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Masterarbeit

Design and Development of a Public Display Survey Platform

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Betreuer: Prof. Dr. Florian Alt
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Zusammenfassung

Kurzzusammenfassung der Arbeit, maximal 250 Wörter.

Abstract

Short abstract of the work, maximum of 250 words.

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, March 27, 2015

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Contents

Introduction and Theory

1 Introduction

1. nice introduction in paper: valkanova2014myposition

1.1 Motivation

Scope for the practical part of the thesis. What is the system supposed to look like. What is the current state of the practical work in research and in the industry. Which partners do we have, where do we want to deploy this system. What are the goals for this evaluation plattform?

1. What are public displays?
2.

1.2 Research Question

1.3 Approach

Benefits of PDSurvey plattform:

- being able to work with big data. collecting 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, having the ability to evaluate and compare the displays between each other. Interesting questions for analysis would be, which role the context plays on how the users behave, 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) – see Chapter 4: Modeling

1.4 Overview

1.5 Our Contribution

1. categorization of questionnaires being useful for the evaluation through automated public survey display platforms

2 Related Work

1. give an overview of related work
2. give background information to this thesis
3. describe the work of others, what have they done so far?

2.1 Evaluation of Public Displays

Ovweview of papers with a relevance for the construction of surveys for public displays.

Creating questionnaires for public displays

1. Jacucci: Worlds of Information (paper 25: `http://www.hiit.fi/u/morrison/chi2010.pdf`)

2.2 Conducting Surveys

- state how complex it is to administer / execute / conduct a survey or questionnaire
- encourage the motivation for creating a plattform like this!
- differentiate between surveys and questionnaires. survey = Umfrage, questionnaire = Fragebogen
-

2.3 Related Tools

Give an overview of other tools

1. give an overview of similar tools
2. LimeSurvey (`http://de.wikipedia.org/wiki/LimeSurvey`)
3. SosciSurvey/LMU (`https://www.soscisurvey.de/`)
4. TODO look for more tools out there
5. +Folgerungen aus anderen Bereichen (?)

and clarify what the difference is between the already existing approaches to my approach.

What is unique about our approach: That we will have the opportunity to conduct surveys across a broad number of devices (large displays, tablets, smartphones, desktops), since they all access the same platform via a RESTful API. Which allows the greatest possible coverage of display providers' public displays and end consumer devices.

2.4 Temp

1. Paper 25: *Worlds of Information: Designing for Engagement at a Public Multi-touch Display (von Jacucci)* liefert einen erstklassigen Ueberblick ueber die Evaluationsmethoden
2. Paper 106: *MirrorTouch: Combining Touch and Mid-air Gestures for Public Displays* (von Joerg Mueller) liefert den Stand von 2014
3. papers 23, 25: Best-practices / guidelines for designing good public display applications

3 Questionnaires

As a result of the literature review, besides getting a better understanding of how public displays were evaluated so far, a side effect was 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 ...

TODO: think about the common theme, maybe rename this chapter

3.1 Approach for Collecting Information

The procedure for the selection of papers to review, was as follows. As a starting point all papers, which are in the appendix of Florian Alt's doctoral thesis [1] were read, to get a first overview. Afterwards interesting related work and citations were followed based on the papers from the previous step. This was supplemented with targeted research on Google Scholar based on the following keywords: **TODO TODO TODO**. A full list of all papers reviewed can be found in Appendix, section D.

The analysis of the appendix was fairly straight forward. All papers were read from start to finish (pages 335 to 343).

The second step, pursuing related work and citations of interest, was carried out in a more subjective manner.

searching for "Standardized Surveys for Usability / User Experience"

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 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 papers 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 evaluating public displays were saved locally and analyzed in more detail. For Jörg Müller the best list of his publications were found on his personal website[1], and for Marcus Foth two websites were evaluated [2].

3.2 Categorization

As a result of the literature review process the following overview of questionnaires arose.

Categorization of all the question and questionnaires found in literature, during the review process.

Clustering of question types

Constructing a unified/standardized Questionnaire

5-point or 7-point Likert scale http://www.measuringu.com/blog/scale-points.php

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

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

Categories	**Description**	**Types of Questions / Questionnaires**	**Papers / Links**
Usability			
User Experience			
Awareness			
Social Aspects & Collaboration			
Expectations & User Goals			
Motivating Factors			
Motivation (reactions to the display)			
User Engagement			
Privacy			
Demographics	User Information, Background Questionnaire, Getting to know the User		
Multi-User Interaction	Parallel Use		
(Information Sharing)			
Interaction Context	Let the user assess in which context the survey took place		
Comments	Leaving room for general feedback		
Misc	Whatever I forgot or doesn't fit into any of the previous categories.		

Categorization ... table notes

Table 3.1: And here is the long caption for this table, going more in detail.

3.3 Standardized Questionnaires

During the literature review phase a comprehensive list of widely used questionnaires was assessed. A first overview of other people's summaries can be found here

1. `http://2013.hci.international/index.php?module=pagesmith&uop=view_page&id=44`
2. `http://edutechwiki.unige.ch/en/Usability_and_user_experience_surveys`
3. `http://chaione.com/ux-research-standardizing-usability-questionnaires/`
4. `http://www.cheval-lab.ch/was-ist-usability/usabilitymethoden/frageboegen/`
5. `https://docs.google.com/document/d/1D925jJ7bmRc1EZdCTz32lmW2hniMiq7GzBWxX8rmhpE/edit`

And later state which ones I chose to use and why.

In the following a full overview of all standardized questionnaires found in literature can be found, grouped by superordinate categories.

BRING A TABLE WITH ALL OF THE QUESTIONNAIRES, A SHORT DESCRIPTION, THE DATE, THE NUMBER OF QUESTIONS, THE REFERENCE HERE

3.4 Findings

Findings: 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)

In the following chapter we will talk about ...

4 Implementation

In this chapter we will deal with the infrastructure and technical realization of the public display survey platform. First off, we will start with the requirements for the survey platform (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 4.3.5). For more specific information and for information regarding maintenance of the project, please refer to the Documentation found on the CD enclosed or on the GitHub repository (see Appendix B).

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

The starting point for the PDSurvey platform and the Master's thesis itself was the official announcement[3], describing the scope of the thesis. This problem statement already included first requirements for the survey platform to develop, and was also a trigger for further literature research and talks with people from the industry.

1. development of a survey tool that allows interactive public display installations to be comprehensively assessed
2. a web-based survey platform will be implemented 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 also via a smartphone or tablet.
4. configuration options for public display owners

Additional requirements, dervived from the previous and complemented with additional ones, 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)
- create an **open research platform** (host project and documentation on GitHub, release it as open source, publish and invite fellow researchers)
- allow for both **quantitative and qualitative** metods of data collection

These derived requirements had an impact on the chosen architecture, which will be discussed in the following.

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 software, programming language and frameworks to use, before starting with the practical implementation of the platform.

[3] `http://www.medien.ifi.lmu.de/lehre/arbeiten/detail.xhtml-php?pub=alt_pdsurvey` (accessed on March 24, 2015)

Two weeks were taken for assessing all of the possibilities, on the one hand to get informed again what is buzzing, on the other hand because every choice also has a significant impact on the later architecture. Changing a technology in between would not be a smart choice in such a short time-frame.

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[4], but also because it can be used on the largest number of devices. Furthermore another huge benefit, only having to use JavaScript on all tiers, from client to server to persistence layer.

This approach has become very popular in recent years, now often being 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[5]. Additional, the feedback from the industry contacts also played a role.

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. With Javascript it is possible to work with the same object model and easily keeping it consistent across all platforms (backend, frontend, server).

Based on these requirements and the feedback received from industry experts, a choice towards Node.js and to fully go along with MEAN stack was self-evident.

Frontend The next question to be answered was which technologies to use in the frontend, leading to the question whether to follow the single-page application approach or not. As of 2014 the JavaScript model-view frameworks most frequently used for creating single-page apps are Angular.js, Ember.js and Backbone.js. Purely based on numbers Angular.js is the clear favorite, it has by far the largest user base on GitHub, Stackoverflow, and Youtube[6]. 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 making good progress for beginners. These were amongst other things the reasons why we chose Angular.js for this project, since the desired requirement is also for other students to further enhance the PDSurvey platform in the future.

- two-way data-binding, syncing, templating, being able to create your own html-tags with custom directives.

To speed up frontend development we chose Bootstrap[7] 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 integration with Angular.js (AngulatStrap[8] and AngularUI), and its short training time. Alternatives considered were Foundation Framework by Zurb, however at the time of writing there was no prefabricated integration for Foundation and Angular.js. A good overview[9] and a comparison[10] of currently popular frontend

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

[5] `http://www.ibm.com/developerworks/library/wa-mean1/index.html` (accessed on March 26, 2015)

[6] `https://www.airpair.com/js/javascript-framework-comparison` (accessed on January 11, 2015)

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

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

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

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

frameworks was also considered.

Backend For the backend it was most important to have a solid and scalable solution with good performance, since our system might need to scale in the future, having a multiplicity of clients attached to the survey platform, all submitting responses and querying for different questionnaires. Additionally an administrator interface and easily being able to exchange data with all clients was of importance. For this reason a backend built solely on the principles of a RESTful API was preferred, being able to use the same data on no matter which platform.

Based on the decision to use JavaScript for all tiers, it was clear to also use Node.js as the underlying platform for building web applications. Reasons speaking for Node.js are its scalability and modular approach, only requiring the parts needed for your project. Another benefit is the easy implementation of authentication or internationalization, due to the concept of middlewares [11].

(Discussion of pro/con Node.js: http://www.heise.de/developer/artikel/2x-Nein-4x-Ja-Szenarien-fuer-Node-js-2111050.html)

The question which web framework to use for Node.js was not as straight forward to answer. A list of current options being Express.js, Conncet, Koa and Restify.

+ say which one I chose why

To facilitate the object modeling process Mongoose[12] was chosen. Mongoose is a object modeling package for Node.js, allowing to model the application data based on schemas. This simplifies making incremental changes to ... and keeping the model synchronized across all layers. Mongoose also takes care of performing CRUD applications.

Due to the decision to build 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, however leading to an increase of data overhead, more logic on server.side, and the loss of statelessness.

Should a component not support HTML or JavaScript execution, then the required surveys can still be communicated directly with the REST API through rudimentary HTTP function calls, being another benefit for using a RESTful API.

Database Another fundamental aspect presented the question where to store the data persistently. Criteria for choosing the right database management system (DBMS) for this project were again the size of community, suitability for prototyping, and ease of integration with Node.js/Angular.js.

The first question presented whether to choose a SQL or a NoSQL DBMS. Because NoSQL is better for rapid prototyping, its Schema can be mixed inside of one collection and develop over time. Combined with the benefit of having a better scalability, a schemaless data representation, faster response time and a decreased development time [4], these are all reasons speaking for using a NoSQL DBMS for our scenario.

Out of the NoSQL databases MondoDB[13] represents the most popular DBMS, especially since it integrates seamlessly into the MEAN stack. With the help of Mongoose, a object modeling package for Node.js, performing CRUD applications on MongoDB and maintaining a solid object model (schema) gets even easier.

Benefits of MongoDB are being non-relational (and schemaless), plus its ability to directly store JavaScript object inside the database, being the biggest advantage. 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.

[11] `http://www.heise.de/developer/artikel/REST-Webservices-mit-Node-js-Teil-1-Connect-als-Fundament-1802258.html?view=print` (accessed on November 24, 2014)

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

[13] `http://www.mongodb.org/`

Alternatives looked at were CouchDB and Redis[14]. Redis being useful for fast changing data, which is not the case for our platform. CouchDB would be an alternative worth looking at, having a better replication and conflict resolution. This additional securitry is however not needed. The speed benefits of MongoDB, also being able to make dynamic queries, are preferred.

Hosting For the hosting of the platform a free and easy scalable solution was of importance. Our first choice was Heroku[15], due to its simplicity of setup, its native support of Node.js and the seamless integration with Mongolab[16], hosting our MongoDB.

Alternative were Google App Engine, IBM BlueMix, Amazon Web Services (Amazon EC2) or hosting everything on local or virtualized machines at our university. However for our scenario all of the above options had their drawbacks in comparison to Heroku. Google App Engine (as of December 2014) still had no native support for Node.js and custom runtimes had to be used to get Node.js support up and running. IBM BlueMix just got overhauled, offered full out-of-the-box Node.js support, however they only the first 30 days were free and the pricing model wasn't as attractive. Amazon Web Services offering a Infrastructure as a Service (IaaS), would have required too much administration of the server, which would have slowed down the main objective of the project, the development of the survey platform. 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.

MEAN In the end, as already predicted in the beginning, it turned out to be the classic MEAN stack.

The clear benefit, being able to use JavaScript from client to server to persistence level.

+ a fantastic short recap of the the last ten years of web development with an introduction to the MEAN stack, also explaining what the differences are between traditional web development (using the LAMP stack), to using the MEAN stack: `http://www.ibm.com/developerworks/library/wa-mean1/index.html` (accessed on March 26, 2015)

[14] `http://kkovacs.eu/cassandra-vs-mongodb-vs-couchdb-vs-redis` (accessed March 26, 2015)
[15] https://www.heroku.com/
[16] https://mongolab.com/

4.3 Modeling

The model for the *PDSurvey* platform is maintained with the help of the Node package Mongoose. Node.js maps the route parameters and routes all requests to the corresponding Mongoose model. Angular.js builds its model upon the REST API and maps it via dynamic two-way-binding to it's scope. Thus all changes to the model originate from Mongoose.

4.3.1 Development Process / Modeling

The development process of the PDSurvey platform was inspired and influenced by the following approaches:

- working agile and user centered... TODO: look up how to best explain it.
- User Centered Design: (paper nr 31): "constitutes an iterative process of system design, deployment and evaluation" (quote from paper 31). Work iteratively, continuous deployment and evaluation.
- Concept of extreme programming[17]: First user stories were written and assessed in a small group. 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, getting more specific. Dependencies between models were defined and this model was continuously refined and improved throughout the dvelopment phase. The last step of the modeling represented screen designs, getting a clear view of what the interface might later look like.
- Used the extreme programming[18] approach: user stories, release planning, release schedule, small releases, iterating
- criteria for good user stories: http://tigertechtalk.wordpress.com/2012/10/17/wie-schreibe-ich-eine-gute-user-story-und-was-ist-das-uberhaupt/

4.3.2 User roles

As of now only two roles are implemented, the admin-role and the guest-role.

In the long term it would be desirable to have the following user roles: Admin, Operator, Evaluator, DisplayApplication.

4.3.3 Software model

In total there are the following classes.

1. list all classes
2. 1 UML diagram is enough, according to Florian

4.3.4 Dependencies

Of special interest are the following four models: Survey, Display, Campaign and Responses.

[17] `http://www.extremeprogramming.org/rules.html` (accessed on November 14, 2014)
[18] `http://www.extremeprogramming.org/rules.html` (accessed on November 13, 2014)

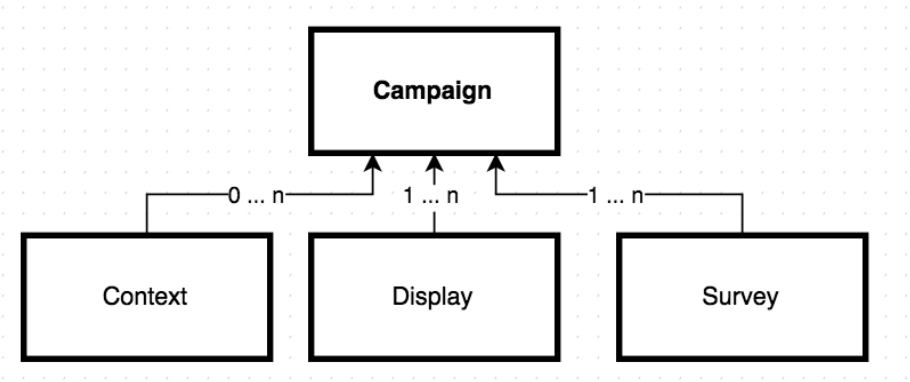

Figure 4.1: Campaign model dependencies

Surveys: Surveys resembles the foundation of PDSurvey, with the aim of reuse and standardization. A survey consists of multiple sections, being built of of multiple questions. Each question is of a corresponding question type and every survey belongs to a category. This allows the filtering for relevant surveys. To be able to create private surveys, not being shared across the entire platform, every survey is assigned to an individual user.

Displays: In the display collection all displays connected to the PDSurvey platform are contained. To allow for an evaluation across multiple display models and based on the context of the displays, the display model and a static and/or dynamic context is assigned to every display.

Campaigns: Campaigns resemble the most integral part, since they glue all of the pieces together and allow the distribution of surveys to public display networks. A campaign consists of displays and surveys and creates the mapping of the questionnaires to public displays. Additionally to each of those mapping an individual context can be assigned, enabling the later comparison of results in between the public displays.

Responses: All responses made to each survey are logged in the Response collection. The queries are carried out individually per user, per display and per campaign. This model will be the base for further extensions, amongst others the automatic evaluation of the survey responses and the comparison inbetween an entire display network, to be able to find out which properties of a display might be related to certain effects.

Context: One of the benefits of creating such a survey platform is being able to collect and evaluate large amounts of data, without having to pay more people for conducting and evaluating the survey. The idea would be 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, having the ability to evaluate and compare the displays between each other. Interesting questions for analysis would be, which role the context plays on how the users behave, 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).

++ neue Namensgebung, um in der domain specific language zu bleiben –> application provider / display provider / space provider (anstatt Operator). Wir werden aber nur mit dem Application Provider (anstatt Operator) im System arbeiten

4.3.5 REST interface

Defining the REST API.

Notes from before I started writing

1. Think about using a Extreme Programming approach http://www.extremeprogramming.org/rules.html

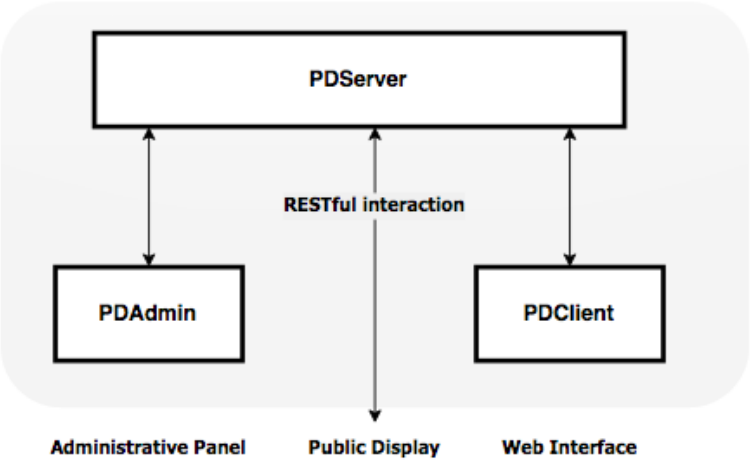

Figure 4.2: Overview of the PDSurvey platform: (a) PDServer containing the Node.js server, (b) PDBackend the Angular.js frontend for administrators and (c) PDClient the interface included on public displays and optimized for mobile devices.

4.4 PDSurvey Platform

+ describe what it is about + describe the main goals / ambitions

The architecture for the public disply survey (PDSurvey) platform can be split into three main sections: 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* encloses

1. begin with describing what the platform does, which views it has (show screenshots).

2. describe the client

4.4.1 PDAdmin

For administrative purposes we created an admin interface, 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 (introduced in section 3).

advancing > modular aufgebaut

All data and actions get transmitted to the server via HTTP request/response calls.

4.4.2 PDServer

PDServer makes a relatively simple impression. It consists of a Node.js server, which to the outside only acts as a REST server. Processing REST calls, performing CRUD operations and responding with JSON objects. 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

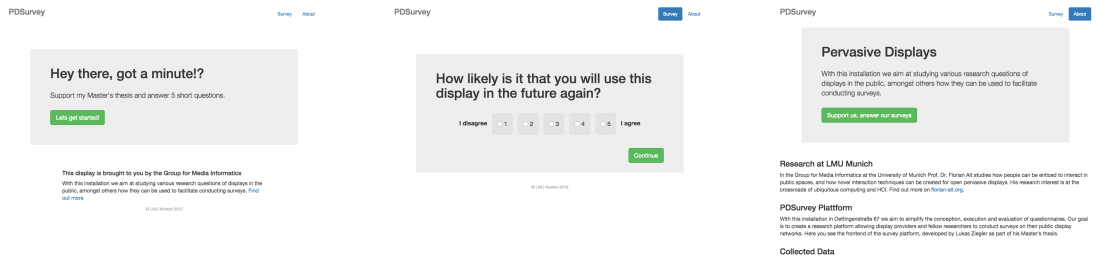

Figure 4.3: PDClient: (a) Welcome Page, (b) Survey page, (c) About page

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 in the documentation (see Appendix B).

4.4.3 PDClient

Our client tool was kept as simple and minimalistic as possible. It is running on a separated code base than PDBackend, the only communication between the two is via REST, exchanging JSON objects. Reasons for this were on the one hand reduction of the application size, on the other hand different requirements for constructing a PDAdmin interface for a limited number of users, compared with PDClient, being embedded at large scale.

The goal is to reduce logic and complexity on client-side. Currently PDClient is implemented as follows: The client either receives all questions for the questionnaire (caching the questions), or it loads just the next question on-demand. For this purpose the REST interface provides the /nextQuestion API is provided. For production use one sub-page per campaign gets created, individualized via the campaign ID.

PDClient has three main components (see Figure 4.3). The principal part being the *Survey page*. All questions are loaded at once on initial startup, then one question gets displayed at a time. Settings for the survey can be modified in the 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 employees from university gave feedback to us regarding the public display installation, prior to the beginning of development for the PDSurvey platform. They said they were skeptical and had doubts regarding the research project, when having no information whatsoever regarding 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 doesn't take long, the research is university-related and that it will be used for a Master's thesis. These arguments were amongst others stated in semi-structured interviews, carried out as part of the field study (see chapter 5).

4.4.4 EmbedCode

The embed code, JavaScript Code Injection, turned out to be a pure proof-of-concept, since it was not needed for the field study at the university. The problem was that the application on which PDSurvey should be integrated did not support any HTTP calls, thus we had to fall back on another solution. This embed code was intended to be used by display operators, wanting to include optional questionnaires hovering over their normal application.

An example use case is exemplified here ...

The implementation is quite simple. - giving one unique line of JavaScript code to the display provider - add it to the end of the HTML body tag - this minified one-liner adds a HTML script-tag to the DOM, - loading a personalized JavaScript file from the PDBackend - jQuery and/or Angular.js get loaded asynchronously - a copy of PDClient gets dynamically built on client side - all questions for the questionnaire get loaded via REST API from the server - and the responses get sent back to the server for logging

Useful links can be found here:

https://developers.google.com/analytics/resources/concepts/gaConceptsTrackingOverview

http://en.wikipedia.org/wiki/Web_bug

http://stackoverflow.com/questions/3534524/how-does-the-embedded-google-analytics-javascri

4.4.5 Feedback Channels

As of now PDSurvey offers a ready built survey tool for all devices being capable of running a browser and displaying the PDClient website. Thus a large number of feedback channels is conceivable. For our scenario these were a tablet, smartphone, and laptop/desktop. Integrating PDClient on a public display itself is also no problem, as long as the public display application is a web application itself (embed code), or it supports embedding a browser window on top of the application.

In case that the application does not integrate well with a web page being displayed on top of the actual application, then a custom integration needs to be built making use of the REST calls. All REST calls needed to receive the questionnaire and send responses to the PDSurvey platform (in JSON format) can be found in the documentation (see Appendix B).

4.4.6 Future Work

Authentication: using passport, HTTPS was not offered in the beginning. As of now it is not needed, since we only had one client. All REST Update and Delete functionality was restricted to the URI of the PDServer, which is also the desired approach in the production setting.

Evaluation of results: dynamic queries, information visualization

Context: refine the Context model and build the evaluation of the responses based on the Context model, assigned to each and every display and/or campaign.

Unit testing: not done yet

5 Field Study

The field study took place during the first two weeks of March, from 3/3/2015 to 3/15/2015 in a faculty building of Ludwig-Maximilians-University Munich. Data was collected on 14 consecutive days and personal semi-structured interviews were carried out on five working days during the same two weeks. A total of 117 interactions were registered with the application installed on the public display and 58 survey responses were recorded.

The goal of this study was to validate the previous thoughts, get better insights into our research questions, and to see how users respond to questionnaires being conducted on displays in the public.

5.1 Research Questions

One of the main reasons why we performed this field study was to get a better understanding of our assumptions and hypotheses. Especially since there is often a discrepancy between what one assumes and what can actually be observed in real world. This phenomena has already been stated in the publication by Ojala and Kostakos in 2011: “Introduction A common criticism targeted at many studies on interactive public displays is that their evaluation usually takes place in non-realistic lab environments, and for short periods of time. Thus, a long-term real- world deployment could be a more appropriate evaluation.” [2].

The assumption we made for the development of our first research prototype of the PDSurvey platform is 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 the hypothesis to multiple more fine-grained statements. The claim, whether the PDSurvey platform facilitates the conduction of large-scale surveys in public, will be evaluated in the following chapter (see chapter 6).

What we will evaluate in the scope of this thesis, are the following research questions:

1. Which question types are best suited for questionnaires carried out in public? How should a survey be constructed to take best advantage of the PDSurvey platform? (quantitative vs. qualitative)

2. Which channels are most suited for completing surveys (on a digital platform) in public?

3. (assessed between the lines) What motivated our users to fill in surveys?

Research questions which would go beyond the scope of this thesis, and might serve as follow-up questions for further research are gathered here:

- In which situations is the user most willing to answer surveys on public displays?

- (not really copious): how many questions are acceptable, the attention span would be of great interest

- (not really copious): how the users noticed / perceived the survey

- (Not treated): where to position the survey on screen. As stated in a paper by Jörg Müller ... TODO reference it TODO ..., the best position on large public displays is directly in the center (not at the bottom, not at the top, close to the center). The larger the screen is, the more relevant a centric positioning will get.

- (Not treated): The influence of the environment on which question types are suited, how personal the questions can get, how much privacy the display should offer (the smaller the display, the more private the context seems)

- (Not treated): How can we best break down a standardized survey with 10+ questions and spread a subset of the questions across multiple users?

In addition to these questions we were also interested in user stories, in the feedback real-world users gave us in regards to answering surveys on screens in the public. For this reason we also conducted semi-structured interviews in parallel to the quantitative evaluation of the PDSurvey platform.

5.2 Study Setup

Both quantitative and qualitative data was gathered as part of the field study. Quantitative data was obtained through the PDSurvey system and qualitative data was collected through semi-structured interviews. To facilitate comparison between quantitative and qualitative data some quantitative questions were asked redundantly at the end of the semi-structured interview.

5.2.1 Design

Our primary goal was to find out which channel the users preferred, the questions they had to answer in the questionnaire played a secondary role. The survey displayed on all four channels contained the same five questions.

- How often have you used this display before? [number]
- How likely is it that you will use this display in the future again? [5-point Likert scale]
- Which devices do you possess or use regularly? [multiple choice with 5 check boxes]
- In which area do you study / work? [text field]
- What was your motivation for approaching and using this display? [text field]

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: numerical question, Likert scale (single click), multiple choice (based on check boxes) and two text fields for an undefinied length of the response. To increase the motivation for participation we stated that the questionnaire consists of five questions, will only take one minute to complete and is for the Master's thesis of student at LMU Munich (see figure 5.1). As proven by Richard Ryan in his self-determination theory [3][19], this additional intrinsic motivation increased the participation and acceptance rate of the public survey additionally.

To find out more about the motive we carried out semi-structured interviews on location.

THIS PART outlines the formal structure of the study. identifies the experiments dependent and independent variables. also state here which study design I have chosen: 1 independent-measures, repeated-measures, mixed-design

1. provide an overview of the overall structure of your experiment.
2. what were the independent variables in the study? what were the factors that I manipulated? » none!
3. how many conditions were there: ... i would say none, since I didn't vary any parameters
4. describe what was measured, what were the dependent variables?
5. »> I would actually say, that I didn't carry out any experiment, I only made an observation with evaluation. I didn't vary any parameters, I only configured a study setup and observed + interviewed the participants

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

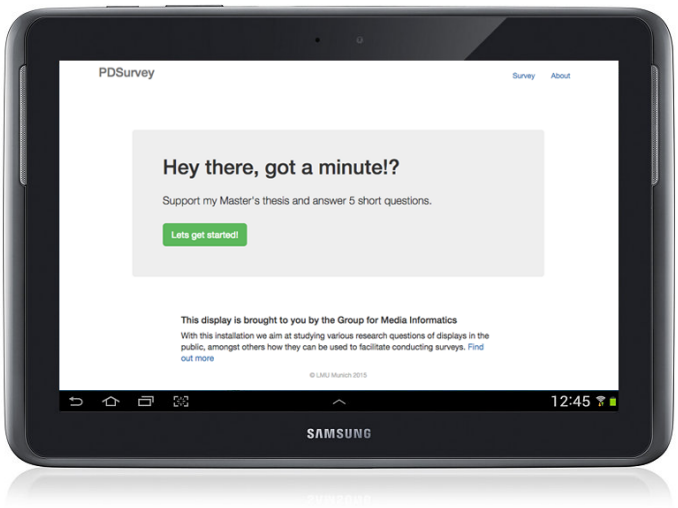

Figure 5.1: PDClient: Motivating users to participate in a short questionnaire

5.2.2 Participants

In total 54 questionnaires were completed and 28 semi-structured interviews were conducted during the two week study period.

Questionnaires were completed by a random number of people with different backgrounds. What they all had in common was their affiliation to LMU Munich, either because of being a student, staff or otherwise related (parents, pensioner, industry partner). Since our research focus was on finding which feedback channel is best suited for conducting automated questionnaires in public, we only included one question to collect demographic data. Based on the fourth question (In which area do you study / work?) it can be seen, that most of the participants are doing something related to computer science. +++ describe the rest of the data, refer to a table +++ ... 54 submissions, 43 non-empty submissions which could be assigned to a study field.

For the participants in the *semi-structured interview* demographic data was also collected. Out of the 28 participants 20 were male and 18 were female. The age of all people interviewed ranged between 20 and 69, with an average age of 31,5 years. Due to the wide variety of faculties and the public library located in the building, various technical backgrounds were present. Two retirees, three workers and 23 students were interviewed. The study fields which were most frequently represented are computer science (4), japanology (4), ethnology (3), political science (3). Besides that students studying sociology, communication science, law, physics or engineering were interviewed.

1. give details on how many participants you used
2. how many took part in which condition
3. include information about demographic values (age, gender)
4. also deliver brief details on how you obtained the participants: they didn't get any reward for participating. XX were passerby, XX participated in the game from their own motivation.
5. describe the population of my participants. what was their background?
6. Before starting the interviews the people participating and passing by were asked whether they noticed the option to fill in a survey, and XX out of XX didn't notice the option.

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

Sample description underneath the table.

Table 5.1: Demography for the survey data (left) and the semi-structured interview (right).

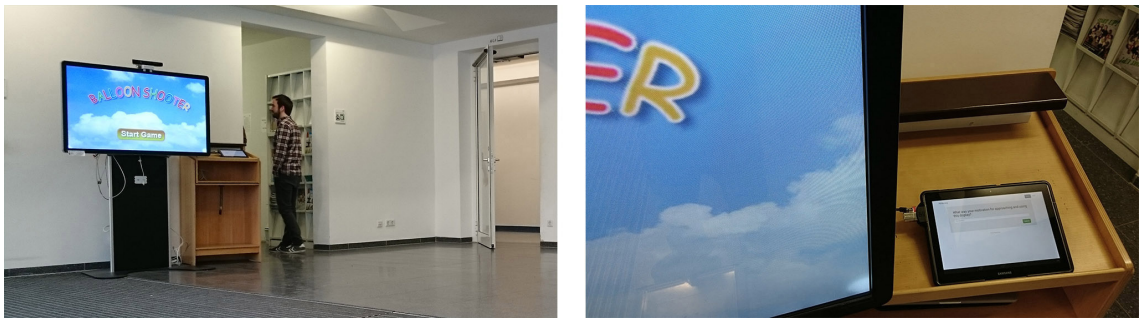

Figure 5.2: Overview of the study setup in the entrance hall of the faculty building.

7. think about which information is relevant. for me the devices they possess might be of relevance. people not possessing a smartphone or tablet, might be less willing to use these devices.

In regards to the semi-structured interview the participants can be differentiated into 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). To increase the amount of feedback, we approached people from all three groups. The distribution between the group was as follows: 9 direct participants, 17 passerby (XX observed, XX didn't approach it) The number of surveys was not explicitly increased thereby.

5.2.3 Apparatus

The apparatus consisted of a XXX-inch TV screen, a Samsung Galaxy tablet, two questionnaires (one for participants, one for passerby), a voice-recorder (smartphone), and the client of the PDSurvey platform installed on the TV screen and on the tablet. The TV screen and the tablet to the right of it (see figure 5.2) were there permanently, the other devices only while conducting semi-structured interviews.

Our object of investigation was the TV screen with touch support, running an interactive *Balloon Shooter* game. After users completed the game, they were asked via a notice inside of the game to fill in a questionnaire on one of the four provided feedback channels.

Each user had the opportunity to respond directly on the TV display (1), on a tablet to the right of the big TV (2), via their own smartphone (3) or via email (4). The first option was embedded directly into the Balloon Shooter game, offering a consistent UI and the most direct feedback channel. Choosing the tablet as an option, the users were prompted to move to the right and to answer five questions on the tablet. The Samsung Galaxy Tab 10.1 was displaying the responsive frontend of PDClient, being enclosed in a Android Kiosk App, namely KioWare Lite[20]. Choosing the option to use a smartphone prompted the user to either scan a QR code or to access a URL. The last option consisted of an input field embedded into the Balloon Shooter game on the TV screen, asking the user to enter their email address. The address was logged from inside of the game to a txt-file which was scanned every 5 minutes by a Windows task scheduler. For sending the email via SMTP a Python script was used[21].Screenshots of all four options can be found in the Appendix on page 35.

For this quantitative part of the evaluation the following data was logged for all four options: 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 (measured via timeout).

For the evaluation in the field study itself 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 section 3. The questionnaires used can be found in the Appendix.

More information regarding the Balloon Shooter game can be found here XXXXX. 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.

5.2.4 Procedure

= Is this section equivalent to the method section?

MY FIRST NOTES FOR WRITING

The field study consisted of a two week gathering of log data. During this time we recorded ...

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 getting indirect feedback from users observing but not approaching the display. 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 with the new setup 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 () see screenshot E.1. This observation is very much in line with the findings of Richard Ryan and Edward Deci published as the self-determination theory [3].

1. How I introduced the scenario to the passerby. Imagine you are in a shopping mall or at an airport using one of those large displays to find some information. In the end you get asked to answer a short questionnaire. (How would you react to it? And to the more qualified students with the right background I also asked how they would feel when getting asked quantitative or qualitative data. / KW-student)

META-INFORMATION FOR THIS CHAPTER

1. This section gives details of how you carried out the experiment in practice.

[20] http://www.kioware.com/android.aspx

[21] https://github.com/lukaszieglerpython-send-mail

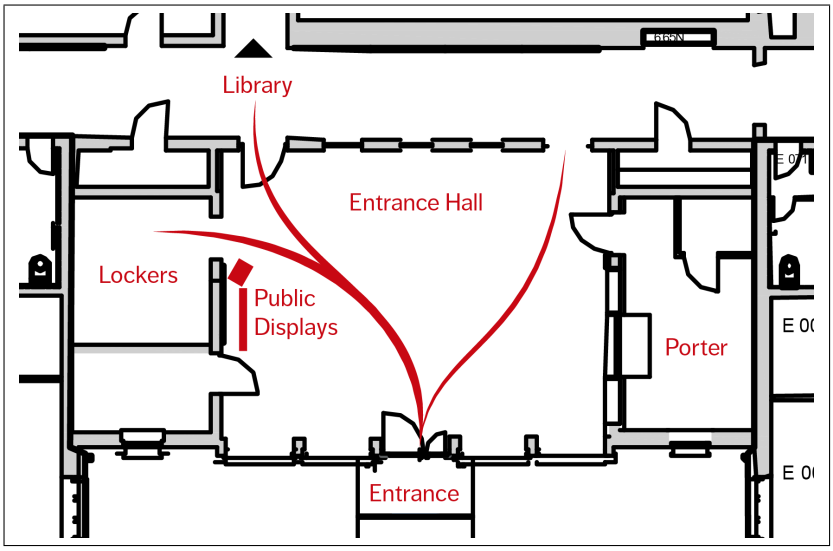

Figure 5.3: Floor map of the entrance hall where the field study was carried out. User paths, and the surrounding environment including facilities such as the library can be seen here.

2. Describe how you executed your experiment. How you approached the scenario, what you did, which parameters were measured and which conditions/parameters were changed?

3. how long were the interviews? 2:30 to 4 minutes

4. which instructions were given to the participants? none!

5. + state how we motivated the users to participate: only 5 questions, results are for a MA thesis

5.3 Not sure where it belongs to

5.3.1 Location

All parts of the field study were carried out in the faculty building for computer science, a building where other 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 5.3 shows an excerpt of the universities floor plan for the entrance hall, allowing for a better understanding of the dynamics.

- which path users choose - that they are usually in a hurry - having a break - or waiting for somebody - facilities near by are: the library, smoking area outside, toilets, lockers

5.3.2 Limitations

1. the tablet was always on, it was possible to approach the tablet directly without having the option to participate in the survey via smartphone or email.

2. the novelty effect played a role for the first part of the evaluation. It was striking to see a response rate of 50 percent. If we exclude all participants who directly accessed the tablet and skipped the appeal to use one of the four options, there was still a response rate of 10 percent.

3. all questions were optional, since we wanted to see if people are less willing to respond to certain question types.

5.3.3 Conditions

No conditions were present, since not a real lab experiment with different conditions was conducted, but a study observing how the user responded to one setting, having four options to fill in a survey:

1. on public display
2. on tablet, next to the large TV display
3. via smartphone:
4. via email, from home:

5.3.4 Methodology

5.4 Results

5.4.1 Quantitative Results

We received a total of 57 filled in surveys, submitted via all four provided feedback channels. The majority of the surveys were submitted directly on the tablet (87.72%).

Regarding the demographics of the participants only the occupation of each participant can be derived from the questionnaire. As far as was indicated, all people playing with the game in our scenario were students. Majority of people interacting with the TV screen study informatics (23.8%), followed by political science (14.3%), japanology (11.9%), anthropology (11.9%), cultural science (9.5%), and business (9.5%). Table 5.1 shows a full list of which study field or work field the participants specified.

The likeliness to use the tablet again for further

> for the large TV screen a much smaller number survey responses were recorded, the overall likeliness for using the display again was much higher (average=4.5, median=5, SD=0.87).

On average 2.4 devices were

The following combinations were most frequent: 12 smartphone, tablet, laptop 12 smartphone, laptop 6 smartphone, laptop, desktop 3 only smartphone

When looking at an aggregated version, allowing the clustering of subsets in between patterns, than the laptop (PERCENTAGE) is the most popular device: 34 smartphone + laptop (possibly combined with other devices) 18 smartphone + tablet 15 tablet + laptop 12 smartphone + desktop 10 laptop + desktop

Overall, the majority of the people participating in the survey already owned a smartphone (79.3%)

42 smartphone (79.3%) 10 feature phone (18.9%) 22 tablet (41.5%) 39 laptop (73.6%) 13 desktop (26.4%)

A total of 28 semi-structured interviews were conducted, of which 72.4% of the participants were male and 28.6% were female. The average age was 31.5 years, with an age distribution ranging from 20 years up to 69 years (median=25.5, SD=13.2). 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.

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 informatics (16.7%), japanology (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).

Based on the interview data, the The most interesting feedback channel for B
FROM DATA 30.7746.1515.387.69
FROM INTERVIEW 32.14% 42.86% 7.14% 17.86%

From Survey Data		**From Interviews**
30.77%	on public display	32.14%
46.86%	on tablet	42.86%
15.38%	on smartphone	7.14%
7.69%	at home / via email	17.86

Table 5.2: Preferred feedback channel for answering surveys.

Pretreatments

1. crossing out any unwanted / distorting data (e.g. the person in pension, who didn't participate, but only argued)
2. making changes to the data

give the reader a clear idea of what you found!

1. For a good SAMPLE of how to list the basic population (x male, y female) of the survey, have a look at paper number 25 from the Appendix. (WIP)
2. describe the results from the evaluation
3. e.g. 1) prefered feedback channel, 2) number of acceptable answers, 3) preferred setting
4. say which implications this gives for the PDSurvey research platform

The first question (numeric) was completed in all surveys.

5.4.2 Qualitative Results

ASK WHETHER I SHOULD COMBINE THESE TWO SECTIONS

5.5 Discussion

1. (summarize the expert interviews)
2. summarize the quantitative results
3. summarize the qualitative results
4. TODO: think about what my evaluation has to do with my platform. make sure that this link is clear! Make this link clear in the following summary.

1. **questions in the public /** 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.

2. 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 an open end. 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.

3. and in regards to the **feedback channel**, no clear recommendation can be made. 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 last group choose 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".

4. and regarding the **display size**: the smaller the display, the safer and more private they 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.

6 Expert Interview

OPTIONAL

To connect to the rationale of the field study from the previous section, we also conducted two interviews with industry experts. It was of interest to us to get feedback on how our thoughts regarding the conception of the PDSurvey platform hold true. To see whether PDSurvey helps display providers conduct and deploy surveys on public displays, or if there are still certain drawbacks.

In order to see whether our thoughts regarding the survey platform itself hold true in practice, we alao chose to conduct an expert interview with a display provider and communication scientist, who are both experts in their area and are able to assess the requirements for public display deployments and for the conduction of questionnaires.

Mateusz Mikusz

Christian Nuernbergk

6.1 Results

1. Gather their feedback
2. First present all of the plain observations and findings, without any personal opinion.

6.2 Discussion

Start with a few sentences that summarize the most important results (+ see `http://www.ldeo.columbia.edu/~martins/sen_sem/thesis_org.html`).

Now allowing room for interpretation and personal opinions

7 Conclusion

Outlook and future work

7.1 Summary

1. foo

7.2 Future Work

Survey Platform

1. Logging, adding more data sources
2. Support the logging of video feeds. One possible approach would be to save the raw data in a dropbox account, to submit the file names via REST calls, and to access the files from PDSurvey via the Dropbox API

Evaluation

1. Number of questions tollerated on each evaluation channel (public display, tablet, smartphone, laptop/desktop)
2. + also see chapter 5, subsection "Research Questions"
3. to also impose variables: context, content, location / setting and to vary those in experimental studies

Appendix

A Content of enclosed CD

1. /docs/
2. /pdsurvey/
3. /pdemail/
4. /pdclient-static/
5. Google Docs

B Documentation of Platform

A user, developer and maintenance documentation for the PDSurvey platform can be found in the GitHub repository [22] and on the enclosed CD.

C 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

D Questionnaires used for Evaluation

Embed the following PDFs

1. interview-participants.pdf
2. interview-passerby.pdf
3. semi-structured-interview.pdf

E Screenshots of Platform

All screenshots including the copyright of the Balloon Shooter game belong to Jiamin Shi.
1st option: tv screen
2nd option: tablet
3rd option: smartphone
4th option: email

[22] https://github.com/lukasziegler/masterarbeit/tree/master/docs

Figure E.1: All four four options for completing a survey, the order being randomized on every instance.

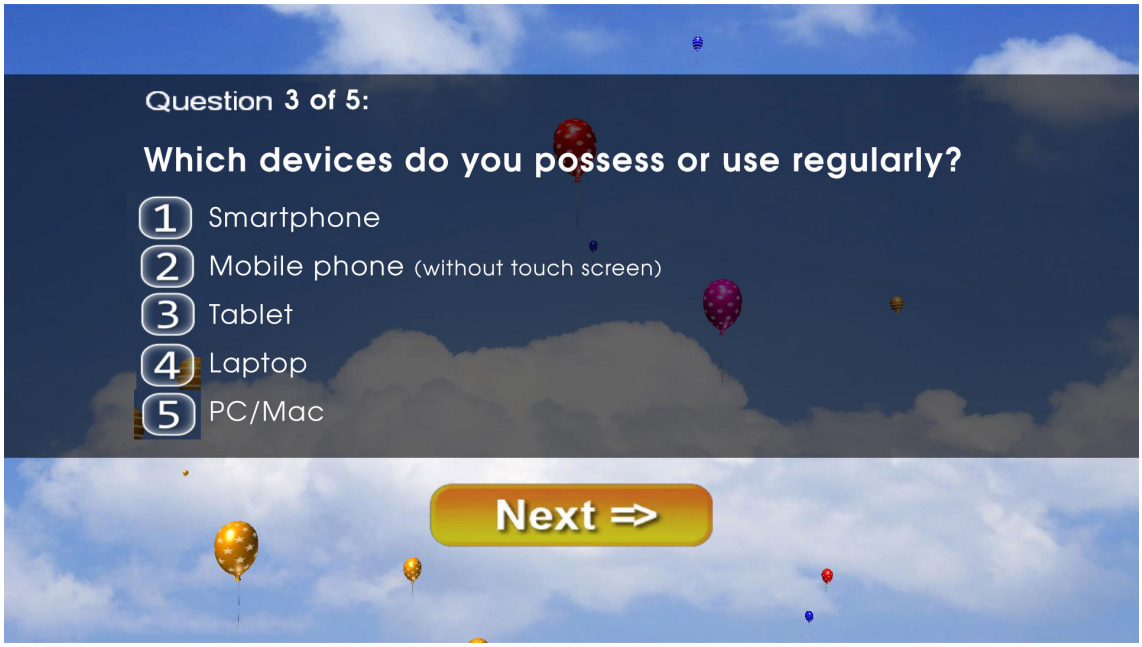

Figure E.2: Option 1, directly answering on the TV screen. Here you see a sample question getting asked on the interactive display.

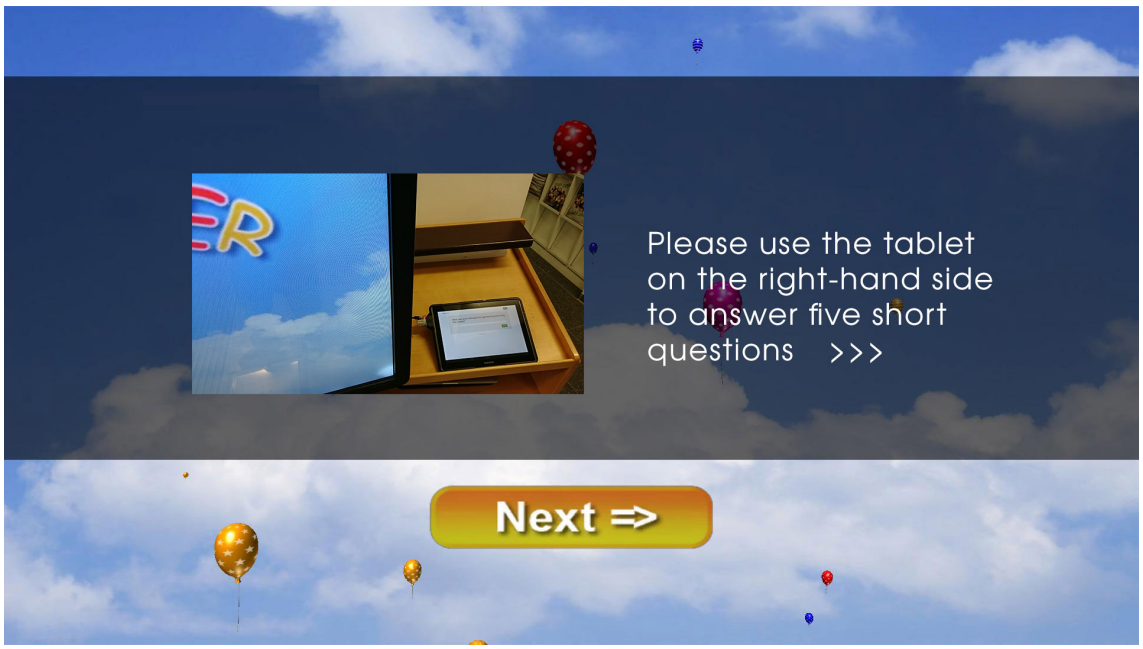

Figure E.3: Option 2, the screen the user sees when choosing to complete the survey on the tablet.

Figure E.4: Option 3, participating with your own smartphone, either by scanning the QR code or by typing the URL in the mobile browser.

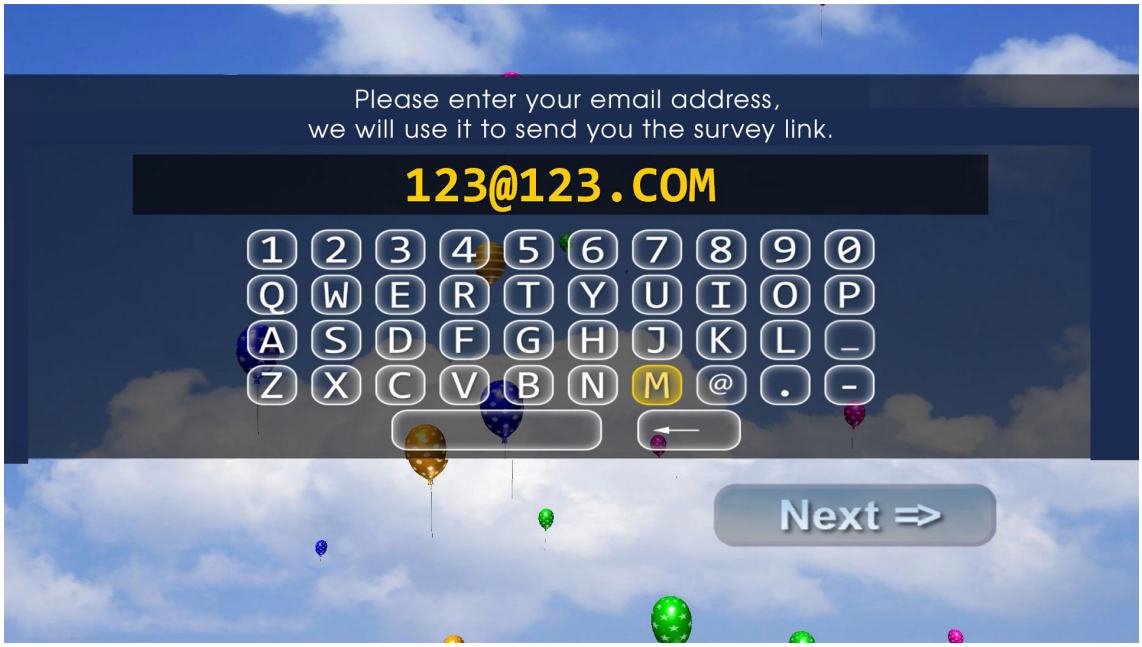

Figure E.5: Option 4, submitting ones email address and getting the survey link to participate in response.

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