Sensor Ball Raffle – Gamification of Billboard Advertising: How to Engage the Audience?

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Abstract. In this paper, we present an interactive game for a large public display. Our focus was on experimenting new ways to enhance the effectiveness of a large, billboard size, display by adding a collaborative interaction mechanism for a user crowd. Working with a pop festival organizer, we developed a technology proof-of-concept of a multiplayer raffle game supporting crowd interaction with a large public display using an air-filled ball, equipped with an accelerometer and a barometer, as an interaction device. We experimented on its possibility to engage festival audience in live pilots in two occasions. Our observations showed that the audience enjoyed the raffle game and participated willingly. In addition, advertisers found the solution interesting.

Keywords: Interactive Digital Signage, Audience Engagement, Interaction Technologies.

1 Introduction

In our daily lives, we are surrounded in public spaces with digital signage – small and large displays as well as huge billboards – with varying purposes. Public displays are being used e.g. for advertising, entertainment and infotainment, but it is not clear to what extent the public displays are able to deliver the intended message and if they have the expected impact or not. Interaction with the display and the presented content is often considered to improve the impact of the public displays.

In our work, the focus was on experimenting new ways to enhance the effectiveness of a large, billboard size, display by providing a collaborative interaction mechanism. In this case, the challenges were related to the development of an interaction mechanism for user crowds with low threshold for participation and to the design of a simple, but alluring, billboard application for a festival audience. Working with a pop festival organizer, we developed a technology proof-of-concept of a multiplayer raffle game supporting crowd interaction with a large public display and experimented on its possibility to engage festival audience during the intervals between different artist performances. The aim of our festival organizer partner was in this way to provide benefit for the advertisers improving the impact of the billboard advertisements. The interaction between the audience and the billboard display was implemented using a ball equipped with sensors monitoring the movement of the ball. In the next sections, we first discuss related work, and then describe our approach, the technology components and details of the implementation. We present also the experiments done in real-world settings to evaluate the feasibility of the technology and design approaches, and finally our concluding remarks.

2 Related work

Impact of digital signage has been studied extensively to evaluate the effect of the displays and the content presented. For example, Huang et. al [1] reported that in public spaces it is difficult to attract and hold the audience attention. People suffer from Display blindness, when they expect display content to be uninteresting [2].

In the research community, interactivity is widely considered to enhance the impact of a public display and different interactive display solutions have been studied. Alt et al [3] showed that with adoption of interactive content on public displays 1) the awareness of the content is increased, 2) the perception of public displays is more positive and 3) the information dissemination is improved. However, in order to have the desired impact the interaction method needs to be simple and clear to the user [4] and the application developers need to understand the user context related to public displays [5].

The focus in the research work is typically on medium sized displays (~55") and single person interaction. Common interaction technologies used include mobile devices, touch screens and gesture-based interfaces (e.g. Microsoft Kinect) [3].

Müller et al [6] studied the user engagement in educational environment adopting interactive public displays with personal mobile devices. WallSHOP [7] demonstrated interactivity between multiple mobile devices and a public display. The purpose of the system was to combine the features of two device types to provide dynamic personalized content for advertisements. The user studies showed the feasibility of the solution, but also underlined challenges related to pairing of personal devices and the public display [8]. Different approaches (NFC, QR code, typing an URL, and connecting to a WiFi access point) to pair the personal device and the public display have been studied in [9]. Yamaguchi et al [10] used a depth sensor installed at the public display and the mobile phone accelerometer to provide data for device pairing. After the device pairing, user could control the public display using his personal mobile device. In [11] mobile devices and a large display are used as an interaction medium between the audience and the orchestra. First commercial applications exist as well e.g. at movie theaters in Finland, before the movie, the audience can join a collaborative game on the screen using their mobile phones and the Leffapeli app. In average 5% of the audience joins in [12]. A comprehensive review on usage of mobile devices to interact with public displays is presented in [13].

In addition to explicit interaction with a public display, approaches to enable implicit interaction with digital content have been studied. For example, Tamaki and Hirakawa [14] present an approach to synchronize the content on a public display with the movement and height of the passerby. ReflectiveSigns has a scheduling system, which learns from audience behavior and adapts the display content accordingly [15].

3 Raffle game for festival audience engagement

Large public displays are used in pop festival context to live stream the artist performance, as with large audiences it is impossible for the entire audience to have a direct view on the artist. The artists perform for example for a period of 30-45 minutes and between the performances of different artists, there is an interval of 15-30 minutes. During this interval, the displays are used for advertising. Typically, advertisement content is displayed in predefined sequence and content is text, images, videos or animations.

The aim of our festival organizer partner was to provide benefit for the advertisers and have more interested clients for the display space during the intervals. As interactive digital displays have proven to have a stronger impact [3], we focused on interactive display solutions for user crowds. The requirements for the interaction method were following

- low threshold for participation, as we wanted to have as large as possible number of audience members interacting with the display
- ease of use, as the festival audience was unlikely to be interested in investing a lot of their festival time in learning an interaction method
- reliability, as the weather and lighting conditions could change drastically during the festival days or audience could behave unexpectedly.

Based on previous research, we evaluated usage of mobile phone based interaction methods and gesture interfaces. Even if in many occasions researchers have reached promising results related to usage of mobile devices as interaction interfaces with public displays, in our case we estimated that the number of audience members willing to install a specific application or use their phones in some other way to interact with the display would have been low. Previous research shows that the user willingness to interact with the display suffers if the process is time-consuming or complex [13].

Gesture-based interaction methods would be easier for the audience to start using. However, in a crowded situation such as audience gathered in front of a festival stage it would be difficult to implement a reliable gesture-based interaction solution. Most technology solutions for gesture-based interaction can operate with a maximum of 3-5 simultaneous users. In our case, the potential maximum number of simultaneous users was huge, thus the usage of a gesture-based interaction method would have limited the number of simultaneous users remarkably.

In the end, we selected an object on which we were able to attach a miniaturized sensor device to track the movement of the object. We considered the object-based interaction to be the best solution in our context.

The requirements already described for the interaction method were used again in the design process of the application. In addition, we wanted the application design to enable multi-brand advertising to add the number of possible clients for the festival organizer and minimize the possible hindering of the normal festival flow. Taking into consideration the nature of the event and the experience of the festival organizer, we estimated various possibilities including:

- controlling a cursor on the screen to complete a specific mission e.g. touching an virtual object visualized on the screen

- division of the audience into teams and a tennis-type of game between the teams
- tasks to throw the ball in specified ways e.g. height of 10 meters.

Together with the festival organizer, we designed a simple application involving game features and a possible reward for the participation. The resulting application involves an air-filled ball equipped with a number of sensors, which when thrown keeps a raffle game wheel rolling on the screen. The advertised brands or products are presented on the rolling wheel. The raffle game is short, less than 30s, and the festival presenter, who also invites the audience to play, initiates the game. The festival presenter throws the ball to the audience, which keeps the ball moving by throwing it from an audience member to another. The person holding the ball in the end of the game, when the raffle wheel stops and an audio signal is given, wins a prize.

4 Proof-of-concept system implementation

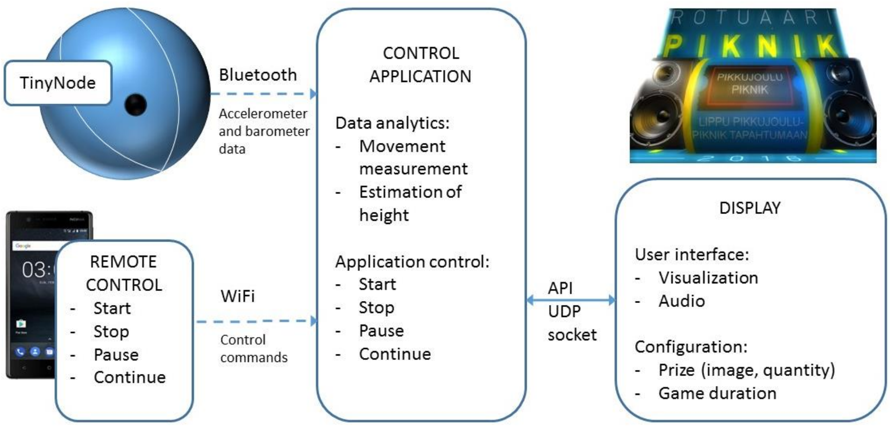

Fig. 1. System architecture

The system implementation (in Fig. 1) consists of four main components: sensors on the ball, large display with the raffle application, remote control software, and a centralized control application. The components operate on three different devices: sensor node attached to the ball, mobile phone for the remote control and a PC that hosts the raffle and control software and is directly connected to the public display.

4.1 Sensor ball

VTT Tiny Node sensor board [16] (in Fig. 2) is attached directly on the game ball. Tiny Node consists of integrated sensors including a 3D accelerometer, a barometer, a temperature sensor, and a humidity sensor. The Tiny Node communicates with other devices using a Bluetooth LE (BLE) data connection. The remote control application allows selecting a specific Tiny Node sensor and the control software opens a Bluetooth connection for the selected Tiny Node. The communication in Bluetooth is initiated by activating the stream transmission of acceleration and barometer data from the sensor to the main control software for activity analytics.

Fig. 2. VTT Tiny Node: a battery operated sensor board.

4.2 Control application

The control application maintains the state of the raffle system, passes messages between the components and performs the sensor data analytics for detecting if the game is played properly and the ball is moving. The festival presenter uses the mobile remote control to initiate the raffle game. During the raffle game, the sensor data from the sensor ball is analyzed by the control application to estimate the movement and height of the ball.

In addition, the pause and continuation of the game can be activated from the mobile remote control. This feature was implemented to overcome in live situation problems related to sensor data streaming and real-time analytics.

Measuring the movement of the ball. The sensor ball is equipped with a three-axis accelerometer and a barometer. The accelerometer data is used for measuring the magnitude of the movement of the sensor ball. The state of the ball motion is compared to the threshold and if the ball is not moving fast enough the game is put on hold.

For each received data block, a running sliding average of the accelerometer data is calculated. The average value is compared against a predefined threshold and if the movement does not exceed the threshold on a period of three seconds, the game is put on hold. Similarly, when the game is already on hold, the movement needs to continue similarly for three seconds, before the game initiates again and the raffle continues.

Estimating the height of a throw. The barometer sensor provides data for estimating the height of the throw. The height estimation is based on the barometric formula

$$h - h_0 = \frac{T_b}{L}\left(\frac{P_h}{P_b}\right)^{\frac{-LR}{g}-1},$$

where h is the current altitude, h_0 is the reference altitude, T_b is the reference temperature, P_h is the current pressure, P_b is the reference pressure, L is the standard lapse rate

(-0.0065 K/m), R is the universal gas constant (287 1/s2K), and g is the gravitational acceleration (9.80665 m/s2). The equation describes how the pressure (or density) of the air changes with altitude. The pressure drops approximately 11.3 Pa per meter in first 1000 meters above the sea level. The reference temperature T_b was initialized manually to 15C° and assumed to remain constant during the event. The reference pressure P_b is initialized and further updated every time when the detected still time exceeds a predefined threshold. The still time detection is based on the principle presented in [17]. The still time is incremented by the sample interval Δt on each time step, resetting to zero if the amplitude of the acceleration or the barometric pressure signal differs by more than a prescribed threshold from the average value of the signal since the current still time period began.

Together the acceleration and barometer data provide an automatic monitoring for the game so that the ball is constantly on a move and it reaches suitable height during the game. If someone tries to hold the ball and thus cheat the raffle, the game goes automatically on pause and the game continues only when the ball is back in the game.

4.3 Raffle game

The game uses the X-Emitter Blender[1] game and particle engine for rendering the raffle unit. The game has a rolling wheel and the raffled prize is presented on the wheel in the end of the game. The rolling of the wheel is animated as well as shaking and lighting effects on the machine. The magnitude of shaking and the light effects is controlled by the movement activity of the ball sensor. The content of the advertisements on the wheel is managed on a configuration list. The list contains information about the game logic: how many prizes are available for each advertisement and what is the probability of each prize. In addition, the list contains technical information, such as texture of the logos and possible effects. The expected duration of the raffle is predefined, but the exact duration is random for each game so that participants cannot predict, when they should hold the ball in order to win the game.

4.4 Mobile remote control

The remote control software is implemented as an Android application and it consists of buttons to start, pause or continue the game and selecting the Tiny Node sensor when multiple game balls are in use. The mobile device needs to be connected to the same WiFi network than the computer hosting the control software. This eliminates the need of Internet connection and allows using a simple UDP socket for communicating the commands from the mobile device to the control application.

[1] www.blender.org

5 Piloting at music festivals

To evaluate the feasibility of our approach from technical and design viewpoints we organized two live pilots in Oulu, Finland, together with our pop festival organizer partner. First, we piloted the solution during Rotuaari Piknik, which was an outdoor festival in downtown, Oulu, in July 2016 and second, in Pikkujoulu Piknik, which was a one-day festival organized in an indoor venue, in November 2016. Our main goal was to evaluate the technical functionality of the sensor ball as an interaction mechanism and audience response to this type of an interactive application.

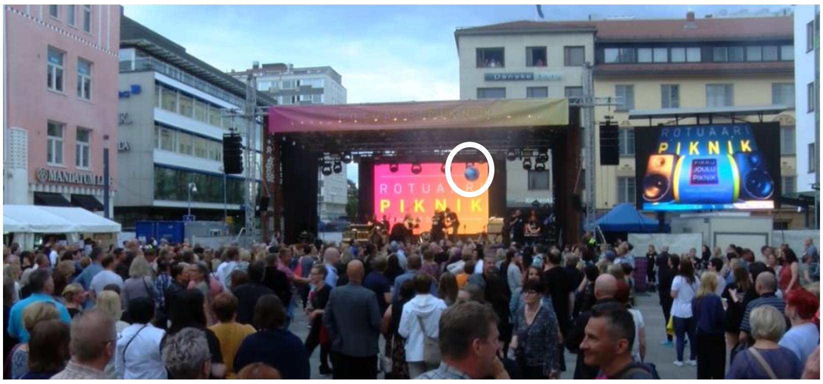

Fig. 3. Rotuaari Piknik context: stage, screen and the ball (circled in the image)

5.1 Rotuaari Piknik – outdoor piloting

Rotuaari Piknik festival was organized on a square surrounded by buildings from three sides and by a stage from the fourth (Fig. 3). For each evening there were three artists performing each for approximately 45 minutes. Our pilot raffles were run for three evenings, when the overall festival operation permitted. Thus, we needed to be sure that the normal festival workflow (specially transferring music instruments for each artist) was not disturbed.

In our first festival pilot, the prizes in the raffle game were tickets to a music festival, movie tickets and gift vouchers for a hamburger restaurant. The range of the value of the prizes was from 10 to 150 euros. For each evening, there was one main prize and a number of smaller prizes. In this pilot, the ball used was a typical air-filled beach ball with a diameter of approximately 45 cm. We had multiple balls in use to keep the pace of raffle rounds fast in case it would take time to get the sensor ball back from the audience after the end of a raffle round.

We run the pilot raffle game multiple times each evening. Typically, 2-5 times before each performance resulting to 6-15 rounds each evening. The festival presenter encouraged the audience to participate informing about the prizes and giving instructions on how to play: 1. keep the ball moving, 2. hold on to it, when the raffle wheel stops and you hear an audio signal, 3. bring the ball to the presenter and retrieve your prize. The duration of the game was short: 20-30 seconds only to keep the interest of the audience high.

The evaluation of the technical functionality of the system and the audience reaction to the raffle game is based on our observations. We had two researchers observing the audience reactions and the game play for each raffle round.

Fig. 4. Audience engagement with the raffle game.

Our observations showed that after the first raffle round the audience understood the idea and participated eagerly (Fig. 4). Not all of the people were participating, but there was a large enough number of hands reaching for the ball to keep the game running. Some persons tried to hold on to the ball, but the system detected the misuse, the raffle wheel stopped and continued to roll only when the ball was moving again. The ball was moving well and the technical functionality of the system was in general acceptable. However, there were some problems with the signal transmission from the sensor ball to our receiver. We anticipated this, because, even if the range of the game was not too large for the BLE connection, the number of devices with radio interfaces in the area was high. Each evening there were more than 1500 persons in the area of a downtown square surrounded by buildings and most probably, all of them had a personal mobile device with them. Thus, we needed to use our remote controller, when the system did not receive the sensor data from the ball.

The companies present in the festival noted our interactive advertisement solution. During the first festival evening, two local businesses approached the festival organizer and wanted to be included in the raffle game. Therefore, for the second and third festival pilot evenings we reconfigured our system to support two new prizes: gift vouchers for two local restaurants with a value of 20-30 euros. For the festival presenter the game became a tool to gather the audience ready for the artist performing next.

5.2 Pikkujoulu Piknik – indoor piloting

The nature of the second festival was somehow different from the relaxed summer pop festival. Pikkujoulu Piknik was in practice a Christmas party with almost 5000 persons organized in a sport hall. The setup was similar: the audience in front of the stage and service points (bars, restaurants) surrounded the audience area (Fig. 5). The main difference compared to the summer festival was the absence of natural light – the evenings in July are bright in northern Finland. To overcome this challenge we used an air-filled ball with an integrated LED luminaire. The LED light ball was larger than the one used in first pilot, the diameter was more than 60 cm.

Fig. 5. Pikkujoulu Piknik context: stage, screen with the raffle game and the sensor ball

The presenter in Pikkujoulu Piknik was the same person as in the first pilot, thus the game was already familiar to the whole team and we repeated the same process as in the summer festival. The game configuration was similar to the summer pilot. The prizes included festival tickets, movie tickets and gift vouchers to multiple restaurants. All the advertisers included in the first pilot were willing to continue in the second pilot.

Two researchers observing the audience reactions and game play performed the evaluation. Our observations showed that the game was familiar also to a part of the audience after the summer pilot, which lowered even more the threshold to participate. The LED lights in the ball created a nice effect and there was no need to add environmental lighting for the ball to be visible. The audience participated actively to the game and there were even battles for the ball. We understood soon that the large size of the ball was a problem – multiple times more than one person was holding the ball, when the raffle stopped, and we had to improvise in selection of the winner. During this pilot, the radio interface between the ball and the raffle game application worked well. However, in one occasion, the audience ripped the sensor off the ball and the remote control was used to finish that specific raffle round in a controlled way. For the rest of the raffle rounds we changed the ball to a backup ball with a functioning sensor.

6 Lessons learned

Our pilot observations showed that the sensor ball type of interaction method works well for a user crowd such as the pop festival audience. It requires minimal effort from the users and is easy to use. However, reliability of the communication interface between the sensor ball and the backend system is of utmost importance.

The game design was simple enough for the audience in this type of festival. The sensors worked well for controlling the movement of the ball and preventing the misplay of the game.

Piloting in real-world settings requires careful preparation for the unexpected, especially when the “show must go on” regardless of problems. Both the remote control and extra sensor balls were necessary and used during the pilots.

7 Conclusions and future work

We have presented an interactive digital signage application for a large billboard-sized screen aimed to engage the audience in a public event such as music festival. We have described our design and motivations behind our choices. We have given implementation details and demonstrated the feasibility of both the concept and the technical implementation. We have also reported our observations from multiple live pilot events, which proved that the audience enjoyed the game and advertisers found the game to be an interesting marketing channel.

For the future work, we will aim at organizing another pilot event to gather audience feedback with interviews. We will develop a solution to measure the effectiveness of the interactive digital signage application in communication of a marketing message to a crowd in a public event based on video analytics. We will also consider novel radio communication interfaces to improve the reliability of sensor data transmission between the ball and the control application.

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