How do 360° representations influence customer behavior in the travel industry? – Implementing a mobile experiment

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***Abstract*—This paper explains the development and implementation of an interactive and mobile experimental setup that allows the examination of the influence of 360° representations on customers. It depicts the initial setup requirements and presents the graphical and experimental features that can be used in further studies to conduct experiments in this field. The graphical design is based on the design of the Airbnb smartphone application and is extended by embedding 360° images instead of traditional images.**

Keywords — 360° representations, Virtual Reality, VR, Airbnb, oTree, react360

I. INTRODUCTION

Virtual Reality (VR) has emerged as a rapidly growing technology and its implications, fields of usage, and possibilities are constantly increasing. Both scientific and commercial organizations have contributed to create a knowledge base on a wide variety of VR topics. While the consumer adoption at home was largely influenced by the gaming industry, other areas such as the travel industry, are progressively recognizing and exploring the potential of VR (Cabello et al. 2011; Guttentag 2010).

Typically, customers in the travel industry require an abundance of information before they book their accommodation. The process of gathering information may demand the customer to view images, look at videos, and read customer reviews and descriptions. This process could be enhanced for users, as VR offers the opportunity to improve their discovery experience. For example, potential guests would be able to discover the residence and get a feel of living before stepping onto the property, through the use of 360° representations A full 360° sphere lets the viewers feel as if they are in the center of the area and allows them to choose their own perspective. Hence, providing them with an in-depth and enhanced experience compared to other digital representations such as traditional images. This way, the process of discovering the travel opportunities can be shortened and designed more efficiently through the intelligent use of virtual reality.

Increased competition in recent years has led to technological progress, making not only VR devices more realistic and affordable, but also spurring on the rapid development of devices capable of capturing 360° images. Several companies, such as Matterport, offer equipment through subscriptions to capture high quality 360° photos and videos. This service is tailored for professionals and semi-professionals in the real-estate and hotel industry, who are willing to pay for the right equipment in order to increase their customer's experience. Many hotels already provide virtual reality elements on their websites, allowing users to experience virtual tours of hotels and hotel rooms (Revfine). Moreover, simple 360° cameras and even multiple apps, also allow private users to capture basic 360° images in just a few minutes using their smartphones. Given this progress, the interest in using 360° representations for showing private residences is growing. Airbnb is the most popular website that permits ordinary people to offer tourist accommodation by displaying images of their residences. The company's hosts have already shown their interest in embedding 360° virtual tours to their listings in one of Airbnb's official discussion rooms and it is already running various initiatives related to this field (Airbnb Discussion Room 2016). For instance, Airbnb announced to develop virtual and augmented reality features to help guests find and navigate rental listings (Airbnb 12/11/2017) They also launched a program called "Sonoma Select", in which they partnered with Matterport, a service that offers 3D virtual tours, to display an interactive 360° tour at the top of each listing.. However, at the time of writing this paper (June 2019), Airbnb currently does not offer the functionality of adding 360° images to a listing.

The scarcity of research about the influence of 360° representations on customer behavior and perception raises the question whether the usage of 360° representations instead of traditional photos is worth the extra effort. To tackle this question, this paper prepares the experimental setup for a behavioral study to examine the influence of 360° representations on customers.

To do so, the design and setup of the experiment is described. An overview of the different technologies used and how to implement the experiment is outlined.

II. Setup Requirements

In order to implement an experiment, we need to specify certain requirements and functionalities that the setup should fulfil and enable. These requirement consider the trade-off between ecological validity and experimental control for experiments (Loomis et al. 1999). Accordingly, the experimental setup should ensure that researchers have flexibility over the independent variables (experimental control), whilst maintaining a high resemblance to everyday life situations (ecological validity). In the context of examining the influence of 360° representations, we aim to create a setup in which participants face a situation similar to an everyday life situation. Additionally, the setup needs to allow the tracking of the participants' perception and the influence of the 360° representations through objective and subjective measures.

A. Design

Since Airbnb is the most popular online platform for rental accommodations, users are likely to be familiar with its design and layout. Given that, the design of our setup should provoke similar user experiences to the Airbnb smartphone app (Figure 1).

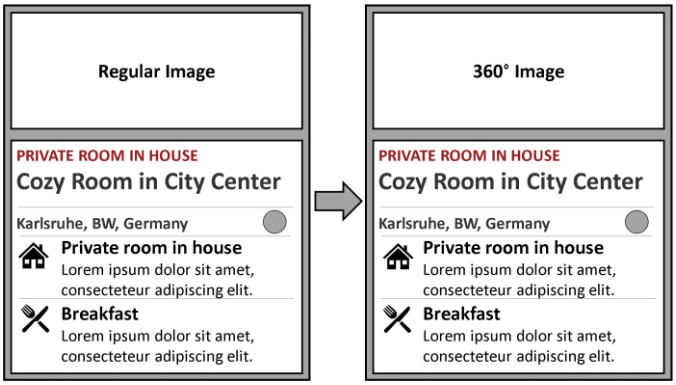

Figure 1: Airbnb Layout

This design allows us to present an acquainted view and, at the same time, make modifications and investigate their influences on the users` behavior and perception. The design setup shall be composed of one view that mimics the basic Airbnb experience with regular images, and one view that replaces the regular images with 360° representations, by embedding a virtual reality environment within the view. This way, participants will have the chance to explore both views and compare the user experiences.

B. Functionality / Mobility

The experimental setup needs to be platform-independent and deployable on mobile devices. Mobile devices present a big opportunity for quantitative research, since they are very suitable for serving as experimental tools. They are equipped with several sensors that can be used to gather data and are able to can connect to server architectures in order to store data. Smartphones and tablets are increasingly becoming tools of everyday life – as a result, individuals participating in the experiment can use their own device, which will further enhance the participants' familiarity with the experimental setup. Familiarity plays an important role in Visual Perception Theories with regards to investigating participants' behavioral intentions to use and accept new technologies (Flanagan 1991, p.93). Moreover, familiarity is further enhanced as the browsing process through Airbnb is mimicked in the experiment – thus, users are able to browse in a genuine and authentic manner. Lastly, a major advantage of using a mobile experimental setup is portability, as people do not necessarily have to come to the lab in order to participate.

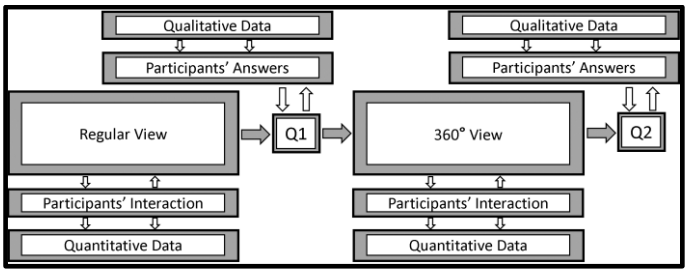

Figure 2: Data Gathering

C. Subjective Meaures

In order to understand participants' evaluation of the different views, questionnaire sections need to be interposed after each section (Figure 2). Experimenters should be able to adjust the questions according to their needs. However, questionnaires ask participants to describe their perceptions and opinions, as well as their own behavioural responses. Hence, these approaches are less reliable due to their subjective nature. In contrast to that, objective measures could provide insights into the subconscious influence of the representations and identify behavioural patterns.

D. Track behavioral data

Schuemie et al. (2001) divide objective measures into behavioral and physiological measures. Whereas physiological measures use measurements such as heart rate, skin temperature and skin conductance as indicators for influence of 360° representations, behavioral measures track how the participants interact with the presented views. Specifically, the setup shall track how much time the participants spend exploring the different views, how strongly they interact with the environment, whether they focus on certain areas of the view, etc. At this point, the above-mentioned sensors of the smartphone shall also be leveraged to track the gyroscope data when exploring the 360° representations. This way, the explored areas of the 360° representations can be tracked, which poses another unique method to objectively measure unconscious and spontaneous visual attentional responses to the environment.

III. Setup Implementation

A. Framework

A setup meeting all stated requirements needs to be implemented using a framework that is able to build and run applications. As our setup needs to be platform-independent and no download or installation shall be required, a web framework is chosen that allows the experiment to run on devices' web browsers. The framework that has proven to be suitable for our requirements is oTree (Chen et al. 2016). oTree is an open-source platform, based on the Django web application framework, for implementing social science experiments. Like most popular web development frameworks, Django is based on the Model View Controller (MVC) pattern that divides an application into three different parts. Firstly, the Model contains the pure application data. The View is responsible for all representations, by presenting the model's data to the user. Lastly, the Controller listens to events triggered by the view, converts the input data into the scope of commands, and executes the appropriate reaction to these events. oTree experiments are web pages using the HTML5 standard. Each oTree application consists of several html-templates, one for each screen. The order of the screens can be defined by specifying a sequence of pages a participant sees. Specifying the sequence is especially useful, because we can interpose the required questionnaires after each section.

B. Experimental Control

When running an experiment, oTree creates an experimental session on the server. This session entails links for all individual participants, as well as for the researcher. In other words, each participant is equipped with a unique participant ID and a unique URL. The participant IDs are randomly generated alphanumeric codes. This gives researchers a high experimental control, as they can distribute these URLs and participants are able to open a URL that is unique to the respective participant and session.

C. Design

Each depicted screen during the experiment can be customized by changing the corresponding HTML templates. Anything that works in HTML5 can be included in oTree, thus, we can clone the Airbnb application by designing a web layout according to our requirements. This has been achieved by using standard HTML5 elements and using the standard front-end framework, called Bootstrap, to make the websites visually appealing. Bootstrap also allows us to intelligently scale the layout of the web application according to the screen size of the device.

D. Virtual Reality

The modification of the individual HTML templates allows us to include 360° representations inside the experimental environment. However, to make the 360° images interactable and explorable, we need to render them separately. This requires another framework that allows us to create 360° content on the web. The best framework for our requirements is React 360. It is a JavaScript framework, developed by Oculus/Facebook, for the creation of VR user interfaces. React 360 renders our 360° images inside a web document on a separate URL. By using inline frames, such as iFrame, it is possible to embed the VR web document inside our oTree HTML templates through referencing to the respective URL. By changing our virtual environment's background, we can change the depicted 360° images inside our experimental environment. React 360 is optimized for the presentation of 360° photos and offers the user multiple ways to control the background. It supports multiple formats, such as 180° mono and stereo equirectangular, 360° mono equirectangular and 360° stereo equirectangular images. Based on the dimensions of the image, React 360 automatically tries to determine the layout format from the aspect-ratio of the image (React 360 2019). The app Street View from Google proved to be very suitable for capturing 360° photos. It creates equirectangular images in jpeg format. Those can be imported in our React 360 project without prior processing. Since React 360 is a web framework based on React, it runs on any mobile device and no prior installations on the end users' devices are necessary. Hence, React 360 fulfills our required features regarding functionality and mobility and increases further our experimental control. Also, React 360 allows use of the devices' sensors such as Accelerometer, Gyroscope, and Magnetometer. By communicating with the phone's gyroscope, users can navigate within the virtual environment by tilting their phones and we can track the areas viewed by the participants.

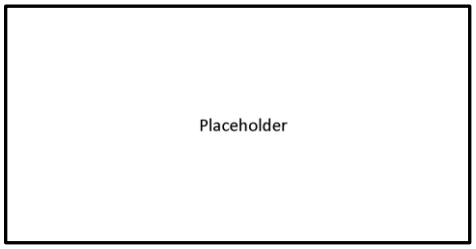

Figure 3: Interplay Frontend/Backend

E. Data Tracking

oTree disposes a built-in data tracking function and the data can be downloaded in standard CSV format. The tracked data includes information about the date and time the participant first accesses the experiment, the current page, whether the participant has finished the experiment, and time spent on each page. This feature offers the researcher a nice possibility to keep track of the participants' state and to see whether our different Airbnb screens were viewed long enough. However, it only provides visibility of the participants' behavior to a certain degree. To examine the influence of 360° images on behavior, we need to track as much behavioral features as possible, such as time spent looking at the regular images, time spent looking at the 360° images, explored areas in 360° environment. Most of the out-of-the-box web analytics data tracking tools such as Google Analytics require to link a specific URL to the data tracker and offer only limited control over the features. Since our experimental URLs will be assigned dynamically respective to the number of participants by oTree, we decided to implement our own simple data tracking tool. This way, the

experimental setup provides a high experimental control, which is one of our main requirements, because new components or features that shall be tracked can be added and the tracker can get customized accordingly. Specifically, the data tracker was implemented by adding event listener to our HTML templates that, in case of a certain event, trigger API calls to our server and store information about the events accordingly.
The JavaScript HTML DOM Event Listener attaches an event handler to a specified HTML element. For instance, whenever a participant presses a button to open the 360° representation in full screen mode, the event is tracked. The data gets tracked through a web API, built using the Django REST Framework. It allows the developer to set up web URLs that are called in order to store data in the Django model. In addition to the HTML event listener, the API URLs can also get called through our React 360 environment. This allows us to track the camera angle of the virtual environment at any time and lets us determine when and where the participants were looking at. Figure 4 shows all events, that are currently tracked, and their respective URL calls.

Event	Environment	Tracked Data	URL
Open regular image in Fullscreen	oTree Regular Screen HTML Template	Event : Fullscreen Open Page: Regular Page Timestamp: date + time	server:port/api/fullscreen/create/
Close Fullscreen of regular image	oTree Regular Screen HTML Template	Event : Fullscreen Open Page: Regular Page Timestamp: date + time	server:port/api/fullscreen/create/
Touch of HTML Item	oTree Regular Scree/ VR Screen HTML Template	Event: Touch HTML Item: Infobox	server:port/api/event/create
Open 360 Image in Fullscreen	oTree VR Screen HTML Template	Event : Fullscreen Open Page: VR Page Timestamp: date + time	server:port/api/fullscreen/create/
Close Fullscreen of 360 Image	oTree VR Screen HTML Template	Event : Fullscreen Close Page: VR Page Timestamp: date + time	server:port/api/fullscreen/create/
Change of Camera Position in VR	React 360 environment Index.js file	X-Coordinate: Camera Pos. Y-Coordinate: Camera Pos. Timestamp: date + time	server:port/api/react/create/

Figure 4: Behavioral Data Tracking

New events can be added conveniently, simply by adding new event listener in the HTML templates and adjusting the stored information accordingly.
Django REST Framework provides the possibility to not only set up URLs for storing data, but also for displaying already stored data. This way the researcher can access the tracked data at anytime through the respective web URL. Additionally, tracked data can be download from the Django model by using simple queries[1].

IV. Source Code

The source code is organized according to the three main parts of the experimental setup (See Figure 3) within three different repositories: 360 (oTree project), 360-react (React 360 project), 360-behavior (Django project for Data Tracking). The code is published within the university's internal Gitlab[2]. Within the repository, a more detailed and technical explanation of the source code is ensured via the attached README file. Additionally, the experimental setup is publicly available on the author's Github account[3].

A. Testing & Deployment

At the time of the creation of this document the experimental setup is still in development mode to offer quick debugging and allow individual adjustments according to the needs of the researcher. To test the experimental setup, all three different projects can run simultaneously on a local machine such as an ordinary laptop. At this point, no full server setup is required. All frameworks offer commands that can be used for running a lightweight development web server (See more information in README). Once the experimental setup is ready to be deployed, the projects can also run on local machines, or can be deployed using commercial cloud hosting provider, such as Heroku, Firebase or Elastic Beanstalk (AWS).

V. Outlook

This paper describes one way to undertake the implementation of an experimental setup that includes 360° representations. It should be seen as preparation for a behavioral study to examine the influence of 360° representations on customers. However, the provided source code of the experimental setup can be used for conducting further studies related to 360° representations. Moreover, the code can be seen as a starting point for further experimental implementations in this field. Suitable extensions could include, for instance, additional virtual objects in the virtual environment on top of the 360° images for more detailed information about the accommodation (Jacobious 2016). Additionally, events other than those shown in Figure 4, could be tracked.

References

Airbnb (12/11/2017): Developing the Next Realities for Travel. Available online at https://press.airbnb.com/developing-the-next-realities-for-travel/, checked on 6/18/2019.

Airbnb Discussion Room (2016): How can I add a 360 Virtual Tour to my listing? Available online at https://community.withairbnb.com/t5/Hosting/How-can-I-add-a-360-Virtual-Tour-to-my-listing/td-p/30741, checked on 6/18/2019.

Cabello, José Manuel; Franco, José María; Collado, Antonio; Janer, Jordi; Cruz-Lara, Samuel; Oyarzun, David et al. (2011): Standards in virtual worlds virtual travel use case metaverse1 project. In *The Journal of Virtual Worlds Research* 4 (3).

Chen, Daniel L.; Schonger, Martin; Wickens, Chris (2016): oTree—An open-source platform for laboratory, online, and field experiments. In *Journal of Behavioral and Experimental Finance* 9, pp. 88–97.

[1] Django documentation for querying models: https://docs.djangoproject.com/en/2.2/topics/db/queries/
[2] Link to Gitlab repository: https://git.scc.kit.edu/yn2099/360
[3] Link to Github repository: https://github.com/Gerdome/airbnbresearch

Flanagan, Owen J. (1991): The science of the mind: Mit Press.

Guttentag, Daniel A. (2010): Virtual reality: Applications and implications for tourism. In *Tourism Management* 31 (5), pp. 637–651.

Jacobious, P. (2016): Virtual reality in tourism. Available online at http://www.virtual-reality-in-tourism.com/, checked on 6/18/2019.

Loomis, Jack M.; Blascovich, James J.; Beall, Andrew C. (1999): Immersive virtual environment technology as a basic research tool in psychology. In *Behavior research methods, instruments, & computers* 31 (4), pp. 557–564.

React 360 (2019): 360 Photos and Videos. Available online at https://facebook.github.io/react-360/docs/photos-and-videos.html, checked on 6/18/2019.

Revfine: How Virtual Reality is Transforming the Travel Industry. Available online at https://www.revfine.com/virtual-reality-travel-industry/, checked on 6/18/2019.

Schuemie, Martijn J.; van der Straaten, Peter; Krijn, Merel; Van Der Mast, Charles APG (2001): Research on presence in virtual reality: A survey. In *CyberPsychology & Behavior* 4 (2), pp. 183–201.