Masterarbeit

Design and Development of a Public Display Survey Platform

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Zusammenfassung

In den letzten Jahren haben sich Public Displays (PD) in der Öffentlichkeit stark vermehrt und wurden Teil unseres täglichen Lebens. In Einkaufszentren, Bahnhöfen und Flughäfen gibt es immer mehr interaktive Anwendungen für PDs. Ihre Entwicklung erfordert eine umfassende Evaluation, was ein komplexes und zeitintensives Unterfangen ist. Bisher greifen viele der interaktiven Anwendungen noch nicht auf Möglichkeit zurück, den Rückkanals vom PD zum Display-Anbieter zu nutzen. Um dieses Problem zu lösen wurde eine interaktive Umfrage-Plattform entwickelt und eine umfassende Literaturrecherche durchgeführt. *PDSurvey* soll die Durchführung von Umfragen auf Public Displays erleichtern und als Werkzeug zur weiteren Evaluierung dienen. In dieser Arbeit wird der Entwurf und die Entwicklung unserer Plattform vorgestellt und eine Liste an standardisierten Frageöbgen vorgeschlagen, welche aus einer umfangreichen Literaturrecherche resultiert. Außerdem stellen wir die Ergebnisse unserer Feldstudie vor, in der wir untersucht haben wie Umfragen auf Public Displays wahrgenommen werden und untersucht haben welcher Rückkanal am besten für den Nutzer geeignet ist um in digitaler Form auf einen Fragebogen zu antworten. Die Ergebnisse lassen folgern, dass eine Mehrheit der Nutzer es vorzieht Umfragen direkt vor Ort zu beantworten. Allerdings hat auch ein Viertel sich gegen die Möglichkeit entschieden, direkt vor Ort auf den Fragebogen zu antworten. Ein Tablet als Rückkanal anzubieten hat sich als beste Option herausgestellt, auch wenn der Benutzer zwischen den Geräten wechseln muss. Umfragen welche direkt auf PDs durchgeführt werden stellen eine sinnvolle Alternative zu Online-Umfragen dar, mit der Einschränkung der sozialen Erwünschtheit und der Abnahme der Privatsphähre.

Abstract

In recent years displays have proliferated in public space and became part of our daily lives. New interactive applications for public displays (PDs) are flourishing in shopping malls, train stations, and airports. Their development requires extensive evaluation, which is a complex and time intensive endeavor. So far, many interactive PDs are still lacking a feedback channel from display to display provider. To solve this problem an interactive survey platform was developed and an extensive literature review carried out. *PDSurvey* aims to facilitate the conduction of surveys on public displays and is a toolset for further PD evaluation. In this thesis, the design and development process of our platform is presented and a list of standardized questionnaires proposed, resulting from an extensive literature review. Furthermore we present the findings of our field study, in which we assessed the general acceptance of questionnaires being conducted in public space and which feedback channels are best suited for users to respond to questionnaires in a digital form. The findings imply that a majority of users prefer to complete a survey directly on-site. However, a quarter refrained from using PDs for responding to the questionnaire. Offering the tablet as a feedback channel represented the best choice, even though users have to switch devices. Surveys conducted on public displays are a reasonable alternative to online surveys, with the limitation of social desirability and a decrease of privacy.

Aufgabenstellung

Development of a Public Display Survey Platform

Problem Statement Public displays are quickly proliferating in public space. At the same time, interactive applications are still scarce, since their development is costly and the effect on the user - and thus their benefit - is often not clear. Hence, interactive displays applications are usually developed, deployed, and carefully evaluated in research contexts. In most cases, evaluation focusses on particular aspects only, such as user performance, user experience, or social implications, due to the significant effort associated with planning, preparing and conducting public display evaluations.

Scope of the Thesis To tackle the aforementioned challenge, the objective of this thesis is to develop a survey tool that allows interactive public display installations to be comprehensively assessed. In a first step, an extensive literature review will be conducted with the aim to identify important aspects of public display deployments - both from a researcher as well as from a practitioners' perspective - as well as to develop an understanding of how these aspects could be addressed through surveys. Based on the literature review, a web-based survey platform will be implemented that can easily be used to evaluate and compare public displays through different channels. Such channels include both evaluation directly at the display or through a (mobile) website that allows participation also via a smartphone or tablet. The platform should allow public display owners to configure their own surveys based on their needs. Optionally, the survey tool itself will be evaluated with an interactive public display application.

Tasks (1) conduct a literature review to identify (research) questions that are of interest to researchers and practitioners
(2) produce a comprehensive set of questions that can be used to assess these questions by means of a survey
(3) develop a web-based public display survey platform consisting of (a) an administration interface that allows (groups of) questions to be selected for use within the tool and (b) a responsive UI that can be rendered on different devices (public display, smartphone, tablet, laptop)

Requirements Strong skills in web programming, independent scientific work and creative problem solving, experience in creating questionnaires is a plus.

Keywords Public displays, interaction, applications, survey, questionnaires, web

Ich erkläre hiermit, dass ich die vorliegende Arbeit selbstständig angefertigt, alle Zitate als solche kenntlich gemacht sowie alle benutzten Quellen und Hilfsmittel angegeben habe.

München, April 23, 2015

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Acknowledgments

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1 Introduction

Throughout the last decade public displays have evolved from screens used for advertisement, to interactive displays with bidirectional capability, enabling an entirely new type of interactive experiences. With the rise of touch and gesture input, a new era of interactive applications is waiting to be used. At airports public displays can already be used for finding your gate, in shopping malls as a store locator, or in brand stores for assessing user satisfaction and giving users a more immersive shopping experience. The areas of application for public displays are ever growing, however still no common design guidelines exist [3] and an individual evaluation of each setup is of importance [25]. This reinforces the need for evaluating all new applications through lab or field studies. The evaluation of public displays however is a rather time-consuming task and requires prior knowledge.

Based on the evaluation of related work and the time-consuming nature of field studies (even for small quantitative questionnaires) the demand for a simplification and automation of the evaluation process becomes apparent. Due to the essential importance for the validation of public display installations and research in general, such an evaluation platform can be a great relief. With the advent of the Internet a similar transition was visible. New capabilities such as direct feedback enabled new ways of conducting surveys. Already in 1983 Sproull and Kiesler [37] looked at the benefits of email vs. traditional mail surveys. The demand for extensive evaluation of the new economy was met with emerging online survey platforms. One such survey platform is SurveyMonkey, founded in 1999 and currently being one of the most popular solutions on the market for conducting web-based surveys [6]. Other well established solutions are eSurvey Creator, SoGoSurvey, and UX Suite by UsabilityTools. A closer evaluation can be found in chapter 2. These survey platforms focus on evaluating the users' opinion through web-based or mobile interfaces.

For our use case however the already existing approaches aren't enough, since the evaluation of public displays states additional requirements. One such constraint of public display research represents the opportunistic nature of the setups and the discrepancy between lab studies and field studies [28]. Thus there is an additional demand for evaluating each public display setup individually and if possible directly in the field. Another significant difference for evaluating public display setups is the additional abstraction layer. Not only is of interest to understand how the user perceives the application, or to assess the users opinion independently of the display setup, but in particular what influence the context of the public display setup has on the users perception. Another important difference is that not only the application itself needs to be evaluated, but the whole display setup including the influence of the surrounding environment. So far none of the platforms reviewed offers this level of evaluation.

To facilitate this step and to allow for a better comparison and analysis of public display setups, we developed *PDSurvey*, an interactive public display survey platform. The interactive capability of public displays is of similar importance for our setup as the rising of the web in the late 1990s for online survey platforms. It is now possible to conduct surveys and to log data directly from public displays and to use the display itself as a feedback channel to the display provider. This facilitates the collection of quantitative and qualitative data from entire public display networks. When additionally collecting the context of every survey response, new insights into the differences between different display setups and the influence of the surrounding environment can be gathered. One interesting question could be which role the context plays on the users' perception of the public display setup, when running identical software settings, but only varying the context.

Our research contributions are the categorization of questionnaires being used for the evaluation of public displays, based on an extensive literature review. Furthermore we introduce the *PDSurvey* platform, and present first practical experiences from our field study. We assess which feedback channel is preferred for responding to surveys. Our fundamental goal is to facilitate the evaluation of public display setups via interactive surveys on the displays themselves. Addition-

ally we present results from the field study, including the motivation for approaching the display setup.

The rest of this thesis is structured as follows. Chapter 2 gives an overview of related work and introduces the reader to the area of public display evaluation. In chapter 3 we present the results of the literature evaluation and our clustering of standardized questionnaires. Chapter 4 deals with the implementation of the *PDSurvey* platform. First the requirements and design decision are discussed, followed by a short overview of the architecture, and concluded with an overview of the finished platform. In chapter 5 we present the descriptive field study make first evaluations of our survey platform. Future work is discussed in chapter 6. A conclusion complements this thesis.

2   Related Work

The goal of the literature review was to find out how other researchers evaluated public displays and to develop an understanding of how these aspects can be addressed through surveys. The aim was to identify important aspects of public display deployments, both from a researcher's as well form a practitioner's perspective. A short summary of the most relevant papers are described in the following.

2.1   Evaluation of Public Displays

Public display evaluation has already been addressed in literature. Alt et al. [3] give an overview of study types, research paradigms, and evaluation methods used for evaluating public displays. Müller et al. [26] present with MirrorTouch a follow-up evaluation and additionally extract metrics used for quantitative field studies. According to their findings almost exclusively descriptive field studies are used in the area of public display evaluation. For a more in-depth introduction to public displays, the doctoral thesis from Alt [2] gives a good overview. For a general recap of how to best design, evaluate, and report experiments, the book by Field and Hole [16] was used. Kirakowski [23] provides a good introduction for practitioners of what to watch out for, covering the most important aspects for conducting surveys.

2.2   Exemplary Papers

A selection of papers, which have inspired us and which themselves have a good approach towards the evaluation of public displays, are amongst others: Overcoming Assumptions by Huang et al. [19], Worlds of Information by Jacucci et al. [22], and Digifieds by Alt et al. [4]. In the following a short overview is given.

Jacucci et al. [22], with *Worlds of Information*, not only provide a superb overview of evaluation methods, but also the way they evaluate their results is exemplary. The evaluation is detailed and the questions asked in their questionnaires are stated. For evaluation they used video ethnography and a variety of questionnaires. Their focus lies in their paper lies on aspects of group use and user engagement, which they measure through questions adapted from Flow (GameFlow), Presence (MEC), and Intrinsic Motivation (IMI) questionnaires.

In *Overcoming Assumptions* Huang et al. [19] analyzed how "large ambient information displays in public settings" (public displays) were deployed and tried to understand how such displays are used, in order to derive best practices and offer design implications. Recommendations given include elements like the position of the display, content, dynamics or how to best present the message you want to convey. In *IM Here*, an older publication by Huang et al. [20] observations, informal conversations and questionnaires are used for evaluation. The focus of their evaluation is social awareness and collaboration aspects. Questionnaires were conducted before and after the primary task.

Ojala et al. present an evaluation of their long-term public display deployment in downtown Oulu, referred to as *UBI Hotspot*. They conducted their surveys in-situ and evaluated data from a time span of eight months. Surveys were also already embedded directly onto the UBI hotspots. They aimed for analyzing the usage and user acceptance rates for their setup with questions based on Nielsen's system acceptance model. Two general demographic questions (age, gender) were asked first, followed by a random selection of 8 statements from Nielsen's system acceptance model.

Alt et al. [4] created a digital noticeboard called *Digifieds* and evaluated the platform using observations, interviews and a field trial. The Digifieds platform was deployed during the UbiChallenge 2011 to an urban environment in Finland and evaluated with the help of SUS questionnaires. The questionnaire accompanied the field trial and was structured as follows. After the users got

a brief introduction to the study, general questions were asked regarding the mobile phone usage, whether the display setup has been used before, and how they are affiliated towards public notice areas. Thereafter, two practical tasks were carried out, each followed by a SUS questionnaire. Finally, questions were asked regarding the user's opinion on public notice areas.

Müller et al. [27] present an in-depth evaluation of *Looking Glass*, an interactive display setup inside of a shop window. Looking Glass gave visual feedback to passers-by and mirrored their movements. Their evaluation consisted of a pre-study, a controlled lab-study, and an "in the wild" field study. Both quantitative and qualitative data was collected, however, no questionnaires were used. Mueller et al. relied on observations, semi-structured interviews, and manual video recording, combined with interaction logs and a depth video log for quantitative data.

The publication by Beyer et al. [8] used the AttrakDiff questionnaire for evaluating user experience in their lab study. Ballagas et al. [36] used a background, subjective and a ISO 9241-9 based questionnaire, for measuring performance. In the *Hermes Photo Display* publication by Cheverst et al. [10] a non-standardized questionnaire is used. The questionnaire is split up into four sections. The first section collected background information, "the second section consisted of seven questions related to interface issues and general acceptability. The third section contained 14 questions related to social and community issues. Finally the fourth section contained two questions relating to possible future features." All questions were answered on a 5-point Likert scale. The focus was on measuring the "notions of community". A later publication by Cheverst et al. [11] focused on determining the "sense of community" index. They first collected ethnographic and cultural data, followed by a focus group and a design workshop.

2.3   Overview of Survey Platforms

To verify that a toolset like ours doesn't already exist and to better understand how web-based survey platforms are carried out, we did some research on which similar approaches already exist on the market today.

The first one we looked at was SosciSurvey [1], a popular tool developed by the Institute for Communication Science at our university. One major drawback of their approach was the difficulty of extending and embedding the SociSurvey platform. For our purpose it was easier to build a new platform already supporting a responsive layout and RESTful interaction. Other tools similar to the SociSurvey platform are LimeSurvey [2], an open-source PHP project.

Commercial solutions considered, which often offer a much larger variety of features compared to free to use solutions, are eSurvey Creator[3], Free Online Surveys[4], UX Suite by Usability-Tools[5], SurveyMonkey[6], SoGoSurvey[7], SurveyPlanet[8], and Qualtrics[9]. For a full list of currently available web-based survey tools, refer to [9, 15].

Many of these solutions already support a large number of question types and a sophisticated administration panel. However, their main disadvantage is their lacking support of mobile phones, the missing REST API, and lack of functionality for embedding pre-configured standardized questionnaires.

UX Suite by UsabilityTools has a handy backend for configuring surveys, although it is lacking the pre-configured standardized questionnaires. SurveyMonkey provides sample surveys[10] and

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[1] https://www.soscisurvey.de/ (last accessed on November 26, 2014)

[2] http://de.wikipedia.org/wiki/LimeSurvey (last accessed on April 6, 2015)

[3] https://www.esurveycreator.com/ (last accessed on April 6, 2015)

[4] https://www.freeonlinesurveys.com/ (last accessed on April 6, 2015)

[5] http://usabilitytools.com/ux-suite/ (last accessed on April 6, 2015)

[6] https://www.surveymonkey.com (last accessed on April 6, 2015)

[7] http://www.sogosurvey.com/Features/List-of-All-Features.aspx (last accessed on April 6, 2015)

[8] https://surveyplanet.com/ (last accessed on April 6, 2015)

[9] http://www.qualtrics.com/site-intercept/ (last accessed on April 6, 2015)

[10] https://www.surveymonkey.com/blog/en/sample-survey-questionnaire-templates/ (last accessed

a mobile app for conducting and evaluating surveys. Their approach already comes closer to what we are looking for. However they do not offer an API for embedding platforms with other programing languages and the standardized questionnaires are relevant to public display research.

The best commercial solutions found on the market were SoGoSurvey, SurveyPlanet and Qualtrics.

> SoGoSurvey. One of the best solutions!

> SurveyPlanet () seems to be the best solution found so far! However the embed code is only based on iframes.

> Qualtrics

2.4   Distinguishing Features

The key difference between our approach and the already existing evaluation platforms, is the ability to associate each survey with the display on which the survey is carried out on, and that the platform is tailored specifically for public display evaluation. By default *PDSurvey* asks the display operator to specify the context of every display connected to the platform. When enough context data is specified, this will allow for a thorough evaluation and comparison of public display installations. Further technical differences, which are not yet standard on all of the free and commercial solutions yet, is the ability to conduct surveys across a broad number of devices and platforms, due to its modular and RESTful architecture. The benefit is that the whole platform retrieves all data via a RESTful API, as of now allowing for the greatest possible coverage of end consumer devices. Additionally we offer a range of standardized questionnaires, simplifying the evaluation of public displays. These questionnaires used for evaluation will be introduced in section 3.2.

These measures allow for a simplified evaluation of public displays. Standardized questionnaires useful for public display evaluation are already implemented by default.

> NEW: by having a clear focus on public display evaluation, this also allows us tweak and modify the question types to better be suited for public displays. Some question types from traditional web-based questionnaires are not well-suited for large displays.

> NEW: Already in 1983 a study was conducted by Sproull and Kiesler, comparing email with traditional mail surveys. Their findings were a faster and cheaper conduction of surveys via email, with less social desirability. Possible restrictions were the limited spread of computers and thus a distorted population [37]. In 1999 commercial companies like SurveyMonkey were founded, providing first online survey platforms. The same counts for surveys being conducted on public displays, which opens up a whole new feedback channel. With the introduction of the iPhone in 2007 and the iPad in 2010 users became much more accustomed to using screens with touch support. The increasing acceptance of touch screens combined with more sophisticated touch screen technology opens the path for interactive questionnaires in public settings.

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on April 6, 2015)

3   Literature Evaluation

Our research is based on an extensive literature review, with over 100 papers viewed. This led to the development of the public display survey platform (see chapter 4) and the categorization of standardized questionnaires (see section 3.2). A side effect of the literature review was, besides getting a better understanding of how public displays were evaluated, getting an overview of the questions asked to evaluate public displays and their applications. This turned out to be a quite valuable approach, since we haven't seen any compilation of questionnaires used for public display evaluation so far. Our goal was to find patterns and to build clusters of questionnaires being useful for the evaluation through automated public survey display platforms.

In the following we will first describe our methodology for gathering the information (section 3.1), followed by a categorization of standardized questionnaires (section 3.2), concluded with a summary of our findings (section 3.3). The categorization of the standardized questionnaires can be found in table 3.2.

3.1   Methodology

The procedure for the selection of papers to review, was as follows. As a starting point all papers form the appendix of Florian Alt's doctoral thesis [2] were read. Afterwards interesting related work and citations were examined based on the papers from the previous step. This was supplemented with targeted research on Google Scholar and the APM Digital Library. To round off the literature review, publications of two authors who are very active in this field were reviewed.

The first step, analyzing all literature of Florian Alt's appendix, was fairly straight forward. All papers were read from start to finish (pages 335 to 343), in order to get a first overview of the current state of research. The second step, pursuing related work and citations of interest, was carried out in a more subjective manner. Whenever interesting papers or projects were mentioned, the cited paper was skimmed through. For the third step, a more strategic approach was used. Based on the insights gained from the previous steps, Google Scholar and APM was checked for literature relevant to our research question. The keywords used amongst others for the research in these online libraries were: *standardized surveys for usability*, *standardized surveys for user experience*, *user satisfaction questionnaire*, *public display evaluation*, and *standardized public display evaluation*. The last step for collecting relevant papers consisted of profiling publications of two relevant authors in the area of public display research, namely Jörg Müller and Marcus Foth. The process started out by first finding a list of their publications. Since the literature review made by Florian Alt (see first step) already covered papers up to 2011, only ones published between 2012 and 2014 were viewed. On each opened paper from this time frame a keyword search was carried out, to see whether it contained an evaluation which might be relevant for us. These keywords were: *questionnaire*, *survey*, *question*, *interview*, *(field) study*, and *evaluation*. If none of these words could be found, the headlines and the abstract was skimmed through. All papers containing a reference to an evaluation of public displays were saved and analyzed in more detail. For Jörg Müller the best list of his publications were found on his personal website[11], and for Marcus Foth two websites were evaluated [12].

3.2   Standardized Questionnaires

As a result of the literature evaluation process the following overview of questionnaires arose. All questionnaires found during the literature review phase were categorized into a schema, inspired by the research questions introduced in chapter 2.8.2 of Florian Alt's doctoral thesis [2],

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[11]`http://joergmueller.info/publications.html` (last accessed on November 17, 2014)

[12]`http://www.vrolik.de/publications/` (last accessed on November 18, 2014) and `http://eprints.qut.edu.au/view/person/Foth,_Marcus.html` (last accessed on November 18, 2014)

serving as a guideline for our classification of standardized questionnaires. Since the categories *audience behavior* and *user performance* can not be evaluated through questionnaires, they are not represented in the following. We extended the prior categorization with findings from the literature review phase. New categories added are *usability*, *context*, *demographics*, and *other* for miscellaneous questions.

Other people's collections incorporated into our categorization can be found in the bibliography [12, 14, 17, 24, 39].

A full overview of all standardized questionnaires found in literature can be found in table 3.2, grouped by the following categories: user experience, usability, user acceptance, user performance, display effectiveness, privacy, social impact, context, and demographics.

A list of other people's collections can be found in the bibliography. Lewis and Sauro [24] list 19 questionnaires at the HCI conference. Garcia [17] describes the SUMI, PSSUQ, and SUS questionnaire. The Université de Genève [14] gives an overview of usability and user experience surveys. HTW Chur [12] provides an overview of ISONorm 110, ISOMetrics, AttrakDiff, UEQ, QUIS, and SUMI. For further information regarding standardized usability questionnaires and evaluation methods for multimodal systems the book by Wechsung and Naumann [39] can be used.

»>   My   Categorization: `https://docs.google.com/document/d/`
`1D925jJ7bmRc1EZdCTz32lmW2hniMiq7GzBWxX8rmhpE/edit` (Google Docs)

We distinguished between *user experience* and *usability* in our categorization, although it is hard and a controversial topic in literature [7] User experience describes the overall satisfaction and experience the user has with a display. Usability can be seen as a subcategory, however one difference is that usability can be measured based on hard facts such as response time, number of clicks, number of errors and has more to do with the effectiveness and efficiency. The evaluation of both user experience and usability can be carried out through questionnaires.

»> Sample questionnaires used for assessing the user experience are .... XXX TODO XXX

User Acceptance   *User acceptance* analyzes user's motives and incentives for approaching the display. The evaluation can be carried out qualitatively (subjective feedback, focus groups) or quantitatively (questionnaires).

Display Effectiveness   Display effectiveness evaluates the economic perspective of display efficiency.

Privacy   Privacy takes a look at the users privacy concerns.

Social Impact   Social impact considers everything related to social behavior, the influence on social interaction and communities, as well as social effects.

Context   One new category is the collection of context data, relative to the public display. On most normal studies the context doesn't change during evaluation and thus is not as important. For the evaluation of public displays, especially when multiple displays are deployed in different locations running the same application, it will become if importance to also assess the static and dynamic context of each deployed display. External influences such as the weather, time of day, special events or semester break can have an influence on the number and type of people passing by a display. Additionally static context parameters, such as the display type, display size, position on wall, the size of the room might also influence how the display setup is perceived in public. Once recorded, these static and dynamic parameters can be evaluated with knowledge discovery algorithms for big data, a whole research field for itself. So far no previous works are known on

this area so far, evaluating a large public display deployment through an automated online platform with the help of context-based comparison.

In most surveys *demographic* background information about the participants is also of interest. This varies from general questions (gender, age, religion, education), more personal questions (relationship status, family, children, country of origin), skills (personal, professional, technical), personal beliefs, political affiliation or voluntary commitment. Three background questionnaires for inspiration, which we haven't used ourselves yet, but which go more in depth, are the Adult Literacy and Lifeskills Survey (ALL) [13], the PIAAC Conceptual Framework of the Background Questionnaire Main Survey [14] and a Police Background Questionnaire [15].

Miscellaneous contains all of the questions and questionnaires, which can not be assigned to any of the previous categories Cheverst et al. [10] evaluated whether there were any previous experience with Bluetooth, or recommendations for possible new features. This can be For the evaluation of the Digifieds platform Alt et al. also evaluated: "We asked them about their mobile phone usage (e.g., how often they used it, if it had a touch screen, if they used it to surf the web, and if they had installed third party apps) and whether they had used the UbiDisplays before" [4].

3.3 Findings

HIER DIE ERGEBNISSE AUS DER LITERATUR ARBEIT NENNEN

Findings:

1. use both quantitative and qualitative methods for data collection (explain why this is important, teaser this as a requirement for the platform, how it could be implemented)

2. support mutliple sections, all displayed at once or (optionally) spread across multiple users

3. support various question types (e.g. 5-point and 7-point Likert scale, multiple choice, numeric responses, comments)

4. support lots of end devices (restful)

5. also support non web-based platforms, some public display applications are written in native Java, Flash or other proprietary software packages

6. evaluate not just the application running on the display, but also the entire environment. Differences in the context of the public display often result in different perceptions and user interaction.

7. One constraint of public display research represents the opportunistic nature of the setups and the discrepancy between lab studies and field studies [28]. Thus there is an additional demand for evaluating each public display setup individually and if possible directly in the field.

8. Additionally a larger number of form factors, platforms and end devices needs to be supported, to cover the whole range of public displays being out there

These findings bring us to the next chapter, the research platform to develop, capable of conducting all of these questionnaires.

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[13]http://nces.ed.gov/surveys/all/ (last accessed on April 1, 2015)

[14]http://www.oecd.org/site/piaac/PIAAC(2011_11)MS_BQ_ConceptualFramework_1Dec2011.pdf (last accessed on April 1, 2015)

[15]http://www.slmpd.org/images/hr_forms/commissioned/BackgroundQuestionnaire.pdf (last accessed on April 1, 2015)

4 Implementation

In this chapter we will deal with the infrastructure and technical realization of the public display survey platform. First, the requirements for the survey platform are discussed (section 4.1). Subsequently the architecture resulting from the design decisions will be the main focus (section 4.2). To facilitate the training period for successors we will also take a brief look at the software model (section 4.3). For more specific information and for information regarding maintenance of the project, please refer to the documentation found on the CD enclosed (see Appendix A) or on the GitHub repository[16].

In figure 4.2 a brief overview of the PDSurvey platform and its components is given. The platform consists of three major parts: a backend for display providers (PDAdmin), a RESTful server (PDServer) and the user interface itself, being embedded on the end user devices (public displays, tablets, smartphones or other devices).

4.1 Requirements

Initial requirements were set by the problem statement of the thesis[17] (page e). These requirements were also a trigger for further literature review and talks with people from the industry. The full listing of the initial problem statement is as follows.

1. *development of a survey tool* that allows interactive public display installations to be comprehensively assessed

2. implementation of a web-based survey platform that can easily be used to evaluate and compare public displays through *different channels*

3. *different channels* to support: 1) evaluation directly at the display or 2) through a (mobile) website that allows participation via smartphone or tablet.

4. *configuration options* for public display owners

Additional requirements, that emerged during research and in discussions, are listed below:

- easy *embedding of questionnaires* on websites of public display owners (provide API / embed code)

- support of *various devices*: public displays of all sizes, tablets, phablets, smartphones, desktop devices (responsive web design)

- allow for both *quantitative and qualitative* metods of data collection

- easy *scalability* of platform; host on a cloud platform

- use a *modular approach*, allowing successors to extend and further refine the platform

- focus on *public display evaluation*, take the context into account for evaluation

These requirements combined with knowledge from literature review, are what makes this platform unique. The long term goal is to create a research platform, optimized for public display evaluation, delivering new insights into how users react to public display setups. Additionally, the requirements mentioned by Huang et al. [19] and Jacucci et al. [22] also influenced the concept and development of the survey platform. All of the mentioned requirements had an impact on the chosen architecture, which will be discussed in the next section.

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[16]https://github.com/lukasziegler/masterarbeit/tree/master/docs (last accessed on April 15, 2015)
[17]http://www.medien.ifi.lmu.de/lehre/arbeiten/detail.xhtml-php?pub=alt_pdsurvey (last accessed on March 24, 2015)

4.2 Design Decisions

After having assessed all requirements for the platform (see section 4.1), the next step was making design decisions for the programming language and frameworks to use, before starting with the practical implementation of the platform. All options were checked, on the one hand to get informed what is currently buzzing, on the other hand because every decision made has a substantial impact on the architecture.

Programming language   Due to the requirements and objective to support a large number of devices, operating systems, and form factors, a device-independent programming language was preferred. The choice fell on Javascript, not just due to the growing popularity[18], but also because it can be used on the largest number of platforms and devices. Another huge benefit is the ability to use JavaScript for all tiers of development, from client to server to persistence layer. Using the same language on all tiers allows us to share some parts of code between server and client. This approach has become very popular in recent years, now often being being encapsulated in a technology stack referred to as the MEAN stack, consisting of MongoDB, Express.js, Angular.js, and Node.js. Some fundamental differences to the LAMP stack (Linux, Apache, MySQL, PHP) are its shift form server-side to client-side single-page applications (SPA), faster prototyping, shift from synchronous to asynchronous, fast page loading times, less time spent writing SQL (schemaless), and the shift to using RESTful services for the backend. [13]

At this point, first thoughts of using the MEAN stack[19] for the entire development arose. Nonetheless, each part of the architecture was compared and evaluated separately, in order to find the optimal solution for this project. Alternative languages considered were: PHP, Python, Ruby, Java and ASP.NET. The biggest drawback was the additional workload on having to maintain the object model on multiple platforms. Javascript reduces the number of models needing maintenance to one. This way consistency across all platforms (backend, frontend, server) can be achieved easily. Based on our requirements of the platform, the feedback received from discussions with industry experts, and the desire to be able to embed questionnaires on 3rd party website, the choice to use JavaScript for the whole development process already became evident.

Frontend   In recent years single page applications (SPA) have become more popular for creating complex websites [29, 30]. As of 2014, the JavaScript model-view frameworks most frequently used for creating SPA, are Angular.js, Ember.js and Backbone.js. When looking at the numbers and the trend from recent years, Angular.js is the clear favorite [35]. It has by far the largest user base on GitHub, Stackoverflow, and Youtube. When comparing the number of third-party modules, Angular.js also takes the lead with 800 ngmodules vs. 236 Backbone.js backplugs vs. 21 emberaddons. All these factors together indicate a short training time and give hope for beginners making fast progress. One of the biggest benefits of using a framework like Angular.js, is the ability to use two-way data-binding. Changes made to the model are automatically represented in the UI, and vice versa. Furthermore, the possibility to use the templating functionality, combined with the custom directives in Angular.js, was a big plus for this choice. This functionality was used for creating custom HTML tags for the question types in our surveys. These were, amongst others, the reasons why we chose Angular.js for this project, hoping that it will also simplify the ramp-up time for other students.

To speed up frontend development we chose Bootstrap[20] as our CSS framework of choice. Reasons for choosing Bootstrap were the large community, extensive documentation with helpful examples, large number of free tutorials and templates, its excellent integration with Angular.js

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[18] http://www.sitepoint.com/javascript-internet-things/ (last accessed on November 27, 2014)

[19] http://mean.io/ (last accessed on March 26, 2015)

[20] http://getbootstrap.com/ (last accessed on December 1, 2014)

12

(AngulatStrap[21] and AngularUI), the short training time, and its broad acceptance. Alternatives considered were Foundation Framework by Zurb, however at the time of writing there was no pre-fabricated integration for Foundation and Angular.js. Additional frameworks were also taken into consideration, evaluated using the following overview[22] and comparison[23] of currently popular frontend frameworks.

Backend   For the backend it was of importance to have a solid performance and scalable solution. Because our system has a multiplicity of clients submitting and querying questionnaires to the survey platform, scalability is of importance in order to be future proof. Additionally, it was of importance to offer an interface for administrators and to easily be able to exchange data with a large number of clients. For this reason a backend built solely on the principles of a RESTful API was preferred. This allows us to query data from no matter which client. Based on the decision to use JavaScript for all tiers, it was also clear to use Node.js as the underlying platform for building web applications. Reasons speaking for Node.js are its event-based and modular approach, only requiring the parts needed for your project. Another benefit is the easy implementation of authentication and internationalization, due to the concept of middlewares [31] and the native serialization of JSON. Furthermore it is great for reusing code, due to its modular and lightweight architecture and the npm package manager[24] [32]. To simplify and speed up development with Node.js, Express.js[25] was chosen as the web application framework. Alternatives considered were Connect (simpler, less functionality, predecessor of Express), Koa[26] (generator concept) and Resitfy[27] (Express reduced for pure REST services).

Due to the decision of building a single-page application, it became vital to separate the data from presentation layer. Using a RESTful service is the current de facto standard. An alternative would be to use SOAP for message exchange. This would not only lead to an increase of data overhead, but also to a higher complexity on the server-side, and to the loss of statelessness in the requests. In the case that a client does not support HTML or JavaScript execution, the required surveys can still be requested directly through HTTP function calls from the REST API. Such an exception was Quest3D[28], a software package used by Jiamin Shi for the development of the Balloon Shooter game. When being in a situation where HTTP calls are not supported natively, then one can still use logging combined with a scheduled task or create a proxy on the operating system layer and tunnel all data to *PDServer*.

Database   Another fundamental aspect presented the question where to store the data permanently. Criteria for choosing the right database management system (DBMS) for this project was made according to criteria like the size of community, suitability for prototyping, and ease of integration with Node.js/Angular.js. The first question presented, was whether to choose a SQL or a NoSQL DBMS. We chose NoSQL for this project, because of better scalability, a schema-less data representation, faster response time and a decreased development time [38]. Otherwise, NoSQL is better suited for rapid prototyping, because multiple schemata can be mixed inside of one collection and easier evolve over time.

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[21]http://mgcrea.github.io/angular-strap/

[22]http://www.sitepoint.com/5-most-popular-frontend-frameworks-compared/ (last accessed on December 2, 2014)

[23]http://www.sitepoint.com/grid-system-comparison-bootstrap-vs-foundation/ (last accessed on March 24, 2015)

[24]http://stackoverflow.com/questions/5062614/how-to-decide-when-to-use-node-js (last accessed on April 9, 2015)

[25]http://expressjs.com/ (last accessed on April 10, 2015)

[26]http://koajs.com/ (last accessed on April 10, 2015)

[27]http://mcavage.me/node-restify/ (last accessed on April 10, 2015)

[28]http://documentation.quest3d.com/index.php?title=FAQ#What_is_Quest3D.3F (last accessed on April 10, 2015)

Out of the NoSQL databases MondoDB[29] represents the most popular DBMS, especially since it integrates seamlessly into the MEAN stack. Benefits of MongoDB are that it is non-relational (and schemaless), along with its ability to directly store JavaScript objects inside the database. Other characteristics of MongoDB are the non-blocking write operations, which is ideal for logging data. MongoDB provides a good compromise between scalability/performance and the depth of functionality. One disadvantage is that MongoDB does not support joins or transactions. For our use case, however, this is no major drawback. The benefits outweigh the disadvantages. Alternatives that we looked at were CouchDB and Redis. Redis is useful for fast changing data, which is not required on our platform. CouchDB would be an alternative worth looking at, as it has a better replication and conflict resolution. However, this additional security is not needed. The speed benefits of MongoDB are preferred.[30]

To facilitate the object modeling process in Node.js, Mongoose[31] was chosen, providing object relational mapping. Mongoose is an object modeling package for Node.js, allowing application data to be modeled based on schemata. Mongoose takes care of performing CRUD applications and simplifies the process of keeping the object model synchronized across all layers.

Hosting For the hosting of the platform a free and easy scalable solution was of importance. Services offering Platform as a Service (PaaS) were preferred over ones offering Infrastructure as a Service (IaaS), because our focus is on developing and evaluating the platform. We considered the following platforms: Heroku (PaaS), IBM BlueMix (PaaS), Google App Engine (PaaS), Amazon AWS (IaaS), or hosting the entire platform on a local machine.

Our first choice was Heroku[32], due to its simple setup, its native support of Node.js, and seamless integration with Mongolab[33], a platform for hosting MongoDB collections. IBM BlueMix was considered as an alternative, which recently got overhauled and now offers full out-of-the-box Node.js support. However, only the first 30 days are free and the pricing model wasn't as attractive. Google App Engine still has no native support for Node.js (as of December 2014) and custom runtimes had to be used to get Node.js support up and running. Amazon Web Services, offering Infrastructure as a Service (IaaS), would have required too much administration of the server. This would have slowed down the main objective of the project, the development of the survey platform[34]. The same goes for the last option, hosting a MEAN-stack environment on our own servers at LMU Munich. All of the above are well-known solutions in the industry. However, due to simplicity and ease of use we chose Heroku. For our requirements during the prototype phase Heroku was sufficient, offering one free Heroku *dyno* [18].

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[29]`http://www.mongodb.org/` (last accessed on March 26, 2015)

[30]`http://kkovacs.eu/cassandra-vs-mongodb-vs-couchdb-vs-redis` (last accessed on March 26, 2015)

[31]`http://mongoosejs.com/` (last accessed on November 14, 2014)

[32]`https://www.heroku.com/` (last accessed on March 26, 2015)

[33]`https://mongolab.com/` (last accessed on March 26, 2015)

[34]`http://smashingboxes.com/ideas/heroku-vs-amazon-web-services` (last accessed on April 10, 2015)

4.3   Modeling

The development process of the PDSurvey platform was inspired and influenced by the concept of extreme programing[35], making iterative improvements, and working agile and user centered. First user stories were written and assessed in a small group[36]. The next step was to transfer these stories to user models, describing in detail which functionality the stakeholders of PDSurvey are supposed to have. Later a first software architecture and software model was built. Dependencies between models were defined and the model was continuously refined and improved throughout the development phase. The last phase included screen designs, getting a clear view of what the interface might look like.

The development of the REST API was influenced by current best practices [5,21,34]. The API is separated into logical resources, while each resource gets manipulated through an HTTP request. For public access GET and POST is defined, for authenticated users also PUT and DELETE. For a more information about PDSurvey's REST API refer to the documentation (see Appendix A). The model for the *PDSurvey* platform is maintained with Mongoose. Angular.js builds its model from the REST API, and maps all changes via dynamic two-way-binding to it's scope. The REST API is provided by the Node.js server, which maps all incoming requests through an Express router to the corresponding Mongoose models. Thus all changes to the model originate from Mongoose. The software model is modeled in Mongoose and stored as MongoDB collections. There are the following collections: Question, QuestionType, Response, Category, Surveys, DisplayModel, Display, Campaign, Context, and User. Of special interest are the following four collections: Surveys, Display, Campaign and Responses (see figure 4.1).
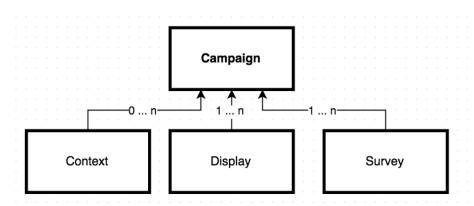

Figure 4.1: Campaign model dependencies

Surveys: Questionnaires are the foundation of PDSurvey, consisting of multiple sections, which in turn are made up of multiple questions. Each question is of a corresponding question type and every questionnaire belongs to a category. This allows questionnaires to be filtered based on certain research questions. Additionally we added the ability to set surveys *private* (by default), *shared* (for sharing with other users), *standardized* (scientifically recognized), or *pending* (waiting for review, to be shared). Every survey is assigned to an individual user of the platform, with the aim of reuse and standardization of questionnaires.

Display: In the display collection all displays connected to the PDSurvey platform are contained. To allow evaluation across multiple display models and based on the context of the displays, the

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[35]http://www.extremeprogramming.org/rules.html (last accessed on April 10, 2015)

[36]http://www.tigertech.de/wie-schreibe-ich-eine-gute-user-story-und-was-ist-das-uberhaupt/ (last accessed April 10, 2015)

display model and a static and/or dynamic context is assigned to it.

Campaign: Campaigns resemble the most integral part of the platform. Each campaign consists of multiple displays and multiple surveys, resulting in a mapping of surveys to public display networks. Additionally, to each of those mappings an individual context can be assigned, enabling a comparison of results of public displays later on.

Response: All responses made to each survey are logged in the Response collection. The queries are logged individually per user, per display and per campaign. This model will be the base for further extensions, such as the automatic evaluation of the survey responses and the comparison of different displays inside one display network. This enables the administrator to find out which properties of a display might cause certain effects.

Context: One of the benefits of creating this survey platform is the ability to collect and evaluate large amounts of data, without increasing the workload on the human component for conducting and evaluating the responses. The idea is to collect a large number of responses from a variety of displays in various settings, and assigning a specific context to every display connected to PDSurvey. Once enough data is collected, the results can be evaluated and compared between the displays. Interesting questions for analysis would be, which role the context plays on how the users respond to the display, when running identical software settings on the displays, but only varying the context (position, size of display, surrounding environment of the display, positioning it outdoors or indoors, influence of the weather, type of building it is positioned in).

4.4   PDSurvey Platform

The public display survey (*PDSurvey*) platform aims to facilitate the conduction and evaluation of surveys on and for public displays. The interactive survey platform, which can be embedded directly onto public displays and be used as a direct feedback channel from inside another application, can be split into three main parts: PDAdmin, PDServer, and PDClient (see figure 4.2). *PDAdmin* contains the administrative interface, allowing display providers to configure questionnaires for their public displays. *PDServer* accommodates the REST service, the persistence layer, and the majority of the application logic. *PDClient* is a web based interface, containing one possibility for responding to the deployed surveys. The code base of all three parts is deliberately separated from each other, allowing the independent refinement and less dependencies between the frontend, the backend, and the server.

PDClient
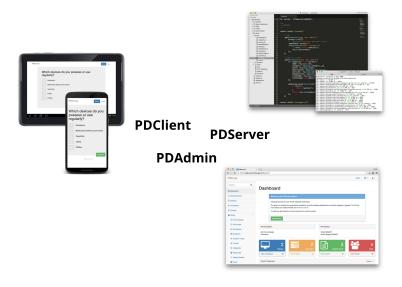
PDServer

PDAdmin

Figure 4.2: Overview of the PDSurvey platform: (a) PDServer containing the Node.js server, (b) PDBackend is the entry point for administrators and (c) PDClient the interface included on public displays and optimized for mobile devices.

4.4.1   PDAdmin

For administrative purposes an admin interface was created, enabling display providers to create, manage and distribute surveys to public displays. Display providers have the ability to create their own questionnaires or to select from a list of standardized questionnaires (chapter 3). The entry point for PDAdmin is the dashboard (see figure 4.3). There users get an overview of all relevant information such as how their campaigns are running, and how many responses have been submitted already. For new users, who haven't created any campaigns, questionnaires or displays yet, the *Wizard* (see figure 4.4) will be the best place to get started with the survey platform. Users get guided through the creation process of campaigns step by step. For more experienced users the navigation options *Displays*, *Campaigns*, and *Surveys* are more advisable. Administrators of the survey platform additionally have the ability to add new *Users*, *Question Types*, or research *Categories*.
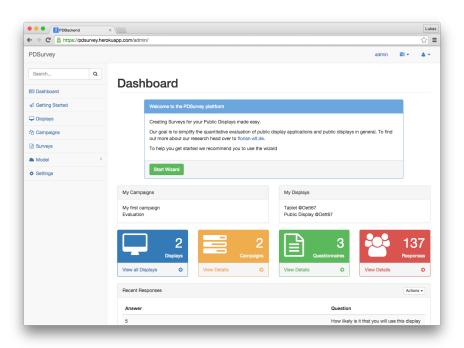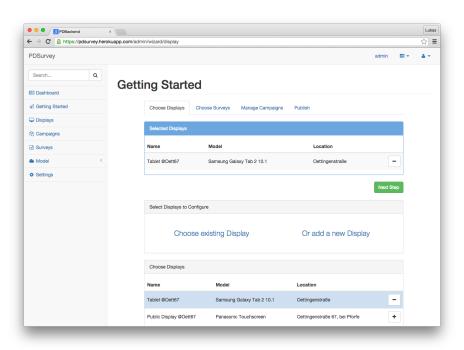
Figure 4.3: Dashboard of PDAdmin

Figure 4.4: Wizard for PDAdmin

4.4.2 PDServer

The server was written in Node.js and to the outside only offers a RESTful API. All interactions users or developers make with the server are HTTP calls. When performing CRUD operations, all REST calls need to be executed and JSON objects are returned. Besides this REST functionality a rudimentary authentication mechanism is already implemented on the server and the capability for further logic, determining which client should ask which question next. This functionality might become of interest when trying to spread standardized questionnaires of longer length across multiple users or multiple displays. It would be intended for the server to keep track which questions have already been answered and to tell each instance of PDClient which question to ask next, in order to achieve a balanced question profile. The specification of PDServer's REST API can be found on GitHub[37] and on the enclosed CD (see Appendix A).

4.4.3 PDClient

Our client tool was kept as simple and minimalistic as possible. The only communication between PDClient and PDAdmin is via REST calls, exchanging JSON objects. Even though both PDClient and PDAdmin are developed using Javascript frameworks, they have a separate code base. Reasons for this were on the one hand reduction of the application size, on the other hand different requirements of the client version and the administrator panel. PDClient needs to be highly scalable and offer a low latency and fast response time. For PDAdmin it is more important to offer a better usability and a more visual appealing presentation of the results. The goal is to reduce logic and complexity on client-side. Currently PDClient loads all questions for the questionnaire at startup and caches them for later access.

PDClient has three main components (see figure 4.5). The principal part being the *Survey page*. All questions are loaded at once on startup, then one question gets displayed at a time. Settings for the survey can be modified from PDBackend (e.g. number of questions to display and duration of the survey). Once the user makes a choice, it is directly logged on the server. In case that a participant aborts answering the survey, the questions answered so far are still recorded. The *About page* was added, since some employees from university said they were skeptical and had doubts regarding the research project, when having no information whatsoever about which information is logged. To motivate people to participate, a *Welcome page* was added. It turned out that a significant larger number of people were willing to participate in a survey, after knowing that it will only take one minute, the research is university-related and that it will be used for a Master's thesis.
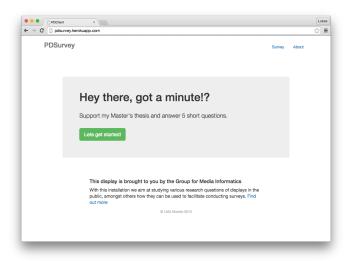
4.4.4 EmbedCode

Offering an embed code for surveys, turned out to be a pure proof-of-concept. The problem was that the Balloon Shooter game, on which *PDSurvey* should be integrated, did not support any HTTP calls or overlays, thus we had to fall back on another solution. This embed code was intended to be used by display operators, wanting to include questionnaires hovering over their web-based public display applications. The technical realization was inspired by Web Bug [38], and the embed code offered by Google Analytics[39].

One minified line of JavaScript code needs to be added before the closing HTML <body>-tag. This minified line creates a <script>-tag in the the Document Object Model (DOM) of the HTML page, injecting a JavaScript file from the *PDSurvey* platform. This personalized scripts first loads jQuery and/or Angular.js asynchronously, creates another instance of PDClient inside of the

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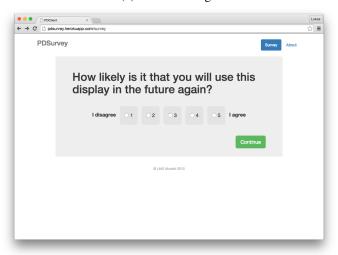
[37]https://github.com/lukasziegler/masterarbeit/tree/master/docs (last accessed on April 15, 2015)

[38]http://en.wikipedia.org/wiki/Web_bug (last accessed on November 26, 2014)
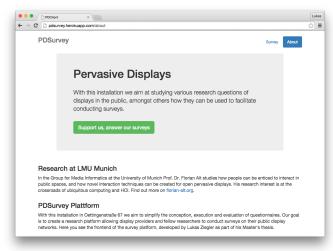
[39]https://developers.google.com/analytics/resources/concepts/gaConceptsTrackingOverview (last accessed on November 26, 2014)

(a) Welcome Page

(b) Survey page

(c) About page

Figure 4.5: Overview of PDClient

primary website's DOM. All questions for the questionnaire get loaded via PDServer's RESTful API and the responses get sent back to the server for logging. To avoid conflicts caused through the code injection, all classes and files are prefixed with a unique namespace.

5   Field Study

The field study took place during the first two weeks of March, from 3/3/2015 to 3/15/2015 in Oettingenstrasse 67, a faculty building of Ludwig-Maximilians-Universität München. Data was collected from the display setup on 14 consecutive days and 28 semi-structured interviews were carried out on five working days during the same two weeks. A total of 117 interactions were registered with the public display installation and 57 survey responses were recorded.

   The goal of this study was to validate our research questions, and to see how users respond to questionnaires being conducted on public displays. We chose to conduct a descriptive study, with a focus on ecological validity, since our research prototype is still in an early stage of development.

5.1   Research Questions

One of the main reasons why we conducted this field study, was to get a better understanding of our assumptions and to see how users react to questionnaires on displays in public. Besides, it was of importance to conduct a study "in the wild", because there often is a discrepancy between lab studies and field studies. This phenomena has been discussed by Ojala and Kostakos in 2011: "The first important conclusion we have arrived at is that there exists a huge difference between results obtained in a lab and in the wild using the exact same configuration" [28].

   One hypothesis we made for the development of our first research prototype of the *PDSurvey* platform was that we can simplify the conduction and deployment of surveys to large public display networks. Since this is a rather large claim, we broke down this hypothesis to the following more fine-grained statements:

1. Which feedback channels are best suited for completing surveys in public?

2. Why did users approach the display? What motivates them to fill in surveys in public?

3. How did the user notice and perceive the survey on the display?

4. Which question types are best suited for questionnaires carried out in public?

   In addition to these questions we were also interested in user stories, the feedback real-world users gave us in regards to answering surveys on screens in public. For this reason we also conducted semi-structured interviews in parallel to the quantitative evaluation of the *PDSurvey* platform. In order to get as authentic and personal feedback as possible, we stuck loosely to the designated questions of the semi-structured interview (see Appendix B), in order to allow users to also tell us new stories, which we wouldn't have thought of before.

   These research questions were represented in the *PDSurvey* questionnaires and semi-structured interviews. Questions which would go beyond the scope of this thesis, and might serve as follow-up questions for further research, are gathered in chapter 6, Future Work.
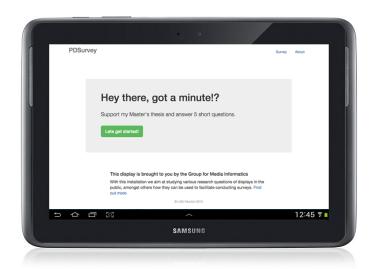
Figure 5.1: PDClient: Using intrinsic motivation to motivate users to participate in a short questionnaire

5.2   Pre-Study

Smaller Pre-studies accompanied the development of *PDSurvey* and the related field study, in order to get early feedback in the development process. For the backend it was good to find out more about the ...

1. intrinsic motivation

2. adjusted font-size for large / small screens

3. Backend: wizard

The day prior to the launch of the actual field study was used for assembly and for last adjustments, like change of font size, adjustment to the position of certain UI elements, and for collecting implicit feedback from users observing but not approaching the display. Only from observing it could be seen that a more effective call-to-action was needed. Many people looked at the display, noticed that something has changed with the setup, but no one started interacting or was willing to complete the questionnaire. Therefore a more catchy start screen was introduced for the tablet (see 5.1) and the option panel of the TV screen was also modified E. This observation is very much in line with the self-determination theory by Richard Ryan and Edward Deci [33].

To increase the motivation for users to participate, additional intrinsic motivation was given to increase the response and acceptance rate of the public surveys, as proven by Richard Ryan in his self-determination theory[40] [33]. We stated that the questionnaire consists of five questions, that it will only take one minute to complete and the results are for a Master's thesis at the university. This information was displayed as a splash screen on the tablet (see figure 5.1).

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[40]http://www.selfdeterminationtheory.org/

Figure 5.2: Options panel to choose a feedback channel

5.3 Study

We deployed the *PDSurvey* platform to a public display setup, which has already been running since several months in the entrance hall of the faculty building. The public display setup has consistently attracted new and returning users to participate. A descriptive research type was chosen as the study type. Our aim is to describe and observe how users react to the new display setup. Only one study prototype is deployed, without varying any variables. The goal was to get first feedback on how people perceive filling in questionnaires on digital signage in public, before getting into more fine-grained research (see chapter 6). Both quantitative and qualitative data was collected as part of the field study. Quantitative data was obtained through the *PDSurvey* system and qualitative data was collected through semi-structured interviews. The distribution of the preferred feedback channel was logged inside of the Balloon Shooter game (see section 5.3.3) and asked in all semi-structured interviews.

5.3.1 Design

Our primary goal was to find out which feedback channel users preferred to respond to surveys in public. Each user had the choice to respond to the questionnaire on a TV display (1), on a tablet (2) to the right of the TV screen, via their own smartphone (3) or via email (4). The order of all four feedback options was randomized. After completing the Balloon Shooter game on the primary TV screen, each participant was confronted with an options panel (see figure 5.2), asking the user to support our research and to respond to a short questionnaire. The feedback channel chosen was logged and the user next had the opportunity to respond to the same questionnaire on all four feedback channels. We displayed the same five questions (see table ??) and chose to limit the number to five questions, to avoid low participation rate and low response rate.

Wording	Question Type
1. How often have you used this display before?	Numeric
2. How likely is it that you will use this display in the future again?	5-point Likert scale
3. Which devices do you possess or use regularly?	Multiple choice, 5 options
4. In which area do you study / work?	Text field
5. What was your motivation for approaching and using this display?	Text field

Table 5.1: Questions asked on all four feedback channels

In order to also get first insights into how well certain question types are suited for surveys in

public, where a short completion time is crucial, we varied between the following question types and kept them in the same order: numeric questions, Likert scale, multiple choice (based on check boxes) and two text fields for responses of undefined length.

Due to the nature of descriptive studies, we only observed the users' behavior and observed how our study setup was used. The parameter of interest was the feedback channel chosen to respond to the survey. Since we didn't vary any conditions, no independent variables are present.

To find out more about the users' motive for approaching the display setup, we also carried out semi-structured interviews in parallel to the field study of the PDSurvey platform. The goal of the interviews was to get qualitative feedback from all age groups and backgrounds. Getting a better understanding of how people respond to questionnaires in public, helps us improve the *PDSurvey* platform.

5.3.2 Participants

In total 57 questionnaires were submitted and 28 semi-structured interviews were conducted during the two week study period. As for the study size, we took the findings from Alt et al. [3] as a rough guide, for how many participants to include four our study. According to Alt et al. most field studys have an average of 26.9 interviews and 38.4 questionnaire responses. Information about the background of the participants was assessed both in the questionnaire and in semi-structured interviews (see table 5.2). Due to the limited number of questions in the questionnaire, only one the age of the participant was asked. In the semi-structured interviews information regarding the participants' age, gender, and working/study area were asked.

Based on the fourth question ("In which area do you study / work?") we can draw a conclusion about the study field of the survey participants. As far as indicated all people responding to the *questionnaire* installed on the public display setup were students. Out of 57 responses, 42 could be assigned to a study field. The remaining 12 submissions consisted of responses such as *bavaria, bib, home, munich, muc* or were left empty. The study fields most frequently represented were Computer Science (23,8%), followed by Political Science (14.3%), Japanese Studies (11.9%), and Anthropology (11.9%), Cultural Science (9.5%), and Business (9.5%). Other study fields mentioned were Physics, Sociology, Ethnology, Communication Science, Sports, and Science & Technology.

For the *semi-structured interviews* we collected more detailed information about the participants' background. Out of the 28 participants, 72.4% were male and 28.6% were female. The average age was 31 years, with an age distribution ranging from 20 years up to 69 years (median=25, SD=13.2). Due to the wide variety of faculties and a library being located in the same building, various technical backgrounds were present. What they all had in common was their affiliation to LMU Munich, either because of being a student themselves, working at the university or being otherwise related to the university. In total 23 students, three employees, and two retirees were interviewed. The study fields which were most frequently represented are Computer Science (16.7%), Japanese Studies (16.7%), Ethnology (12.5%), and Political Science (12.5%). Other areas mentioned were Sociology, Communication Science, Law, Physics and Engineering. Eleven of the 28 interviews were conducted with actual participants of the public display study setup (39.3%), the remaining 17 interviews (60.7%) consisted of people passing by the display setup.

The selection of participants for the completion of the *questionnaire* was not influenced by us. All survey responses were made in their own interest, no reward was given for participating in this "in the wild"-study. The selection of the participants for the *semi-structured interviews* was influenced by how users reacted to the display setup. Our primary goal was to observe and interview active users of the public display setup, in order to get a better understanding of how they perceived the setup and to get insights into which feedback channel they chose why. In order to also understand why people did not approach, or if they have any concerns, people passing by

were also interviewed.

Before starting the semi-structured interviews, all people participating were asked whether they had already noticed the display setup and/or the option to fill in a survey. This allowed us consider the novelty effect for evaluation and to differentiate between three groups: participants who approached the display by themselves (and were observed doing so), people passing by the display (noticing the display, however not approaching it) and the last group of people simply passing by (not having noticed the display). The distribution between the groups was as follows: 11 active participants, 14 passerby (who have noticed the displays before), and 3 passerby (who saw the display setup for the first time).

Out of all people passing by no one has noticed the option to fill in a survey. Out of the active participants, 5 out of 11 have noticed the option to respond to a survey on different channels. To increase the amount of feedback, we approached people from all three groups. The number of survey responses was not artificially increased by asking passersby was.

5.3.3   Apparatus

The permanent setup consisted of a 55-inch touch-sensitive TV screen, connected to a laptop running on Windows 7, and a Samsung Galaxy Tab 10.1 tablet positioned to the right of the TV screen on a console. The TV screen was positioned on a 60cm high stand, resulting in a positioning at eye level. The tablet was placed on and fixed to a conductor's stand to the right of the TV screen (see figure 5.3). Our object of investigation was the TV screen with touch support, running an interactive game called *Balloon Shooter*, developed by Jiamin Shi. After users completed the game, they were asked via a prompt to fill in a questionnaire on one of the four provided feedback channels (see figure 5.2). The courtesy for the Balloon Shooter game and the survey implementation on the TV screen goes to Jiamin Shi.

Each user had the opportunity to respond to the *questionnaire* either directly on the TV screen (1), on the tablet to the right of the big TV (2), via their own smartphone (3) or via email (4). The first option was embedded natively into the Balloon Shooter game, offering a consistent UI and the most direct feedback channel. When choosing the tablet as an option, users were prompted to move to the right and to answer five questions on the tablet. The Android tablet was running KioWare Lite[41], a kiosk app for Android, and displaying the responsive frontend of PDClient for the entire time of the study. Choosing the third option prompted the user to either scan a QR code with their smartphone or to open a URL[42] in their mobile browser. The last option consisted of an input field embedded into the Balloon Shooter game on the TV screen, asking the user to enter

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[41] http://www.kioware.com/android.aspx (last accessed on April 21, 2015)

[42] https://pdsurvey.herokuapp.com/ (last accessed on April 21, 2015)

	people participated in survey		people interviewed
10	Informatics	4	Informatics
6	Political Science	4	Japanology
5	Japanese Studies	3	Ethnology
5	Anthropology	3	Political Science
4	Cultural Science	3	*employees (PhD, public officer, SysAdmin)*
4	Business	2	*in pension*
2	Physics	1	Communication Science
2	Sociology	1	Sociology
1	Ethnology	1	Law
1	Communication Science	1	Physics
1	Sports	1	Engineering
1	Science and Technology		

Table 5.2: Demography for the survey data (left) and the semi-structured interview (right).

Figure 5.3: Overview of the study setup in the entrance hall of the faculty building.

their email address. The address was logged to a txt-file, which was scanned every 5 minutes by the Windows task scheduler. An email reminder was sent to the user with a request to complete the survey. For sending the email from the TV screen, a Python script[43] was written, using a modified version of TLS authentication in order to comply with the university's SMTP server. Screenshots of all four options can be found in Appendix E on page 47. For the permanent setup the following data was logged: the timestamp of the users choice, which feedback channel the user chose to respond to the survey, and whether they skipped the call to participate in the survey or if they stopped playing the game (determined via timeout). On all four feedback channels a self-made questionnaire was used, since the focus was on finding which channels and question types are best suited in general for being used on public display. This was the reason why we did not use any of the standardized questionnaires mentioned in chapter 3.

For conducting the *semi-structured interviews*, two questionnaires were used as a rough guidance, one for participants, and one for passerby. A voice-recorder (smartphone) was used additionally to record the interviews, to be able transcribe and code all of conducted interviews. Each semi-structured interview loosely followed the outline presented on page 44. Audio recordings and transcriptions are on the attached CD. The main application installed on the public display was a game called *Balloon Shooter* developed and run by Jiamin Shi, a PhD student at the Group for Media Informatics at LMU Munich. It was first installed on January 7th 2015 and has been running in different versions since then. Public audience was already used to it for roughly two months and adapted to it well. In 2,5 weeks in February[44] usage statistics reported that the game was played a total of 305 times.

5.3.4 Location

All parts of the field study were carried out in Oettingenstrasse 67, the faculty building for Computer Science of Ludwig-Maximilians-Universität München. In the same building research institutes for Ethnology, Political Science, Japanese Studies, and Physics are also located. The study was carried out in the entrance hall of the university building. Figure 5.4 gives an overview of the entrance hall and of the paths most people take while crossing the room. The excerpt is based on the universities floor plan[45], and was inspired by Sandra Zollner [1]. For her bachelor's thesis she conducted a study in the same location one year ago and analyzed the visitor flow. According to Zollner "approximately 59% of all passers-by used path 1" to get something from the lockers or to leave through the door to the library. 28% of the people were taking path 2 and 13% were taking path 3. In our field study it was also evident that the majority of the visitors took path 1. This

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[43]https://github.com/lukasziegler/python-send-mail (accessed on March 15, 2015)
[44]Based on the evaluation of log data from 05/02/2015 to 23/02/2015, reported by Jiamin Shi.
[45]http://www.uni-muenchen.de/funktionen/gebaeudeplaene/7070_d_00.pdf (last accessed on March 22, 2015)

group usually was fairly target-orientated, or in a hurry. Otherwise, on days with bad weather, people had their break in the entrance hall, or waited for someone. On days with good weather people usually took their breaks outside and only passed through the entrance hall, coming from the library, picking up something from the locker room and going outside.
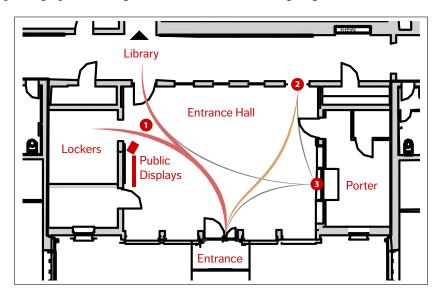

Figure 5.4: Floor map of the entrance hall, where the field study was carried out. User paths, and the surrounding environment including facilities such as the library can be seen.

5.3.5   Procedure

All participants of the semi-structured interview were asked a similar set of questions (see Appendix B). Based on the group they belonged to, either questionnaire 1 (for participants of the display setup) or questionnaire 2 (for passersby) was chosen. In order to speed up the interviewing process and to get away from a plain question-response schema, the questions on the printed out questionnaire only survey as a rough guideline.

For people having trouble understanding the concept of the public display installation, the situation was described as follows. "Imagine you are in a shopping mall or at an airport using one of those large displays to find some information. After having found what you were looking for, you get asked to answer a short questionnaire. How would you react to it?" A full transcription of all questions and responses can also be found on the enclosed CD.

The participants for the PDSurvey questionnaire were not additionally motivated. All they saw was the options panel after completing the Balloon Shooter game (see figure 5.2) or the welcome screen of the tablet (see figure 5.1) while passing through the entrance hall. A complete copy of what the users were able to interact with, can be seen on the attached CD (see Appendix A).

5.4   Results

We received a total of 57 filled in surveys, submitted via all four of the provided feedback channels, and carried out 28 semi-structured interviews. No treatments were applied to the dataset, descriptive statistics will follow bellow. The presentation of the evaluation is divided into three parts. First we will have a look at which feedback channel is most popular, followed by the quantitative results of the PDSurvey questionnaire, and rounded off with the results from the semi-structured interview.

5.4.1   Feedback Channels

NOT SURE HOW TO BEST POSITION THIS PART

The majority of the surveys were submitted on the tablet (87.72%). Four responses were recorded directly on the TV (7.02%), two via smartphone (3.51%), and one via email (1.75%). Since this listing only contains the number of responses, it should not be taken as a base for the comparison of the feedback channels' popularity. Due to the tablets sole purpose to be used to fill in surveys in our setup, and the additional intrinsic motivation given on this channel (see section 5.3.1), this ratio has to be treated with caution. For a comparison of the **feedback channels** the log data from the option panel and the responses from the semi-structured interviews are better suited (see table 5.3).

After having completed one session of the game, users had the option to choose a feedback channel. Based on this log data of the TV screen a better comparison of the feedback channels can be made, since all direct responses made on the tablet are excluded from this summary. The most popular feedback channel was the tablet (46.15%), followed by the TV screen (30.77%), smartphone (15.38%), and email (7.69%). In order to have another source of input, the same question was asked at the end of every semi-structured interview. Based on this quantitative data from the interviews the response via tablet (42.86%) was most popular again, followed by the TV screen (32.14%). Interestingly, for the interview data the option to respond via email (17.86%) is more popular than smartphone (7.14%).

From Survey Data		From Interviews
30.8%	on public display	32.1%
46.1%	on tablet	42.9%
15.4%	on smartphone	7.1%
7.7%	at home / via email	17.9%

Table 5.3: Preferred feedback channel for answering surveys.

5.4.2   Survey Responses

How often have you used this display before?   In our questionnaire executed on the public displays we asked five questions. Out of the 57 responses people have on average used the display 6.9 times before. For 25 people (43.9%) of the users it was the first time using the display setup, 11 people (19.3%) have used it once before, 18 people (31.6%) between two and ten times, and the remaining 3 people (5.2%) more than ten times.

How likely is it that you will use this display in the future again?   For the second question, based on a 5-point Likert scale, the response was fairly uniformly distributed (average=3.04, SD=1.46). The whole scale from 1 (not likely at all) to 5 (very likely) was represented. No clear trend could be seen. When only considering the responses collected from the large TV screen, a better perception can be noticed. There the responses to this question had an average of 4.5

(SD=0.866), showing a trend towards a positive perception of the large display setup. However, due to the low number of responses for the TV display, this conclusion can not be regraded as significant.

Which devices do you possess or use regularly?   Taking a look at the devices users possess might give us first insights into why users chose which feedback channel. Overall, the majority of the people participating in the survey already owned a smartphone (79.3%). The second most popular response was laptop (73.6%), followed by tablet (41.5%), and desktop computer (26.4%). Still, 18.9% of the users indicated that they possess a feature phone and use it regularly. On average each participant possessed 2.4 devices. When looking at which combinations of devices were most frequent, twelve people responded that they own a smartphone + tablet + laptop. Twelve other people indicated that they possess a smartphone + laptop, and six people own a smartphone + laptop + desktop.

In which area do you study / work?   The fourth question was used to get a little insight into the background of the survey users. Only the occupation of each participant can be derived from the questionnaire. For a full evaluation of the demographic background of all participants, refer to section 5.3.2.

What was your motivation for approaching and using this display?   The main reasons why people have approached the display were "curiosity" (12x), "fun" (10x), "boredom" (8x), "interest" (2x), and "during breaks" (2x). Other reasons mentioned were "it is there, so why not?", "it is there and colourful", or "I've never seen it before in this spot, wanted to know what it is about".

5.4.3   Interview Responses

The evaluation of the semi-structured interviews was based on Grounded Theory, promoting a systematic evaluation of the interview transcripts.

To avoid any interferences between the two groups, each passerby was asked before starting the interview whether he has noticed the public display installation, and whether he has already interacted with the installation. Out of all passerby no one has previously been interacting with the game or survey platform. 82.4% (14 of 17) of the passerby have already noticed the public display installation before, however, none of the passerby has previously participated in the game. The remaining 17.6% have neither approached the display nor noticed it previous to the interview.

Looking at the scientific background of all 28 participants, 79.2% are students, the remaining 20.8% either already worked full-time or were in pension. The majority of students studied Computer Science (16.7%), Japanese Studies (16.7%), Ethnology (12.5%) or Political Science (12.5%).

From what has been mentioned, the main reason for approaching the public displays was in 6 out of 8 cases "curiosity" (6x). Two other reasons were "for fun" (1x) and "waiting for someone" (1x). Reasons for not approaching the display were "no time" (2x) and "it is in the entry zone of the university, it feels strange when one plays with it" (1x).

From the open coding phase the following patterns can be seen:

ASK JULIE!

- reason for approaching: see above - number of questions found acceptable: 5 - 10 - reasons for choice of feedback channel: - requirements for a survey, to attract users:

- most interesting feedback: reason PRO / CON using a certain channel

The semi-structured interview was most useful to get a better insight into why certain users chose which feedback channel. Reasons mentioned influencing their choice were ""

see Table D.1.

5.4.4   Additional Observations

The response time for responding to the five questions was on average 1:02 minutes, ranging from 0:36 to 3:06 minutes.

How many questionnaires were fully completed, how many were aborted? Which questions were left empty? Does this infer anything for the quantitative vs. qualitative surveys?

Questionnaires on public displays are best suited for quantitative surveys. Users want a short interaction time, not having to think much about their answers and for roughly XXXXX percent of the participants it holds true, that they do not like being observed while making responses in public. From this observation, the implication for the **question types** can be derived: question types ideally with a single-click interaction are preferred (e.g. Likert scale, multiple choice with all options given, yes/no-questions). Then followed by numeric, dropdown and multiple choice questions with one option for open-end responses. For these question types the user has to think a little bit more, he has to assess more precisely in order to make his response. One example stated by a participant, in regards to the numeric question 'How often have you used this display before?', was that "It would be great if you had the possibility to choose from a predefined range, because typing is not always optimal. I would prefer if areas would be given instead of oneself having to think about the exact number." Last, being no big surprise, are text fields combined with open-ended questions. As a take away for text fields: wherever possible rephrase the question so that you can respond to it as short as possible.

5.5 Discussion

It is interesting to see that the tablet is the most popular **feedback channel** in all scenarios, although responding via the TV screen would be more a more direct approach and not require moving to another device. Nevertheless all offered feedback channels were present in the evaluation and during the semi-structured interviews for each channel a good reason was given. What can be said that the crowd usually distinguishes into three groups. The first (and slightly larger) group preferring the option of *direct response*. They are not as considerate about answering questions in public and their privacy aspect. For them it is more important to complete the survey as quick as possible and not having to think about it later, as long as nothing too private or personal gets asked. One person said "If something too private would be asked, I would simply abort and go away from the display". The second group is more *privacy* concerned, often older of age, or actually wanting to take the time to think about all of their responses in depth in order to give high-quality responses. This group prefers to take the questionnaire away from the public setting into their home. The third group chose the feedback channel purely based on their *habit* and what they are accustomed to. Two ladies in their mid-twenties responded immediately "on my smartphone, because I am most used to it".

These observations go along well with the five adaptation factors stated by Huang et al. [20]: task specificity and deep integration, tool flexibility and generality, visibility and exposure to others' interaction, low barriers to use, dedicated core group of users.

Another assumption we had was confirmed by our observations and the semi-structured interviews: the smaller the display, the safer and more private the users feel. An exception to this finding could be old people. Once people become short-sighted or more insecure and unconfident with using new devices, they prefer having a large input surface. But for the majority of younger people this held true.

Additionally we made the observation that users responded ...

» POSSIBLE DRAWBACKS OF PUBLIC DISPLAY EVALUATION: privacy, social desirability » discuss these two aspects more in depth in this section.

The people who prefer the direct option, didn' take options 3 or 4, because it is too indirect. it would require additional commitment, which is not in the moment. therefore they would prefer to do it right now, to do someone a favour or because they are curious. but their envolvment to the topic of the research is not high enough, that they would offer to contribute later.

We are aware of certain limitations of our descriptive study. Our limitations are consistent with the findings found by Ojala et al. [28]. The effects of curiosity, impact of novelty, and influence of weather had an influence on our field study. Due to the novelty effect caused by the tablet, and the intrinsic motivation we added through the splash screen on the tablet (see section 5.3.1, selt-determination theory), the participation rate on the tablet was increased. For our primary research question, which feedback channels is best suited, the impact of novelty, curiosity and of the always-visible tablet, should not have an impact. We based the evaluation of the feedback channel not on the overall number of responses, which was therefor distorted, but on the option panel and on the interview responses.

Despite these effects, it was striking to see a response rate of 42.4%, when comparing the 50 responses made on the tablet with the total number of 117 interactions made with the public display setup. When we exclude all participants who directly accessed the tablet and did not see the option panel to use one of the four feedback channels, the response rate on the tablet was still 5.1%.

Otherwise, it should be mentioned that both the TV screen and the tablet were always on and that all questions were optional. One suggestion for improvement is to only turn on the screen of the tablet when it is selected on the TV screen as the desired feedback channel.

All in all, it can be said that people prefer to respond to questionnaires in public directly, as long as the questions don't get too private. Nonetheless the more feedback channels one offers,

the better it is, since the variety of user backgrounds also bring different preferences and attitudes. When designing public display setups for getting more sensible user input, the display size should also be taken into consideration. So far we have made the observation, that users feel more secure on smaller screens.

For the development of our public display survey platform the study showed that we are on a good path. - people are willing to respond in public - put a higher priority on how users are motivated to participate, currently not embedded yet for scalable solutions, currently it was manually embedded - a higher focus on fast, one-click responses

Notes for Discussion   » we assume that the size of the public display has a direct proportional influence on the level of privacy and security. This however only is an assumption, which needs to be further investigated.

Concerns that have been expressed: social desirability, less privacy These concerns should be taken into consideration when designing questionnaires, whether the benefit is larger than the drawback. Benefits being: direct response, no procrastination, immediate feedback of the users impressions, less people needed for evaluation, semi-automated evaluation of the log data.

6   Future Work

Based on the development process of the *PDSurvey* platform, inspired by the literature review and survey responses, we came to the following thoughts of what else might be of interest for follow-up studies.

For the survey platform itself we had to cut back on our goals early, due to the limited resources and development time of 2,5 months. Since the intention is to further improve the platform through fellow students, certain aspects of a classic survey platform were omitted. It would be interesting to see some of the following extensions to *PDSurvey*. The first and biggest need for improvement is a proper visualization of the quantitative and qualitative results, e.g. with the use of information visualization and JavaScript libraries such as D3.js[46] or Morris.js[47]. Because this was not our main focus for the thesis, we only implemented basic logging of all results, without any automated evaluation or visualization. A second aspect for improvement would be to support more data sources. Currently 'only' data from questionnaires are logged, but it could also be of interest to support the logging of video feeds, audio feeds, touch interaction (pixel coordinates), or other meta data from the display setups. For logging large amounts of data an integration with storage solutions such as Dropbox could be of interest. Based on their Dropbox API[48] files can be stored and referenced from third-party applications. It is conceivable to also log audio or video responses to questionnaires. A third chance for improvement could be to offer more sophisticated evaluation mechanisms. When combining more log data with advanced evaluation mechanisms, better insights can be achieved. One such enhancement could be a context-based approach for evaluation. When collecting the context of each display setup and of every response, a comparison across a multitude of displays becomes feasible. This can provide new insights into patterns responsible for certain effects. Another improvement would be to integrate the automatic evaluation of all survey responses based on their validity, reliability and on metrics such as standard deviation. This will not only simplify the overall evaluation of public displays and their interactive applications, but also the overall quality of the end product being evaluated. As more information gets collected and as the platform grows, it would be good to further refine the context model and to add a proper authentication mechanism. From a technical perspective it would be good to add unit testing and to add authentication to the platform.

While executing our field study we thought of additional research questions, which would be of interest, but would go beyond the scope of this thesis. One such aspect is the number of questions tolerated per feedback channel. While executing the field study and semi-structured interviews some people noted that they would be willing to give more detailed responses, when they could fill in the questionnaire at home. Getting better insights into the constraints of each feedback channel would be of high interest for the construction and deployment of questionnaires in public settings. To find out whether this variable differs between the chosen feedback channel, location of the display setup, and its surrounding environment, or if other factors also play a role here. Another interesting question might be in which setting a user is most willing to answer surveys on public displays.

Another research question of interest might be how to best deploy standardized questionnaires consisting of 20+ questions. The problem is that no user wants to complete too extensive questionnaires in a public setting. One approach could be to analyze, whether it is possible to break down long questionnaires across multiple users, and aggregate the results, taking into account that the derived findings will not be as extensive and may not allow any inferences. According to Jacucci et al. [22] there are often significant similarities between standardized questionnaires. Therefore it might be possible to break down each questionnaire to its principal components, to bundle all matches, in order to reduce the total amount of questions and to be able to split all questions across

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[46] http://d3js.org/ (last accessed on April 13, 2015)
[47] http://morrisjs.github.io/morris.js/ (last accessed on April 13, 2015)
[48] https://www.dropbox.com/developers/datastore (last accessed on April 13, 2015)

multiple users on the same display. Should this turn out not to be feasible approach, then questionnaires of different length could still be distributed based on metrics such as user involvement, or the chosen feedback channel. Users choosing a well-established and comfortable feedback channel, such as email, might be willing to respond to longer questionnaires, than participants in public. Another approach could be to track users across time and recognize returning users, in order to continue with the questionnaire where they last left off.

Getting a better understanding of public displays in general, and their design guidelines in particular, will also improve how to integrate questionnaires in public display deployments in the best way possible. Finding better design guidelines for the development of interactive applications will also be of benefit for this platform. Questions can include the influence of the environment, e.g. how personal questions can get in different public settings, or how much privacy the display should offer (the smaller the display, the more private the context seems). This is one assumption derived from the interview responses in our field study. The influence of the display size on parameters such as perceived privacy and security is an area of high relevance when conducting surveys in public. Other questions of interest might be what the ideal placement of the question itself on the screen is, how to best embed the survey (as a pop up, overlay, or full screen), how (un)obtrusive the design should be, or when to best interrupt the user from his primary task (before, during, or after).

Last but not least, getting better insights from through experiments in controlled lab settings on the effects of the content, context, environment and further parameters would be interesting. Being able to assess how many qualitative and/or quantitative questions can be posed, is of interest. Also getting insights into which question types are best suited for which feedback channel. One result of our field study was the importance of fast responses, when possible single-click interactions. Doing further research on these questions would not just improve the *PDSurvey* platform, but also lead to getting better insights into how surveys should be constructed.

7   Conclusion

Evaluating interactive applications on public display installations is as crucial as the development process itself. In this thesis we gave an overview of how other public display applications have been evaluated in literature, presented a categorization of standardized questionnaires, and introduced the *PDSurvey* platform. This survey platform allowed us to assess our research questions through a lab study. Our main research questions were which feedback channel is best suited for completing surveys in public and what motivated our users to participate. In the field study we offered the users four feedback channels to respond to the questionnaire. The options allowing users to respond directly in-situ were most popular. However, the tablet turned out to be more popular than the primary display (TV screen). The tablet was preferred due to its smaller form factor, better usability, and because responding didn't feel as public. Despite the additional effort for responding via smartphone or email, these feedback channels were still an option for some. Reasons stated for the smartphone were personal possession and habit, for email because of having more time, being able to do it at home, and better warranty of privacy. It is interesting to see that around a fifth of the participants chose an indirect and more time consuming option, even though they had the opportunity to use low effort input devices such as the tablet or the TV screen.

Our field study has shown that there is an area of application for surveys being conducted on public displays and that this approach can simplify and support the evaluation of interactive applications. Of importance is a fast interaction time and low-effort input technique. When scaling this approach to large display networks, the evaluation process of new interactive applications can be simplified. In order to gain good insights into why certain effects and differences arise in public display setups, it is vital to assess detailed information about the context of each application, allowing us to determine which characteristics cause certain effects. This aspect is also the point which makes our platform unique. We expect the number of interactive public display applications to increase in the future, and herewith also the demand for fast and easy evaluation of such. Why not utilize the interactive capability of todays public displays and use it as a direct feedback channel for quantitative evaluation? When running large display networks, this can be the first step towards a better understanding of the displays surrounding the environments and a faster problem analysis.

With this thesis we gained first insights into which feedback channels are suited for which context. We delivered a proof-of-concept for the evaluation of public displays to be executed on the displays themselves. The response rates were good (10%), especially since the attraction of participants was solely based on intrinsic motivation. We came to the conclusion, that using public displays for assisting in the collection of survey data is a viable approach and worthy for further research. With our work we addressed the issue of time-consuming public display evaluation and contributed to the systematic evaluation of public display setups. With the overview of standardized questionnaires for public display evaluation we hope to bring a benefit to research community.

Appendix

A Content of enclosed CD

1. $/docs/$ - Documentation of the PDSurvey platform

2. $/pdsurvey/$ - Source Code for the PDSurvey platform

3. $/pdemail/$ - Python Script for sending Emails from the Balloon Shooter Game

4. $/pdclient-static/$ - A copy of PDClient, the interface users saw

5. Google Docs -

6. $/interviews/$ - The audio recordings of all interviews conducted during the field study, including a transcribed version

7. $/thesis/$ - LaTeX version of the thesis

8. **TODO** noch einige Ordner mehr...

The source code and the documentation of the PDSurvey platform can also be found in the GitHub repository: `https://github.com/lukasziegler/masterarbeit/tree/master/docs`

B Papers Evaluating Public Displays

List of relevant papers, which include an evaluation of public displays.

TABLE: 1st column (paper), 2nd column evaluation (quantitative, qualitative, no evaluation)

TODO

TODO

TODO

C   Questionnaires for Field Study

LUDWIG-MAXIMILIANS-UNIVERSITÄT MÜNCHEN

Questionnaire for Participants

1. General information   Date: _____   Time: _____

Gender: male / female   Age: _____ years

Study field / work area: _____

Coming from: _____   Going to: _____

2. Feedback channel (1: PD, 2: Tablet, 3: Smartphone, 4: Email)

a. Which feedback channel did you choose? Why did you choose it?
     (1) on the public display
     (2) on the tablet next to the public display
     (3) via smartphone
     (4) via email

3. Awareness

a. At what point of time did you notice the opportunity to answer a survey?
     (1) before starting the game
     (2) while playing the game
     (3) after finishing the game / when the sign showed up

b. What was your motivation for approaching the display? _____

4. Experience

a. How often have you used this display before? _____

b. Which of the following devices do you possess?
     (1) Smartphone
     (2) Tablet
     (3) Laptop
     (4) Desktop PC

5. Other feedback

Questionnaire for Passersby

1. General information   Date: _____   Time: _____

Gender: male / female   Age: _____ years

Study field / work area: _____

2. Feedback channel (1: PD, 2: Tablet, 3: Smartphone, 4: Email)

a. Which feedback channel would you prefer for answering surveys?
        (1) on the public display
        (2) on the tablet next to the public display
        (3) via smartphone
        (4) via email

3. Why did you pass by

a. Did you notice the display?   yes / no
b. Did you notice the option to participate in a survey? yes / no

c. Why didn't you stop? _____

4. Experience

a. Which of the following devices do you possess?
        (1) Smartphone
        (2) Tablet
        (3) Laptop
        (4) Desktop PC

5. Other feedback

Semi Structured Interview
for passersby

Date: _____   Time: _____   Voice-Recording: _____   Group size: _____

1. Introduction

Do you also get so many surveys via email?
When do you usually answer them?

What is your motivation to complete a survey?

We are looking at Surveys on displays in the public.
How do you perceive completing a survey on a public display?

(optional: For Passersby)

Did you notice the *option to participate* in a survey?   Why didn't you stop?
What is your attitude towards completing a survey on a public display?
How many questions would you find acceptable on a public display?

2. Feedback channel (1: PD, 2: Tablet, 3: Smartphone, 4: Email)

Why did you choose channel _____ to complete the survey?

Which *pros/cons* do you see per channel? / Why would you use which one?

> 1: PD
> 2: Tablet
> 3: Smartphone
> 4: Email

3. Awareness

How did you get attracted to the display? Why did you approach the display?

4. General information

What did you just do? Where are you coming from / going to?
> coming form: _____
> going to: _____

5. Other feedback

D   Results of Field Study

Reasons stated for and against each feedback channel

TV Screen

Pro	Contra
	Display is too large (4x)
Most direct, immediate feedback (4x)	Everyone could watch me (2x)
I am already standing here (2x)	Feels too public (3x)
Seems easiest	That is mean, when the screen is so large
Requires less personal information	The keyboard on the display would have been too large and confusing
All on one device	Display is uncomfortable for reading long questions
I can use it without putting my glasses on	Don't feel comfortable standing in focus in such a large room
Seems to be the fastest option	The system is too innovative, that is why I wouldn't trust it yet
	Because of social desirability influencing my responses

Tablet

Pro	Con
The display is smaller and better laid out (5x)	
Better sensitivity / user experience (2x)	
It feels more private (2x)	
Because it is its sole purpose	
You are not in the way of others	Redundancy (2x), why do I need a tablet when I can respond on the T...
I am more used to it	Personal aversion (1x), he had bad experiences with tablets
Most interactive option	
Less people watching	
Because I expect a better input	
Requires less personal information	
More comfortable standing here	

Smartphone

Pro	Contra
	Too much effort (4x)
	Too indirect (3x)
	Requires more personal information (3x)
	I am not sure how complex and time-consuming it would be to set it ...
I use it most often	I don't know if I would know how to do it
It belongs to me	Too small display for comfortably answering surveys and long questi...
	Too cumbersome
	I would assume that I would have to install some sort of software
	Privacy aspect

Email

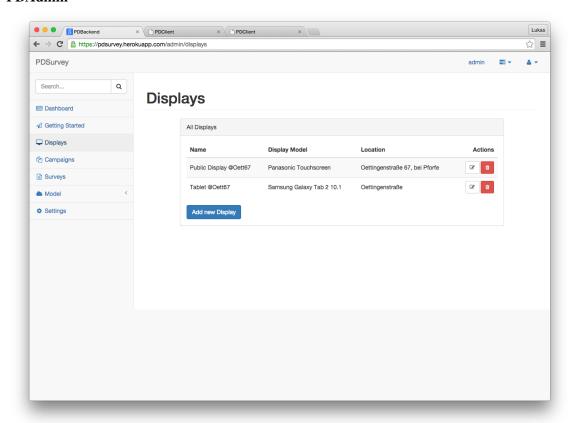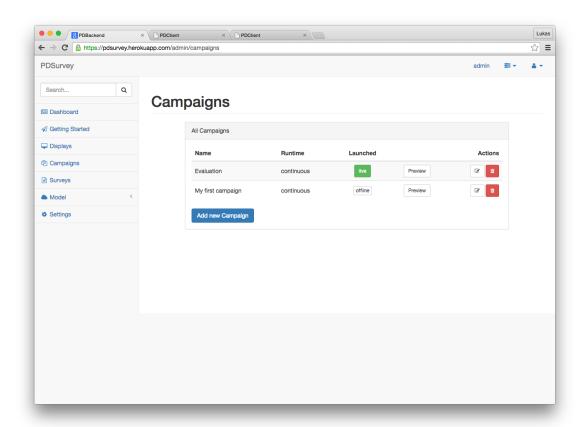| Pro	Contra
	I would forget about it (5x)
I can do it at home (4x)	I don't like to submit my email address (4x)
I have more time to complete the survey (3x)	I don't like to postpone it (3x)
Better warranty of privacy	It would take too long to complete (2)
I could deliver qualitatively better results	Too much effort (2x)
I wasn't sure which kind of questions to expect	Requires more personal information
	Too Indirect
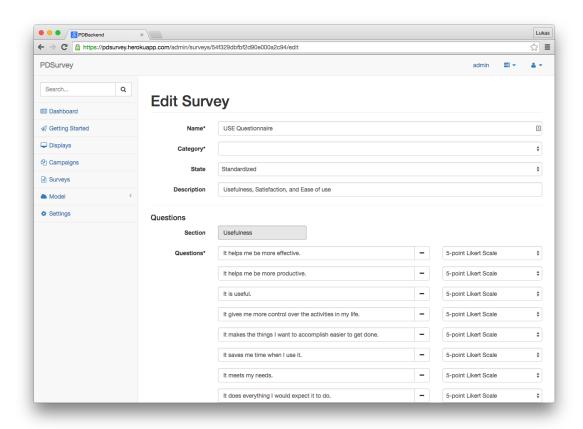
Table D.1: Reasons stated for or again each feedack channel
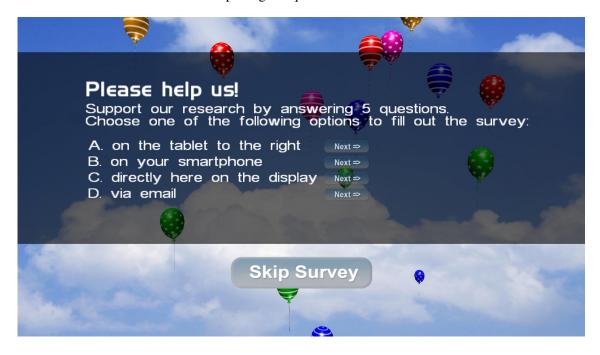
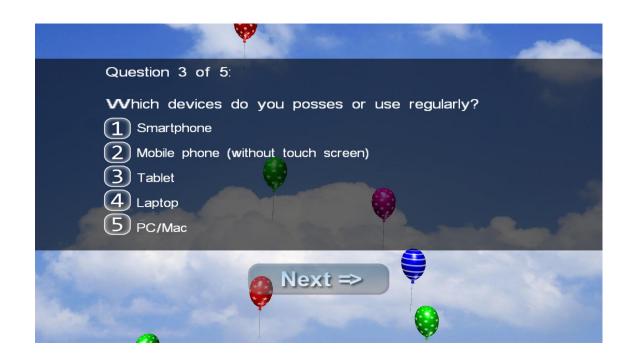# E   Screenshots of Platform

PDAdmin

The following screenshots originate from the Balloon Shooter game developed by Jiamin Shi.
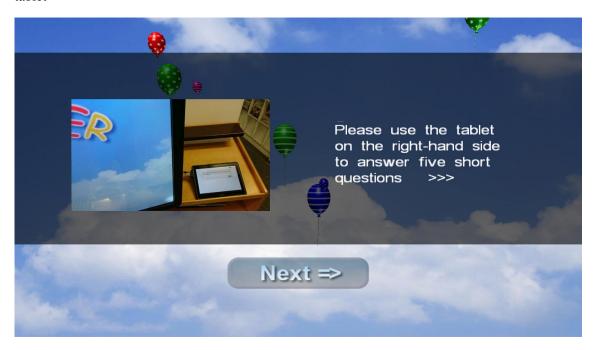
Options panel   Each user saw this options panel after completing the Balloon Shooter game. Four channels were offered for completing the questionnaire. The order was randomized.

Option: TV-Screen   directly answering on the TV screen. Here you see a sample question getting asked on the interactive display.

Question 3 of 5:

Which devices do you posses or use regularly?

1. Smartphone
2. Mobile phone (without touch screen)
3. Tablet
4. Laptop
5. PC/Mac

Next =>

Option: Tablet Option 2, the screen the user sees when choosing to complete the survey on the tablet

Option: Smartphone Option 3, participating with your own smartphone, either by scanning the QR code or by typing the URL in the mobile browser

Option: Email   Option 4, submitting ones email address and getting the survey link to participate in response.

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