Motivatio: A standalone music selection system for seamless technology-mediated audience participation.

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Abstract

This thesis describes the design and implementation of a standalone music selection system designed for technology-mediated audience participation: Motivato. The creation of Motivato is part of a case study to address design issues emerging with the use of technology-mediated audience participation. Feedback and observation from existing literature in the field of technology-mediated audience participation are used to detect the emerging issues. Design issues found are further used as guidelines in the design decisions of Motivatio. For instance, previous works find that spectators do not tend to use objects during concerts, and therefore states that we need to consider the role of tangible interfaces in the interaction design for technology-mediated audience participation. Furthermore, previous works also indicate that participants prefer seamless interaction to tangible interaction in technology-mediated audience participation. Consequently, a seamless interface for interaction has been implemented in Motivatio. Results demonstrate several design issues emerging from the use of technology-mediated audience participation, emphasizing two key issues: clear feedback and the total number of participants.

Acknowledgment

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1. INTRODUCTION

This introductory chapter presents the motivation for this work, as well as the research question, the limitations and an outline of the thesis.

Music performances have been around for a long time, and with the rise of technology, the scene of performing have evolved. Both the music creation and the performance as a whole have changed in accordance with new technological breakthroughs. Wireless microphones and guitars have provided freedom of movement to performers on stage. A more futuristic example is the use of holograms of virtual performers, making the appearance of deceased artists possible in a performance. Whereas the way audience attend these performances have not changed much. Throughout history audience have usually been taking part of the performances as passive participants, which is the concept of being an audience. However, audience often show an overall interest for interaction, by clapping their hands, sing along and communicate with the performer in various ways. The use of Technology-Mediated Audience Participation (hereafter TMAP) enables the audience to actively participate to the performance. TMAP systems consist in the use of technology for allowing audience to actively participate during a performance, by adding an extra layer of interaction to the performance. This extra layer of collaboration between the performers and the audience makes the performance more complex, but also intensify the experience and the expressiveness of the performance as a whole (Hengeveld, Frens, and Funk 2013). Besides making the performance more complex, there are design concerns that occur with the use of TMAP. Some design concerns can be found in the form of feedback and observations in previous works in the field of TMAP.

Glimmer (Freeman 2005) and *Flock* (Freeman and Godfrey 2010) are examples of two TMAP-systems. Practical exploration of both these systems have led to feedback and observation regarding design concerns in TMAP. Some of the participants in *Glimmer* got frustrated because their action did not seem to have any effect on the performance, due to the challenge of differentiate the actions of such a big number of participants. In *Flock,* Freeman and Godfrey found that the interactive behavior of participants is correlated with the total number of participants. In the work of (Kayali et al. 2017), evaluation of TMAP in three music performances are presented. Unfortunately, the works presented above in addition to most other works in the field have not systematically identified the design concerns that emerges with the use of TMAP. However, the work of (Hödl et al. 2017) addresses this gap in knowledge. Hödl et al. collect information from audience and musicians in the form of a survey regarding the use of TMAP in live music. These surveys are then analysed, and the result is used to identify emerging design issues of TMAP.

This thesis describes the design, implementation and evaluation of a prototype of a TMAP system based on feedback from both performers and audience. The aim of making this prototype, is to address design issues emerging with the use of TMAP.

1.1 Research question

TMAP has many uses in the field of music technology and is likely to become more commonly used in performances and installation, with technology being more present than ever before. In the research history of TMAP, most studies tend to design and implement a system for TMAP, then use this system for practical explorations, with a purpose of doing observation and get feedback. The observation and feedback gathered from these explorations can reveal design issues of TMAP. However, most works have been limited when it comes to address these problems. This thesis seeks to address the design issues of using TMAP. This thesis uses findings from feedback and observations in earlier research in the field of TMAP to reveal design issues. These issues are emphasized in the design of Motivatio. The aim of this thesis is to address design issues emerging with the use of TMAP:

- *What design issues emerge with the use of technology-mediated audience participation?*

I have chosen to use a seamless interface in the interaction design of Motivato, instead of the more commonly used – tangible interaction. The decision of using seamless interaction are based on findings in (Hödl et al. 2017) paper, which states that we need to consider the role of tangible interfaces in the interaction design for TMAP, due to their findings regarding the use of objects, or the lack thereof. Based on these findings I have come up with the following hypothesis:

- *Seamless interfaces are more suited than tangible interfaces in the interaction design of technology-mediated audience participation.*

1.2 Limitations

The initial plan was to approach the research question and the hypothesis presented in the previous chapter in three phases.

The first phase was to conduct a literature review, where I researched literature to find feedback and observations from previous research in the field of TMAP. My research in the literature review was used to find design issues regarding the use of TMAP. The second phase was to use the design issues found in the first phase as design guidelines in the creation of an interactive music system designed for TMAP, which led to the creation of Motivatio. The initially planned third phase, was to use Motivato for a practical exploration with the use of audience to further explore the design concerns of TMAP, but mainly make an A/B test for my hypothesis. Due to the Corona crisis, the practical exploration with audience (the third phase) has been difficult to conduct without breaking rules of infection control, as well as finding a location that is not closed to do this exploration. As a result of that, the third phase (exploration) was not conducted. Even if less ideal than what originally planned for, more time was spent on the first and second phase, resulting in deeper insight of previous works in the field and more time spent on the development of Motivatio.

1.3 Thesis outline

This thesis is organized as follows:

Chapter 2 presents findings from previous research in the field of TMAP. Particularly findings regarding audience feedback and observations on the system design of TMAP. This information is used to identify and understand the design concerns in the use of TMAP. Lastly, design decisions for Motivatio are presented and discussed.

Chapter 3 presents Motivatio – a standalone music selection system for seamless technology-mediated audience participation. It briefly introduces what Motivatio is as well as the software, framework and tools used to create Motivatio.

Chapter 4 explains how Motivatio works, by describing the implementation and use of the two applications – the tracking and client application – used in combination to form Motivatio.

Chapter 5 briefly repeat the aim of the thesis and its findings. In addition, design concerns directly related to Motivatio and further implementations/modifications of Motivatio are dicussed.

Chapter 6 will give a summary of the thesis and suggestions for further research and exploration of Motivatio.

2. BACKGROUND

Technology has enabled audience to actively participate to human and/or computer-generated music, which is referred to as technology-mediated audience participation. This has often been done by the use of tangible interaction, letting the audience interact through handling objects, for example a light stick (Freeman 2005) or the more commonly used – smartphone (Weitzner et al. 2012) (Lee and Freeman 2013) (Gimenes, Largeron, and Miranda 2016), by which they contribute to a musical output lead by one or more performers. However, the works of (Hödl et al. 2017) find that spectators do not tend to use objects during concerts, and therefore states that we need to consider the role of tangible interfaces in the interaction design for technology-mediated audience participation. Their work also identifies and characterize several design issues emerging from the use of TMAP. In this thesis I will therefore explore seamless techniques for interaction in a standalone music selection system. The system design is based on feedback and observations from earlier research in TMAP. With the aim of addressing design issues emerging from the use of TMAP. Findings from previous research in the field of TMAP are presented in the following sections.

2.1 Feedback loops

In participatory interactive systems, the feedback loops (Hengeveld, Frens, and Funk 2013) between the system, the performer and the audience complicate the collaborative nature of music making (van Hout et al. 2014). Audience complicates these feedback loops by taking a more active role, especially in the music creation. The interactive need of the audience and the performer will also differ when it comes to both the type and complexity of the interaction. The participating audience might not have any musical skills, which means the interaction should be quite simple and easy to learn to make them understand the feedback loop when they interact with the system. The performer on the other hand will have musical skills, which means that their interaction can be more complex, which might lead to a feedback loop which is more difficult to understand for the audience. It is therefore important to have these feedback loops in mind when creating a system for TMAP.

2.2 Number of participants

To clarify, throughout this thesis the word "participant" refers to the users of a TMAP-system and not to individuals partaking in a case study.

The number of participants in earlier research of TMAP varies, which is normal for musical performances, where the number of audiences can vary from just a handful to thousands. When it comes to performances involving TMAP, the size of the audience has design implications for the TMAP system. At least the number of participating audiences have an implication on the TMAP system. It is therefore handy to separate the audience in two groups: active and passive. The active audience are referred to as “participants”, while the passive audience can be referred to as “spectators” or simply “audience”. The ratio between active and passive audience identifies how many people from the audience that are participating actively during the performance. In the majority of cases, the role of an individual audience member is fixed (either passive or active). However, there are TMAP systems such as *Experio* (van Hout et al. 2014), that dynamically allows passive participants to become active and vice versa. *Experio* use designated areas on the dancefloor for the audience to interact with. *Experio* is designed for club settings and uses laser beams on the dancefloor for the audience to interact with. If a member from the general audience enter the area of one of these laser beams, the laser light is interrupted, and a MIDI signal is generated and sent to a computer, which contributes to the musical output and the audience member become an active part of the music creation, hence providing an active audience/participant. This means that both the total number of participants and the ratio between passive and active audience can change throughout the performance.

2.3 Feedback and observations in TMAP

This chapter present feedback and observations on previous works in the field of TMAP. These works have been selected on the basis of two premises: Firstly, the work needs to contain some feedback and/or observations. Secondly, the feedback and/or observation have design implication for TMAP. I present the findings from each research paper used to gather feedback and observation, in the following way:

In Freemans, *Glimmer* (Freeman 2005), each and every audience member get a light stick they can decide to turn on or off during an orchestral performance. The musical output will change depending on how many light sticks that are turned on, and in that way the whole audience of around 600 people is participating in the performance. When an audience become a certain size, it can be difficult to differentiate each participants contribution in the performance. For Freeman to evaluation *Glimmer* as a success, he concludes that every audience member needs to believe that the performance would have been different without him or her. While some audience members felt this way, others were frustrated that their actions did not seem to matter. As Freeman states, one of the problems is due to *Glimmer’s* algorithms responding to the activity of audience groups, instead of individual member. Meaning that *Glimmer* will not give any feedback reflecting the actions of an individual, but rather the whole group, which seem to be a disadvantage for some of the participants. If the audience members of a specific group had been working together and synced their actions, they could probably manage to get a clearer feedback, and in that way feel like they made a change. Freeman hoped that some interesting group behaviour would emerge over time due to the competitive aspect of the piece, which were designed to encourage this behaviour. But it failed to meet its original goal. In discussions with the audience members, Freeman learned of several reasons why groups had failed to collaborate. Some complained that the piece too short to develop a group sensibility. Others had trouble seeing all the people in their group, making it difficult to respond to each other’s actions. Differentiating each participants contribution seems difficult to manage if the size of the participating audience become too big, even though the audience has been settled in smaller groups. The exact size is difficult to say and will differ depending on the interactive system. I also think that it is safe to say that the preferred size of an audience will often be on a spectrum, ranging from too few to too many, like a board game. Unless the systems require a specific number of participants. Freeman questions if the work could ever make all 600 audience members feel truly indispensable to its performance. By which he claims that works such as *Glimmer* reveal the impossibility of this goal.

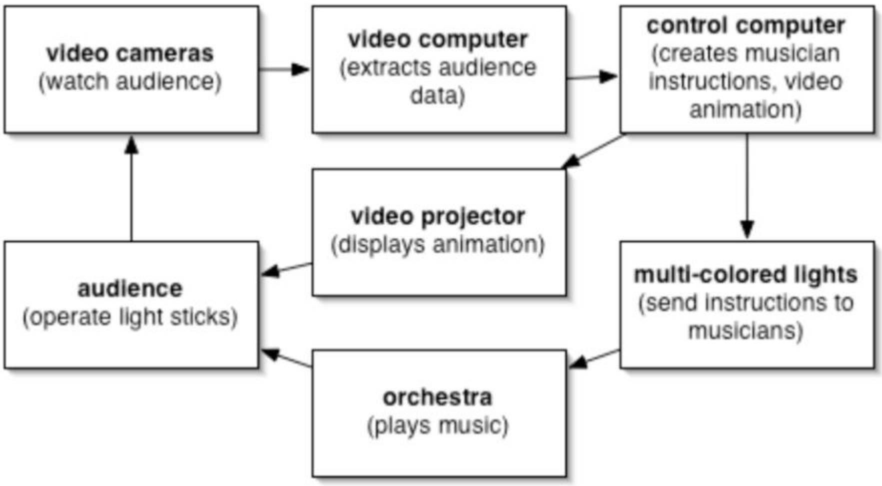

Figure 2.1: Glimmer´s interactive feedback loop (Freeman 2005)

With *Flock* (Freeman and Godfrey 2010), Freeman and Godfrey have designed a collaborative environment that links together the creative activities of composers, performers, and listeners in a live performance. In *Flock*, participating audience move around in an open performance space. *Flock* uses a computer vision system to tracks the location of participants as they move around in the space, and custom software then uses that data to generate music notation, video animation, and electronic sound. A saxophone quartet then reads these music notations generated by the system and play accordingly. The number of participating audience members seem to impact how the participants interact with the system. The ratio between active and passive audience can change throughout the *Flock-performance.* Freeman and Godfrey found that the creativity of participants was negative correlated to their number. They also observed that as the stage became more crowded, most of the participants preferred to wait to follow the actions of others, rather than making up their own creative movements. Since this system use motion tracking of the participants as an input, the participants need a certain space to move around freely. If the free space for movement becomes too small, because of an overcrowded space, this will not only impact the interactive possibilities of the participants, but also their willingness to take a creative part in such an environment. Participants sense of contribution to the music and visuals was also negative correlated to their number. With fewer participants on stage, each participant was better able to sense their contribution. There might be a correlation between the participants creativity and their sense of contribution. The movements of the participants are converted to music notations as explained above, and these music notations needs to be read and played by musicians, which adds a delay between participants movements and the corresponding changes in the music. Freeman and Godfrey observed that this can make it harder for participants to follow their role in the music, as well as discourage faster movements through the space. It seems that clear feedback is important for the participants to understand their interaction with the system. This feedback seems to correlate with the participants understanding of the system, by which a negative impact on the feedback leads to a poorer understanding of the system, as in the ability to sense their contribution.

The work of (Kayali et al. 2017) present an evaluation of the use of TMAP in three music performances, which found place in a single music event. The paper focuses on first impressions of the performances from the perspectives of the musicians and audience. These impressions are gathered in the form of critical reflections of the musicians, video analysis and qualitative interviews with audience members. Which gives the perspective of both audience and musicians/performers. Kayali et al. find that clear feedback seems to be important for the participants experience of interaction in a TMAP system, which the two works presented previous also indicate. In this paper they also mention the importance of clear instructions and reliable systems. To have a reliable system are important for most types of human-computer interaction systems, unless the purpose is to afford some kind of randomness. A system itself can afford clear instructions, but if the system and interaction become complicated, one might need to clarify of the system works. Some systems are made with the sole purpose of letting the audience explore the system without any guidelines, for example to afford creativity. A system can also be self-explanatory, by which you would not need any instructions, even though one could argue that the system itself afford some instructions. In interviews, Kayali et al. find that most of the interviewees seemed to like the idea of interacting with lasers during a performance. On the other hand, the interviewees often dislike the idea of interacting with smartphone during a performance. This indicate that audience prefer seamless interaction to tangible interaction in TMAP, which support the hypothesis proposed in chapter 1.

The work of (Hödl et al. 2017) identifies design issues in technology-mediated audience participation in live music. Implications for interaction design are also considered in their work. The paper presents an analysis of a survey based on questions regarding the use of TMAP in live music, with focus on design implications with the use of TMAP. The survey was done by over two hundred musicians and audiences. Which gives the perspective of both audience and musicians/performers. There are some contradictions in the findings from the surveys, as the writers point out in this paper. One of these contradictions is about the influence of sound. Most of the audience would like to influence the sound in some way, while most musicians do not want the audience to influence the sound. Even though musicians mostly reject any influence on the sound, the extent of their disagreement of audience influencing the sound might depend on what type of influence the audience have on the sound. In case of such influence, audience members mostly wish to control the volume of the music, which does not change the musical output in a drastic way. Changing the volume of a performance might be something the musicians would disagree with to a lesser extent, in comparison to other influences that change the musical output in a more drastic way, like directly manipulating the sound produced by the musicians. Another contradiction is the audiences desire of selecting songs being played during a concert by using TMAP, but most audience strongly disagreed with the idea of using a smartphone app for voting/selecting. In general, the audience do not tend to use objects – like a lighter, phone or camera – during concerts, which raises the implication of using objects. While the audience could imagine the use of other sensor technologies, like cameras for visual recognition and floor sensors. Based on the findings of Hödl et al. work, indicate that technologies that allow for seamless interaction in TMAP are preferred by the audience, and that the audience might disfavour the use of tangible interaction in TMAP due to the uncommon nature of using objects during concerts. Like the research presented in the previous paragraph, this also supports the proposed hypothesis.

2.4 Design of Motivatio

This chapter present the method used in this thesis, in addition to discuss design decisions of Motivatio based on the design issues found in the previous chapter.

In order to meet the goal of this thesis – addressing design issues emerging from the use of TMAP – a case study approach have been used. The works of Teegavarapu et al. shows that case study is one of the most suitable methods for design research, if not the most suitable method (Teegavarapu, Summers, and Mocko 2008). This method is also widely used in the field of TMAP, though the approach of this thesis is somewhat different from the majority of the previous works in the field of TMAP. Seemingly, most of the works presented throughout this thesis tend to focus on a specific system. Take for example *Glimmer* (Freeman 2005), *Flock* (Freeman and Godfrey 2010) and *Experio* (van Hout et al. 2014) as presented previously. These works focus on the creation of a specific system and feedback and observation related to these specific systems. While the method used in this thesis is inspired of these works, the main focus is not the system itself, but rather the process leading to the creation of the system. This difference can be seen in the extensive use of previous feedback in the creation of Motivatio. The extensive use of previous works in the field of TMAP can be seen as an initial phase of this thesis. These works reveal several case specific design issues emerging from the use of TMAP. By analyzing and comparing the design issues found in these works, some design issues tend to be recurring and therefore stand out. The recurring design issues serve as the basis for development of

Motivatio. The creation of Motivatio enables exploration of the design issues found in the first phase in a practical matter and are also an attempt to highlight these.

Motivatio is a standalone music selection system, as described previously. By “standalone”, I mean that Motivatio is autonomous, in the sense that there is no need for any performer. The lack of a performer makes it easier to control the feedback loops in Motivatio, as discussed in section 2.2. Even though playback of music is a part of Motivatio, the essence of Motivatio is the participants ability to select the music being played. The music playback itself is a triviality, meaning that Motivatio could be developed further to fit to live performances, where instead of Motivatio playing the music, the music playback would be done by the performers. The idea of allowing the audience to select the songs being played by the use of TMAP, came from the audience desire in the form of feedback in earlier research (Hödl et al. 2017). As pointed out in the previous chapter, the most desired idea of the audience was to be able to select the songs being played during a concert, while the audience would not want to use a smartphone app for voting. This inconsistency leads to a contradiction, as discussed in previous chapter. This raises the challenge of finding a solution to resolve this contradictory situation. My hypothesis is also a motivation for resolving this contradictory situation with the use of seamless interaction. As a result, Motivatio let the audience select the preferred next song with the use of seamless interaction, without the use of any smartphone app.

Figure 2.2: Graphical interface for song selection with 6 seconds remaining and two tracked participants in the form of markers (ID 2 and 3)

Motivatio uses computer-vision to track individual participants. The participants are showed a screen that is divided into four areas, one for each song as seen in figure 2.2. The participants can also see their relative position on a screen, in the form of markers – the black circle containing a unique ID number. These markers are used for voting. To vote for a particular song, the marker needs to be in the area representing that song. Each participant has a unique ID number and a marker representing their position. Since these markers are following the movement of the participants, a participant can move the marker just by moving physically in the tracked area. In chapter 3 and 4 the song selection will be explained in more detail.

Fiducial markers are used to track the participants in Motivatio, which we will come back to in the next chapter. Motivatio use a unique fiducial marker for each participant and since the provided number of unique fiducial markers are 216 (see 3.1.2), 216 are the maximum number of participants in Motivatio. As seen in the feedback and observation previously, the number of participants needs to be considered when creating a system for TMAP. The maximum number of participants in a TMAP-system can depend on several factors. The design of the system might have technical limitations for the maximum number of participants, which is the case of Motivatio. The type of interaction used in the system might also imply limitations, as we saw in *Flock* (Freeman and Godfrey 2010), where an increase in number of participants had an negative impact on their creativity. Even though some system does not have a technical limit to how many participants the system can handle, it is important to understand that the number of participants might have implications for the overall experience of the participants, as discussed previously. There might also be implications with too few participants. Meaning that the preferred size of an audience ends up being on a spectrum, ranging from too few to too many, as discussed in previous chapter. When it comes to the implications of the number of participants in Motivatio, the audience needs enough space to move around freely, in order to vote for the next song being played. If the tracked area become overcrowded, this would impact the participants ability to move, and they might not get to vote as desired. The number of participants will also have a negative correlation with the weight of the votes. And when the impact of each vote lessen, we might end up with the same situation as in Freemans *Glimmer* (Freeman 2005), where some of the audience get frustrated, because their contribution does not seem to matter.

In the previous chapter the importance of clear feedback was emphasized. Clear feedback appears to have a positive effect on the participants experience of interaction in the TMAP-system. Most of the TMAP-systems presented in the previous chapter allowed the audience to directly affect the musical outcome, which meant that the musical feedback would be affecting the participants experience. While Motivatio arguably has musical feedback, in the form of playback of the selected song. That playback is rather something that happens as a consequence of the song selection, and the playback happens after the song selection and not simultaneously like the other TMAP-systems presented. To afford clear feedback there is a graphical interface implemented in Motivatio as described previously, to give the participants a sense of the tracked space and their position in that tracked space (see figure 2.2).

3. MOTIVATO

The name “Motivato” come from the combination of two words – motion and motivate. Motivato is designed to motivate the audience participating by giving them the option of song selection. The audience is interacting with Motivatio by moving around – hence motion.

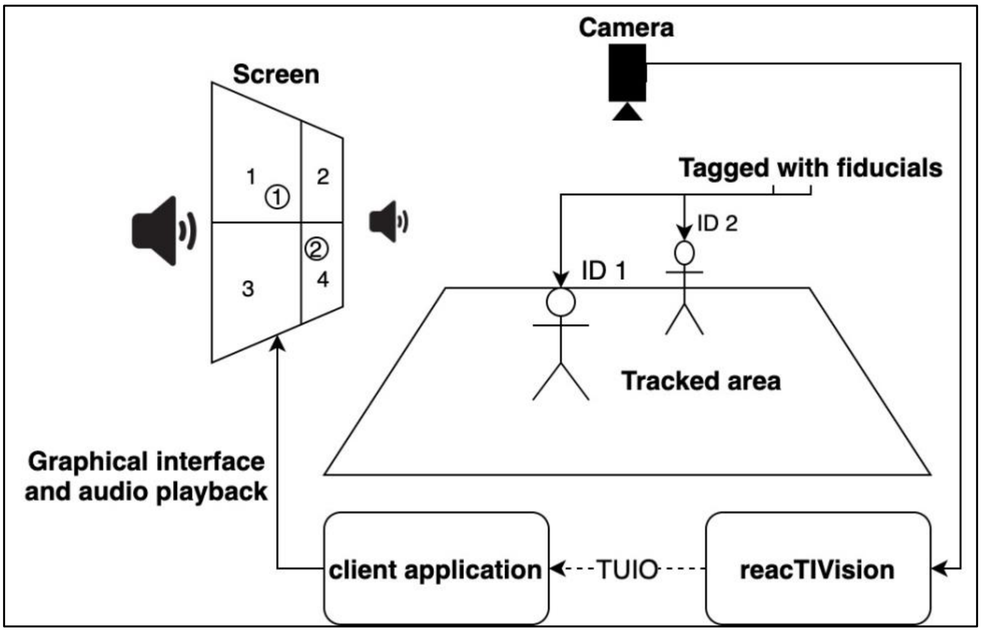

Figure 3.1: Architecture of Motivatio

Motivatio allows participants from an audience to take part in a music selection by moving around in a tracked area. The tracked area is divided into four equally sized zones, in the form of squares. Each square represents a song. Before each playback of a song, the audience get four song alternatives and a set amount of time to select one of these songs. The four song options will be displayed on a screen (see figure 3.1). To select a song, the audience has to move to the square that are representing their song option of desire. Motivato will then then sum up all the votes and pick the song that are represented by the square that got the most votes. Motivatio will then play the song represented by this square. During the playback of the song, the audience control the volume of the playback. If the audience move, the volume will increase until it reaches a maximum level, and by standing still, the volume will decrease until it reaches a minimum level. When the playback of the song is finished, Motivatio will start the song selection over again and then play the selected song. This interaction will loop until Motivatio is stopped.

Motivato consist of two application, a tracking application and a client application. The tracking application uses computer vision to track individual participants. This lets the audience interact freely with the music playback system through their movements. Parameters from the participants movements are then sent to the client application. These parameters are then used in the client application to make the visual interface and the logic behind the music selection and the volume control. I will come back to how the tracking application and the client application have been implemented and used in chapter 4. The following sections details software, framework and tools used to implement Motivatio.

3.1 ReacTIVision (Tracking application)

Motivato uses the reacTIVision computer-vision framework for tracking (Kaltenbrunner and Bencina 2007). ReacTIVision is originally designed as a computer-vision framework for table-based tangible interaction. The framework is open-source and cross-platform. The main component of the framework is a standalone application for fast and robust tracking of fiducial markers in a real-time video stream. The real-time video stream is gathered from a camera connected to computer running the reacTIVision application. ReacTIVision also includes a collection of client example project for various programming environments. This makes it quick and easy to use ReacTIVision in projects like Motivato, since these client examples can easily be customized to suit the purpose.

ReacTIVision are being used for seamless interaction in Motivatio, by tracking participants wearing specific fiducial markers (see figure 3.2). The reacTIVision framework is originally designed to track these fiducial markers laying on a transparent tabletop, with a camera laying underneath facing the tabletop, tracking the location, rotation and identity of fiducials. But it does not matter if these fiducials are laying on a transparent tabletop or worn by a participant, since reacTIVision will track these fiducial markers as long as they are in the field of vision of the camera.

3.1.1 TUIO

The reacTIVision framework also defines a transport protocol called TUIO (Kaltenbrunner et al. 2005), which ensure an efficient and reliable transmission of object states via a local or wide area network to any TUIO enabled client application. The TUIO protocol is implemented by using Open Sound Control (Wright, Freed, and Momeni 2017) and is therefore usable on all platforms supporting this protocol. Java, C++ and C# are some examples of programming languages supporting TUIO.

The TUIO protocol defines two main messages – set messages and alive messages. The set messages are used to communicate information of an object state. Such as the position, orientation and other states of the object. The alive messages are used to communicate the current set of objects that are present in the camera frame. The objects have a unique session ID to differentiate them. These objects we are referring to are the fiducial markers, which we will come back to in the following chapter.

3.1.2 Fiducial markers

Fiducial markers (Bencina, Kaltenbrunner, and Fabra 2005) are a type of unique patterns made especially for the reacTIVision framework to track. The fiducial is designed to be functional, but also aesthetically appealing due to their organic appearance. The design of the fiducials makes them easily separable for the computer vision system, as well as efficient calculation of the marker's center point as well as its orientation. The fiducials are also referred to as “amoeba”.

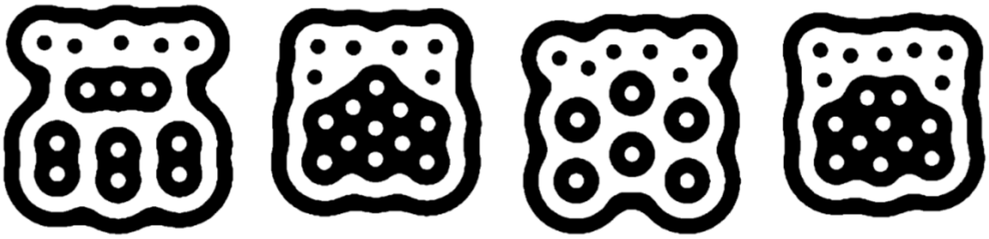

Figure 3.2: Exmaples of four fiducial markers (Bencina, Kaltenbrunner, and Fabra 2005)

ReacTIVision, as of the 1.5.1 release, comes with a folder named “symbols”. Inside this folder there are another folder named “amoeba”, where you find the “default.pdf” document. This document consists of 216 different fiducials. That means by using this set of fiducials you are able to track 216 unique objects at a time.

3.2 Processing (Client application)

Processing (Reas and Fry 2006) have been used in the implementation of the client application in Motivato. Processing is a language and environment made for media arts. Processing also comes with its own integrated development environment. When it comes to semantics, Processing code and Java code are quite similar. Processing code are actually being converted to Java code, and Processing also allows embedding Java code directly in the sketches. As for the implementation of the client application, several libraries have been used. Like the TUIO library implemented in the reacTIVision client example and an audio library called Minim, to mention some.

4. IMPLEMENTATION

This chapter describe how Motivatio works. As I have explained earlier, Motivato consists of two applications, the tracking application and the client application. The tracking application is a off-the-shelf computer-vision framework/software, while I have written most of the code for the client application myself. How the tracking application and the client application have been implemented and used in Motivatio are explained in the following chapters.

4.1 Tracking application

As mentioned earlier, reacTIVision are used as the tracking application in Motivatio. See previous chapter for more information about reacTIVision. The reason for using reacTIVision is its simplicity of use, as well as the thorough use and development over years, making it reliable and robust. ReacTIVision is a free software provided under the GPL license. ReacTIVision requires that there is a compatible camera connect to the computer running the software. There is more information on which cameras that are suited for reacTIVisions on their website (see footnote) and in chapter “Camera and Lens” of (Kaltenbrunner and Bencina 2007). When reacTIVision are running it will start to send TUIO messages. These messages contain information of the tracked fiducials.

When setting up reacTIVision for Motivatio, there are a couple of practicalities that needs to be addressed. Like the placement of the camera used by reacTIVision for tracking, and the placement and size of the fiducial markers worn by the participants. The positioning of the camera depends on a couple of factors – the size of the area to be tracked and the Field Of View (FOV) of the camera. The FOV of the camera depends on the viewing angle of the camera in addition to the distance between the camera and the objects to be tracked. To make sure the fiducial markers are visible for the camera at any given placement in the tracked area. Ideally the camera should be placed right above the audience, facing down at the audience, while the fiducial markers are placed on the head of the participants. To check if it is possible to place the camera right above the audience (in the ceiling), one would have to calculate the FOV of the camera as well as the size of the area one would like to track. If this does not add up, one might need to place the camera otherwise, like in the ceiling in front of the audience and angle the camera toward the audience. Or possibly use several cameras, combining the images with the use of camera stitching. ReacTIVision version 1.5.1 does not support several camera inputs at a time, but more details on this topic can be found on reacTIVisions forum[1] and reacTIVision might come with an option for several camera inputs in a later release. But as for now, it might be best to stick with one

[1] https://sourceforge.net/p/reactivision/discussion/user/thread/9504717b/

camera. When the camera is set up and reacTIVision is running, the next step is to start the client application.

4.2 Client application

As mentioned earlier, reacTIVision comes with a collection of client example project for various programming environments. One of these client examples are written in Processing. This client example has been used as the basis for the implementation of the client application. The client example sketch provided by reacTIVision implements a TUIO-client and a series of callback method that are called whenever a TUIO event occurs. There are four different callback methods:

Add – called when a fiducial is added to the scene

Update – called when a fiducial is moved

Remove – called when a fiducial is removed from the scene

Refresh – called at the end of each TUIO frame

In the client application I use these callback methods to store and update information about the fiducials captured, in the form of Tuio Objects. A Tuio Object is a data representation of a fiducial. These Tuio Objects contain information about their location, angle and speed (motion speed and acceleration). Parameters from these Tuio Objects are used in the two main functions of the client application – Song selection and Volume control. I have also implemented a graphical interface for the client application. The graphical interface has two states, one state for the song selection and another for the playback/volume control. Furthermore, the graphical interface displays a graphical representation of the Tuio Objects in the client application.

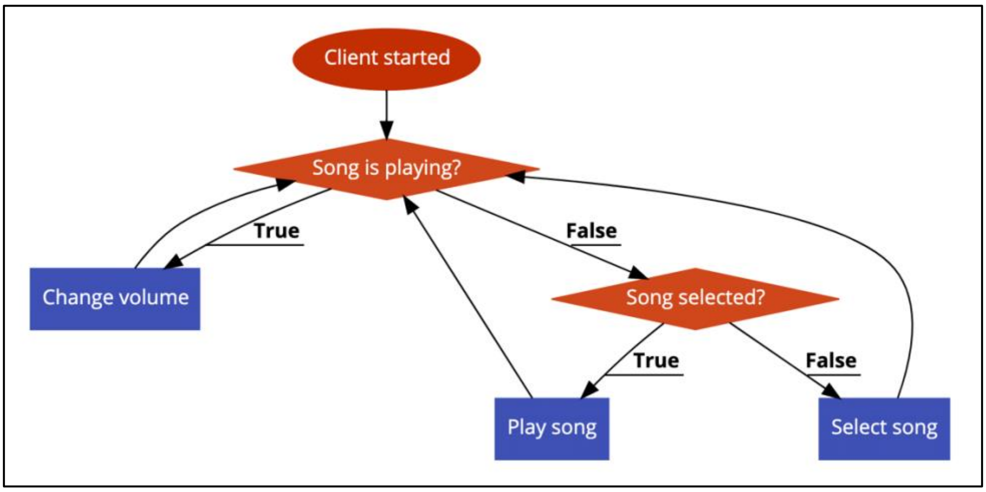

Figure 4.1: Simplified flowchart of client application

4.2.1 Song selection

As explained in the previous chapter, the audience get four songs options to choose between and the song with most votes will be played, unless there is a tie. To vote for a song, the participating audience needs to be standing in the area tracked by reacTIVision. The tracked area is divided into four squares, each representing a song. The position of each participant in this tracked area is used as a vote.

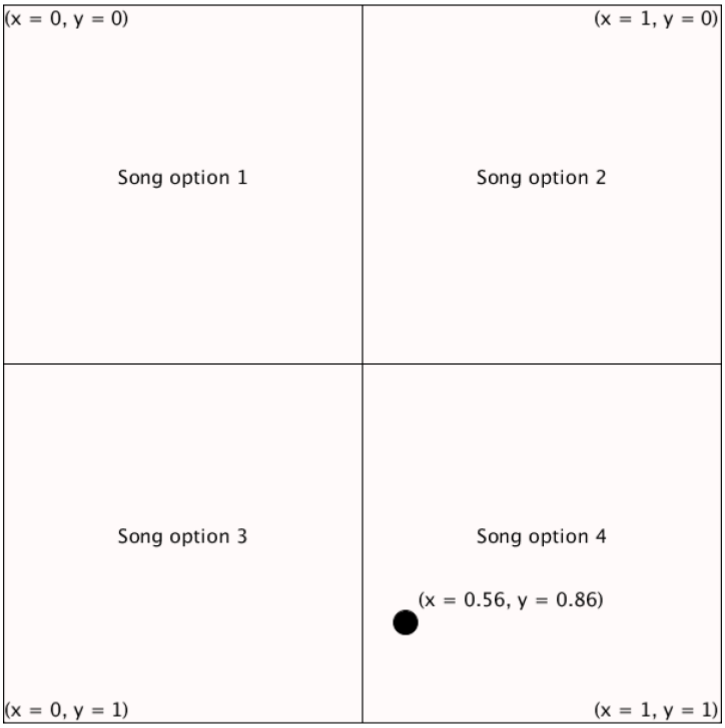

Figure 4.2: Visualization of song selection

In the implemented code, each participant is represented by a Tuio Object, which contain x and y coordinates. Both the value of the x and y coordinate range from 0 to 1. The coordinates correspond to the placement of the fiducials – worn by the participants – in the captured frame of reacTIVision. The frame captured by reacTIVision is in the form of a square and have four corners with the following coordinates: (x = 0, y = 0), (x = 0, y = 1), (x = 1, y = 0) and (x = 1, y = 1). By dividing the captured frame into four equally sized squares, each square will represent an area with nearest proximity to one of these corners. For example, if the coordinates of a Tuio Object are x = 0.56 and y = 0.86, means that the corresponding participant are placed in the square closest to the corner with x = 1 and y = 1 coordinates, representing a vote for song option 4 (see figure 4.2. The song with most votes will then be played, unless there is a tie. If there is a tie, Motivatio will take the average position of all the participants, which will end up in one of the squares. Since each of these squares represents a song option, the song represented by the square where the average position ends up being will be selected and played.

4.2.2 Volume control

The volume control uses the motion speed of the participating audience to change the volume of the audio playback. The volume decreases by standing still and increases by moving. This has been implemented by taking the average motion speed of the participants and comparing it to a threshold value. The motion speed of the participants is provided by reacTIVision in the Tuio Objects. If the average motion speed is above the threshold value the volume will increase, and if the average motion speed is below the threshold value the volume will decrease. There is also an upper and lower limit to the increase and decrease in volume, to make sure the playback is not being too loud or to quiet. The volume change by changing the gain of the incoming signal, with 0 dB as the upper limit to make sure the signal is not distorted, and -12 dB as the lower limit.

Figure 4.4: Graphical interface for volume control with one tracked fiducial (ID 4)

5. DISCUSSION

This chapter present result from the work of this thesis and discuss further implementations/modifications of Motivatio.

As stated in the introduction, the aim of this thesis is to address design issues emerging from the use of TMAP. The works of (Hödl et al. 2017) highlight the limited work of identifying and characterize design issues in previous literature. In the research field of TMAP, case studies constitute a large part of the works. Even though some of these works reveal design issues in the form of feedback and observations, these issues are derived from specific systems, which means that they cannot be generalized explicitly. By comparing the findings from several case studies and the works of Hödl et al. as done in chapter 2, some patterns were found. There were especially two design issues that stood out: clear feedback and the number of participants. Clear feedback refers to the correlation between the interactive input from the participants and the feedback delivered by the TMAP-system. The number of participants refers to the total number of participants that interact with the system at once. There seem to be a correlation between the number of participants and clear feedback, which are worth noting. The findings from chapter 2 indicate that there is a negative correlation between the total number of participants and clear feedback. As the number of participants rises, the harder it gets to differentiate the contributions of each participant, which in turn makes it difficult to provide clear feedback to the participants. Further work needs to be carried out to confirm the negative correlation between the number of participants and clear feedback.

The creation of Motivatio have given some insight as for exploration of seamless interaction technics for TMAP. First of all, Motivatio have showed that seamless interaction can be used to solve tasks that might at first be thought of as a problem best solved with tangible interaction, referring to the voting function of Motivato for song selection. When it comes to whether the song selection task is best solved with seamless or tangible interaction, my initial plan was to conduct an A/B test, but as mentioned in the limitations section, this was not conducted. A/B testing is a way to compare two versions of something to evaluate which perform better. In this case, the "something" refers to the song selection task and the "two versions" refers to the solution implemented with both seamless and tangible interaction respectively. Here, Motivatio is the solution implemented with seamless interaction. As for the solution implemented with tangible interaction, any system allowing some kind of voting through a tangible interface could have been used, and for each round of voting play back the song with most votes.

As Motivatio has not been tested with an actual audience, the design decisions of Motivatio are fully based on the findings presented in chapter 2. To verify these decisions there should have been conducted one or more practical explorations of Motivatio with the use of participants. Some design concerns directly related to Motivatio have also brought my attention in the development process and there are especially two design decisions that have brought my attention. The first is the way the voting function have been implemented, where the votes of the audience are equally weighted, unless there is a situation where two or more songs end up having the same number of votes, where the average position of the audience members are used to select a song. By using the average position, the votes nearest the corners of the tracked area are weighted higher than the votes closer to the center of the tracked area. Implementing the voting functions with average position allows the audience to stand closer to the center or between two options if they are not sure which song to pick, on the other hand having equally weighted votes means that the participants only need to focus on which area to stand in to vote for their desired song option, without worrying where to stand in this area to get highest possible weight for their vote. Still, I am not sure if the audience would rather prefer the implementation with equally weighted votes, the implementation where the votes are weighted differently or the use of both, which is the case for Motivatio. Even though the implementation with differently weighted votes are only used in the edge case, where two or more songs have equal number of votes. The second concern regards how the volume control have been implemented. When implementing the volume control, I thought it would make sense to map the gain to the motion speed of the audience, where the motion speed is compared to a threshold value. Meaning that the gain increases if it is above this threshold and decreases if it is below, with a minimum and maximum level for this gain. I could not find a better way of implementing this volume control without directly mapping the x and/or y position of the audience, which I think would have interfered with their ability to freely move around, since they would then change the volume. Even though how the volume control has been implemented also interfere with the participants movement in a way, it does not matter where they move in the tracked area. These design concerns, which are directly related to Motivatio, shows the importance of testing the prototype of the system throughout the development cycle, to gather feedback and to find out if the right design decisions have been taken. This can also be said for the more general design issues regarding the use of TMAP.

The making of Motivatio also raised some other ideas in discussion with fellow students and professors. The song selection of Motivatio, which is basically a voting function, could be used for different purposes. It could for example have been used to let the participants express their feelings towards a song they just heard or while the song is playing, by display some sort of Likert scale (Likert 1932) and use the positions of the participants for voting, as used in the song selection, but instead of voting for songs the participants vote how much they like the song. Another example of the use of the voting system, would be to use it in a silent disco situation, where the voting system could be used to decide which playlist/DJ to listen to by moving to different parts of the tracked area. Where the different parts of the tracked area would be mapped to different playlists/DJs.

6. CONCLUSIONS

This thesis has highlighted design issus emerging from use of TMAP. As a case study, Motivatio was created to emphasize these issues, by using the revealed design issues as design guidelines. As we saw in chapter 2, design issues have been addressed in existing literature. But for most existing literature these issues are derived from case-specific feedback of participants. By contrast, the work of (Hödl et al. 2017) collect quantitative data detached from any particular study, to identify and characterise issues emerging from the use of TMAP. The creation of Motivatio is inspired by both existing case studies in the field of TMAP, in the form of feedback and observations gathered in these research papers, in addition to the works of Hödl et al. Findings from these works have been compared and discussed, and further used to establish some design guidelines. There is also evidence from works referred to in this thesis that support the hypothesis proposed in the introduction of this paper, which states that seamless interfaces are more suited than tangible interfaces in the interaction design of technology-mediated audience participation. The most important limitation of this thesis has been the implication of not being able to do any practical study on Motivatio with participants, as a result of the corona crisis. Nevertheless, this thesis has highlighted some design issues emerging with the use of TMAP, by demonstrating these issues in the creation of Motivatio.

6.1 Future work

A practical exploration of Motivatio with participants, leading to feedback and observations, would perhaps expand the insight of the design issues previously found, and with the possibility of discovering new once. Further experimental investigations should also explore the correlation between the number of participants and their perceived feedback. Returning to the hypothesis, there should also have been conducted an A/B test, which could have been carried out by giving participant the possibility of selecting songs with the use of both Motivatio and another system with a tangible interface, such as Kahoot[2], to test what design interface the participants would prefer. Future work could therefore be to conduct an A/B test, in addition to explore Motivatio with participants.

[2] https://kahoot.it/

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APPENDIX

The following URL link to a related blog post, as there is a requirement to include a URL to a related blog post to get the master thesis graded. Though, there are no requirements regarding the content of the blog post:
https://mct-master.github.io/masters/2020/06/15/Motivatio-Elias_Sukken_Andersen.html

The client application for Motivatio are found in the folder as Motivatio.pde. The pictures and mp3 files are example files to run Motivatio. To open and run Motivatio.pde you would need to install Processing. The client application will start and run without ReacTIVision connected, but for the voting function and volume control to work, ReacTIVision needs to be connected. Which is as easy as installing and running ReacTIVision, then start the client application.