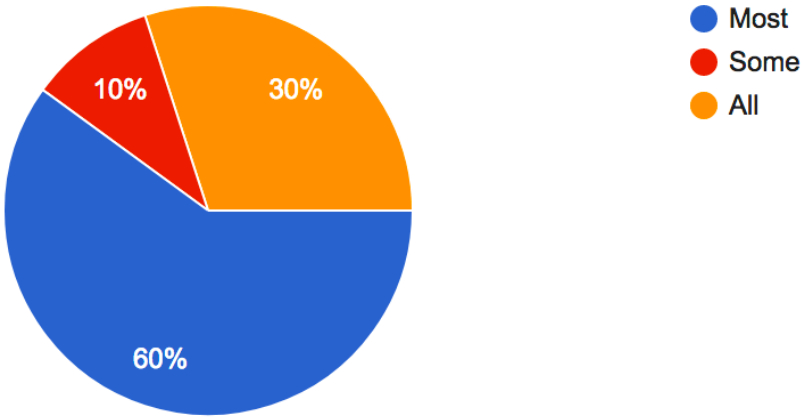


From these graphical results the following insights are reached:

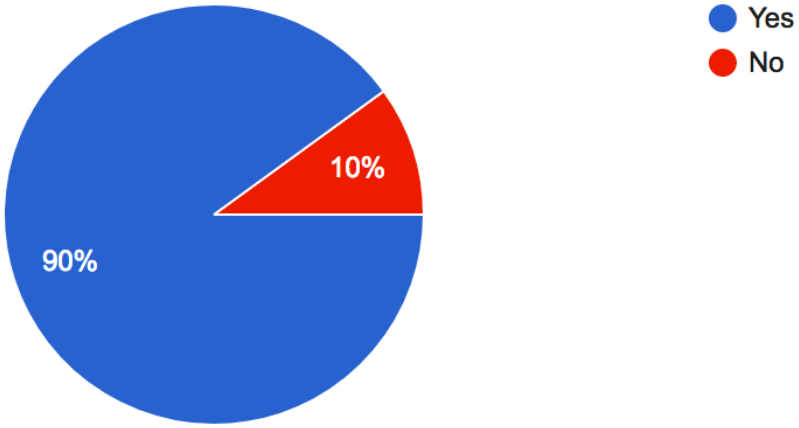
- When users received the neural network's predictions on what they had drawn, the were most usually surprised and interested. However, some occasionally found the predictions insightful or lacking insight.
- A majority (70%) of users did wonder how the predictions were reached
- The neural network's predictions are a lot more usually correct than incorrect
- The neural network was not able to always correctly predict the half drawn objects

7.2.3. Graphical results regarding the user experience after the completion of the game

If these same objects were to be drawn by someone else, also using a smartphone flashlight. Would you be able to recognise all objects drawn on the app's canvas?



Would you have liked to draw more objects for the app to recognise?



From these graphical results the following insights are reached:

- Most users would doubt their ability to recognise all drawn objects if someone else were to draw them using the interaction mechanism of drawing with a flashlight
- Nearly all users would have liked to continue drawing objects for the app to recognise

7.3. Discussion of results and gained insights

We can now use the gained insights from the results of the user testing to know whether the application meets its functional requirements and whether the experience that it offers meets the previously set user requirements. One of the functional requirements was that the installation should contain an interactive mechanism that is effective in inciting interaction with people. Considering that most users find the interaction mechanism fun and intuitive, this requirement can be considered met to a certain extent. Another of the functional requirements was that the installation's game delivers an experience that is of interest to users and is able to captivate users' attention to a certain extent. This requirement can also be considered met, since the results show that most people found the game's predictions to be interesting and surprising above all other thoughts. Additionally, nearly all users were captivated enough by the game that they would've liked to continue playing it by making the neural network guess other drawn objects.
These previous reasons also justify that certain user requirements have been met. The user requirement on how the experience of the installation must be entertaining and challenging is proven to be met by these previous results. The rest of the user requirements are not yet proven to be met by the results of this user testing. A different user testing methodology where the application is tested in the public space of interest would be necessary to prove the remaining requirements. Such user testing methodology will be outlined and discussed in the "Discussion and future work" chapter.

Chapter 8: Conclusion

The aim of this graduation project was to design an interactive installation for a public space. An installation that acts as in interactive playground for people to enjoy when they are present at a public space. For that reason, the installation has to introduce a game that is entertaining for people of all demographics, and that engages them physically to a certain extent.

Through an iterative process of idea generation partially involving the client, an installation concept has been designed, developed, and tested: Flashlight drawing with a neural network A.I.

The results of the user testing with the application that delivers the installation's game experience (experience prototype) indicated that, even in a premature state, the installation complies with its aims. Nevertheless, the user testing was relatively small and the game experience was not tested within its intended context of a public space, therefore this testing cannot be considered fully conclusive. However, what can be concluded is that the game experience as a whole (from the results on the user experience of playing the game with the interaction mechanism) is considered fun, entertaining, and captivating. With such results, it can be concluded that this interactive installation concept does answer the research questions that were set in the second chapter of this report. The extent to which the installation is able to captive people that pass by a public space could not be tested yet, but the user testing results give a indication that the extent would be of significance. The user requirements are also not fully proved to be met, these would only be proved with a user testing of the installation in its intended public space. Such a testing was not possible because of contextual factors. For example, the installation's setup at the public space used a surveillance camera equipped with infrared, this infrared brightened up the camera's pixels feed, and thus this feed could not be used for input for the game application.

The designed installation is an interactive game installation that invites passersby of a public space to draw using the flashlight on their smartphones with the aim of drawing certain objects so that a neural network A.I. can guess them. Such a game is intended for people of all demographics, which, with such game experience enabled by a novel interaction mechanism is entertaining and captivating to most people. Not only that, but the nature of the game allows for open-ended and emergent play. The extent to which it allows this can be tested in future work, but from previous results and user testing observations there is to a certain extent proof that it allows for such play.

By the end of this project there is still room for improvement, therefore further design, implementation, and testing suggestions for the interactive installation will be defined and discussed in the following chapter on future work.

Chapter 9: Discussion and Future Work

For future improvement of the interactive installation concept that has been developed, there are certain suggestions concerning the installation's design and its testing.
First of all, an important design feature that is important for the installation game experience is its communication with users. The installation should start by inviting people to turn on their flashlights and pointing it towards the virtual drawing canvas displayed on the facade of a building in the public space. This communication must be done by means of an instructional animation, that must also include instructions on how the user should correctly hold their smartphone (as parallel as possible to the display), and showing that to start drawing the flashlight should be turned on and to stop that it should be turned off. These instructions are essential to make sure that the user experiences the least of a learning curve as possible in using a smartphone's flashlight to draw. Whether such an instructive starting screen is effective in decreasing the learning curve and in improving the user experience of the installation's game could be tested by setting up a user testing session taking place at the public space using the predetermined physical setup. During this testing session the moderator would have to observe the users on how fast they are able to start interacting with the game, and a questionnaire should also be given to each user at the end of the session to ask them about the interaction mechanism's learning curve and the user experience from using it.

Furthermore, continuing along the lines of the installation's communication with its users, the game user interface of the installation should display messages that convey the feeling that these messages are sourced from the neural network's intelligence. This means that the messages should appear in a way that is machine like, or that the message should be accompanied by a robotic sounding voice sourcing from some speakers placed around the display of the installation. To test whether these messages and accompanied sound voice effectively transmit the feeling that the game's predictions source from artificial intelligence, users in a testing session could be asked to fill in a questionnaire that includes a question asking whether they became aware of where the predictions sourced from. These are the design improvements for future work that are most important to fulfil the desired user experience that the interactive installation should offer.

Some more design improvements could be added, such as adding temporary object illustrations to the game's interface when users are asked to draw an object, so that these illustrations act as temporary examples of what can be drawn. Such design feature would benefit younger users as well as the elderly because their imagination for drawing can be encouraged by some hints. Additionally, such design feature could encourage any kind of user to draw more within the game and thus promotes one of the goals of the interactive game.

With these possible design implementations for the game's user interface, a user testing session could be carried out in the public space of interest to test whether the interface is suitable for the space, and whether it would communicate with users appropriately. To test the interface as a whole, a variety of users of different demographics should participate in the user testing. They should all be minimally instructed, and left free to explore and navigate the game through its interface. After they are done playing the game they should be given a questionnaire where they answer a few questions regarding the user experience delivered by the game's user interface as a whole. To accompany the results of the questionnaires, the test moderator should have noted down some observations on whether user testers had understood the communications the interface communicated.

Moving on to improvements in the design of the installation's game that runs on the openFrameworks application. Improvements could be done in the code by having an experienced professional programmer revise it, to make sure the game runs efficiently and is completely stable and bug free. This would be an important improvement to be made before the game is introduced to the public. In addition, the application up to this point lacks certain functionalities that would be important for when the game is placed in a public space. These are functionalities that were carried out by a "wizard of oz" method in user testing. One of them is that the game predicts drawings while the user is drawing, instead of having a moderator wait till the drawing is finished to click to get the prediction. Such a functionality is essential to the user experience of the game, because with such constant predictions, users get more of an impression that these predictions originate from a machine's intelligence.

Appendices

Appendix A:

User testing questionnaire:

1. To what extent was it easy to draw using your smartphone flashlight?

Rate from 1-5:

2. Were your movements with the smartphone's flashlight translated accurately onto the drawing canvas?

Rate from 1-5:

3. Was drawing with a smartphone's flashlight intuitive?

Rate from 1-5:

4. Did you notice a learning curve in drawing with a smartphone’s flashlight ?

Yes/No

5. Did you eventually overcome this learning curve?

Not fully / Yes, completely / Other

6. Did you experience any difficulties while drawing with a smartphone’s flashlight?

Quite a lot / Quite a few / Some / A few / None

7. To what extent did you feel that drawing with your smartphone's flashlight was fun?

Rate from 1-5:

8. What was your first impression when you saw what the app had 'predicted' from the circle you drew at the beginning?

Surprising / Not surprising
Interesting / Not interesting
Insightful / Not insightful
Other

9. What was your first impression when you saw what the app had 'predicted' from the arrow and shovel you drew together within the drawing canvas?

Surprising / Not surprising
Interesting / Not interesting
Insightful / Not insightful
Other

10. What was your first impression when you saw what the app had 'predicted' from all the objects drawn together within the drawing canvas?

Surprising / Not surprising
Interesting / Not interesting
Insightful / Not insightful
Other

11. If these same objects were to be drawn by someone else, also using a smartphone flashlight. Would you be able to recognise all objects drawn on the app's canvas?

Most / Some / All

12. What was your first impression when you saw what the app had recognised from the objects that were half drawn together within the drawing canvas?

Surprising / Not surprising
Interesting / Not interesting
Insightful / Not insightful
Other:

13. What was your last impression from the overall experience, or what specific insight might you have gained?

Open answer:

14. To what extent were the app's predictions correct?

Rate from 1-5:

15. Were the half drawn objects predicted correctly?

Yes / Some / No

16. When you saw the app's predictions, did you wonder how they were reached?

Yes / No

17. Would you have liked to draw more objects for the app to recognise?

Yes/No

Appendix B:

Tables with the results from the questionnaires:

Table 1:

1	2	3	4	7	14	15	16	17
3	4	4	Yes	5	4	Yes	Yes	Yes
2	4	5	Yes	3	5	Yes	Yes	Yes
3	4	3	Yes	4	2	No	Yes	Yes
2	4	5	Yes	5	3	No	Yes	Yes
1	4	3	Yes	4	2	No	No	Yes
3	4	4	Yes	5	4	Yes	Yes	Yes
2	4	4	Yes	5	3	Some	Yes	No
3	4	4	Yes	5	4	Some	Yes	Yes
2	4	4	Yes	5	4	Some	No	Yes
4	3	4	Yes	5	4	Yes	No	Yes

Table 2:

5	6	11
Yes, completely	some	All
Not fully	Yes	Some
Kind of	Some	Most
Not fully	Some	All
Not fully	Some	Most
Yes, completely	A few	All
Not fully	Quite a few	Most
i got better over time	A few	Most
Not fully	A few	Most
Not fully	Some	Most

Table 3:

8	**9**	**10**	**12**
Insightful	Interesting;proud of my drawing skills	Interesting	Insightful
Surprising;Interesting;Not insightful	Surprising;Interesting;Not insightful	Surprising;Interesting;Not insightful	Surprising;Interesting;Not insightful
Interesting	It did not fully work yet	Interesting	It did not fully work yet
Surprising;Interesting	Interesting	Insightful	Not insightful
Interesting	Interesting	Surprising	Not insightful
Interesting;Not insightful	Surprising;Interesting	Surprising	Surprising;Interesting
Surprising;Interesting	Surprising;Insightful	didn't work	Surprising
Interesting	Insightful	Surprising	Interesting
Not Surprising;Interesting;Insightful	Surprising;Interesting	Interesting;Insightful	Interesting;Insightful
Surprising;Interesting	Surprising;Interesting;Insightful	Surprising;Interesting;Insightful	Surprising;Interesting;Insightful

Table 4:

13. What was your last impression from the overall experience, or what specific insight might you have gained?
had the impression that it ended too early, was fun so i´d like to keep playing with it and get better
Coding seems complicated
I wondered how this system works!
it is quite difficult to draw an object with your flashlight but it is impressive the the system sometimes recognises the shapes
its really hard to draw with a flashlight
I was thinking there should be other ways to track the movement
the detection worked surprisingly well
it is interesting to see that the app fills out forms that one draws and also recognizes the shapes
I want to draw more with it and try out different shapes, felt like i was spraying with a spray can
Great, Enjoyed it

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