NOTIFY-AND-INTERACT: A BEACON-SMARTPHONE INTERACTION FOR USER ENGAGEMENT IN GALLERIES

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ABSTRACT

Existing interactive systems suffer from low user engagement due to their passiveness and steep learning curve. To address these issues, this paper presents an interactive framework, *Notify-and-Interact*, which leverages the Bluetooth low energy (BLE) beacon infrastructure to notify and a smartphone to interact, such that it transforms a passive interactive system into an active one. The proposed framework is demonstrated in the Ping Yuan and Kinmay W Tang Gallery, where a series of wildlife artworks are exhibited. Engagement conversion rate is measured, and users' quality of experience (QoE) is surveyed through likert assessment. Artworks with *Notify-and-Interact* outperforms the QR code with a high engagement conversion rate at the interaction stage, i.e., 86% over 53%, and an average engagement time of 55.67s over 28.69s, respectively. The mean opinion score (MOS) shows that around 80% of the users expressed high satisfaction with the installed *Notify-and-Interact* framework in the gallery.

***Index Terms*—** Interactive Display, Cyber-physical System, Interactive Gallery, Bluetooth Low Energy, Beacon

1. INTRODUCTION

To date, interactive technologies have been integrated into both the traditional and modern displays to increase user engagement. Notwithstanding the increasing integration efforts, user engagement is not increase proportionally as expected. The assumption of the combination power of the appealing multimedia content and the interactive technologies to increase the engagement is deemed a failure: first, the multimedia content failed to draw users' attention; second, users might unaware of the installed interaction modalities though they are attracted to them; third, some interactive technologies are too complex for the average user with little computer literacy.

While many have assumed the attraction power of the multimedia content, study [1] has proven the opposite. It has been found that users often assume a boring multimedia content and barely pay attention to the display. The overwhelming number of today's public displays has resulted a phenomena known as "Display blindness" [2], which describes users' tendency to ignore displays. Moreover, users are unaware of the installed interactive technologies as most of the technologies exhibited a passive characteristic, simply waiting for users to discover the technologies and initiate the interaction.

With the rise of the smartphone, smartphone-based interaction has become the best substitution for traditional interaction techniques (e.g., direct touch, bodily gestures). The coupling of the smartphone and sensors attached physical devices (e.g., displays, artpieces, etc.) allows fluid information exchanges across cyber-physical domain [3] [4]. Smartphone-based interactive system has been adopted by industries ranging from retails to edutainment. However, most smartphone-based interaction requires users to pair up their devices or scan an embedded code prior to any interaction. The device pairing/scanning varies from application to application, and can be a tedious process to learn and apply at the time. Such a steep learning curve has caused frustration in users and prevented them from further interaction attempts.

As discussed, the failure to engage users has diminished the purpose of an interactive system. To address the above-mentioned issues, an interactive framework, *Notify-and-Interact*, is proposed. *Notify-and-Interact* leverages: the strength of a Bluetooth low energy (BLE) beacon to notify, the cloud to facilitate the data exchange, and the smartphone to interact. The novelty of the proposed framework is two-fold: active notification subject to the user's activities, and intuitive interaction by keeping the complicated technology in the background.

The main contributions of this paper are as follows:

1. *Notify-and-Interact*: an interactive framework that is able to notify and invite a user to interact is described. The framework is active in the way that a local notification is sent to invite users for interaction if and only if users show their interest. The interaction is simply intuitive as it can be initiated straight away without the need for device pairing/scanning.

2. *Engagement Model*: the engagement conversion rate at the interaction stage is investigated. The main objective here is to examine how active notification can contribute to the engagement conversion rate. The interaction overhead induced during the interaction process is examined to evaluate the quality of engagement.

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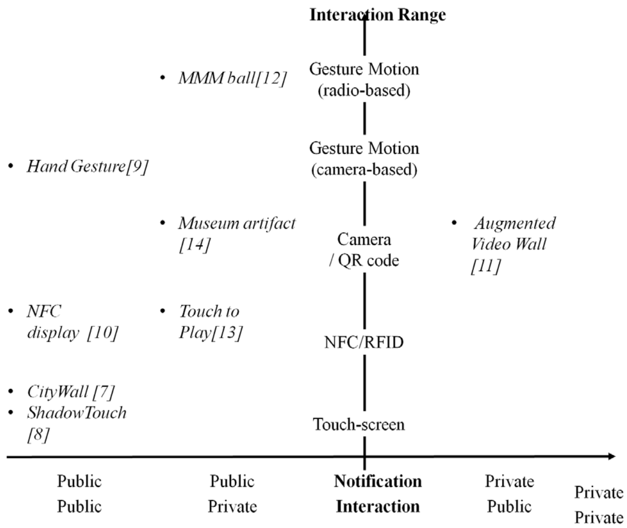

Fig. 1. Classification of prior research based on the type of notification and interaction used.

3. *Implementation and evaluation*: the framework is implemented in a real gallery setting. According to the mean opinion score (MOS) collected from the Likert assessment, around 80% of users are satisfied with the proposed framework, compared to the existing touch-screen displays and QR code in the gallery, which only scored 35% and 53%, respectively.

The rest of the paper is organized as follows. Section 2 reviews the related works; Section 3 presents the framework of *Notify-and-Interact*; Section 4 discusses the engagement model; Section 5 describes the implementation of the proposed framework in the gallery; Section 6 evaluates the results; and Section 7 concludes the paper.

2. RELATED WORKS

For most of the interactive systems, notification is used to raise a user's awareness. Generally, the notification can be classified into 2 types: public notification and private notification. Public notification is a message broadcast massively to the public. For example, multimedia content shows on the displays [5]. This kind of notification is passive as the broadcast mechanism is unidirectional. Private notification, on the other hand, is an active notification, where the system can customize the notification message according to the target individuals. For example, by manipulating the display-side speaker, the display can react to an encountered user accordingly via an embedded audio [6]. However, some users might find their privacy been invaded with this type of notification.

Over the years, diverse types of interaction techniques have been developed, which can also be classified into either public or private. Public interaction is an open form of interaction, where the interaction activities are exposed to the public. The common forms of public interaction are touch-screens (cf. Citywall [7]), ShadowTouch [8] and gesture motions (cf. Hand Gesture through smart glasses [9]). An NFC-display [10] and smartphone camera [11] have also been utilized to allows users to interact with public displays using their smartphone. Private interaction, on the other hand, is a closed form of interaction, where the interaction activities are invisible to public. The prevalence of use of smartphones for private interactions has received a higher acceptance rate as users' privacy is assured. Various smartphone-based interactive systems have been developed by leveraging the wireless communication features: WiFi (cf. MMM ball [12]), NFC (cf. Touch to Play [13]), camera (cf. scan a QR code with the smartphone camera [14]).

Fig. 1 classifies the prior research based on the type of notification and interaction used with respect to the interaction range. As the field of interactive systems continues to evolve, one can observe the convergence from public to private, for both the notification and interaction techniques. BLE beacons have been widely used for various push notification applications. However, there have been less studies of the integration of push notifications and smartphone-based interaction. Most of the push notifications are designed to inform users about the proximity services in general without triggering users for further action. This paper presents a user-oriented interactive framework, *Notify-and-Interact*, to bridge the gap between notification and interaction, and to provide a smooth transition from private notification to private interaction.

3. NOTIFY-AND-INTERACT

The framework of the *Notify-and-Interact* can be classified into 3 main parts: the beacon associated display, the smartphone-based interactive application, and the cloud-based content management system (CMS).

- *"Notify" via Beacon*: While most interactive systems are developed on top of the digital display, a beacon can be associated with both digital and traditional display, so as to add onto them interactive capabilities. With advertising signals broadcast through the associated beacon, the displays can implicitly announce their presence to their surroundings. The time users spent in front of a display is a good indicator of users' interests; if the time exceeds a pre-defined period, a local notification is sent to invite the users for interaction.

- *"Interact" via Smartphone*: A smartphone is used as the medium for users to interact with the encountered displays. Fig. 2 shows how the scan, notify and interact events work between the smartphone, the beacon and the cloud. As discussed, it is encouraged to

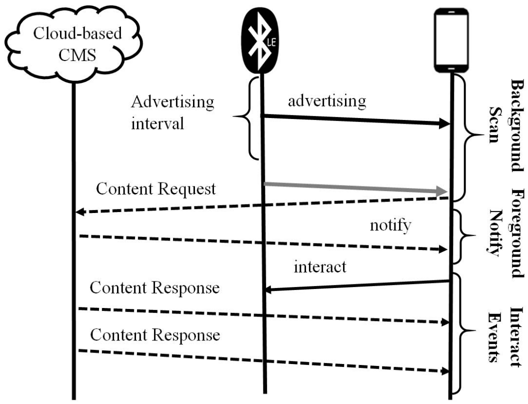

Fig. 2. The background scan, foreground notify and interact events of a *Notify-and-Interact* framework

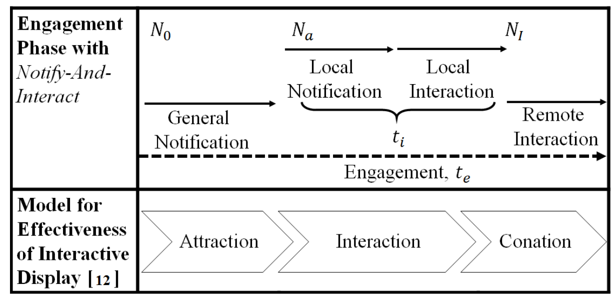

Fig. 3. An engagement model based on the existing interaction model defined by prior research.

keep the complicated scanning technique in the background, whilst having a user-friendly notification in the foreground to guide users for further interaction. Upon receiving the notification, users can initiate a content request to start the interaction event: to browse the content in private using their smartphone, write a comment, watch the related video, etc.

- *Content Management System (CMS)*: A CMS is used to manage and synchronize the content for both the beacon associated display and the smartphone. Within the CMS, a lookup table is constructed to map the corresponding keys (i.e., major and minor) values pair. The values can be any beacon related attributes (e.g., advertising interval, transmit power), display related content, or the interaction record.

4. ENGAGEMENT MODEL

A user's awareness and activities around the interactive systems are important elements for a people-centric interactive system. This section describes the user engagement model developed on top of the existing interactive model, and then follows with a discussion on the quality of user engagement.

Even though the model of [15] focuses on the effectiveness of the interactive system for advertising, a common issue is identified: a lack of user engagement. Hence, with reference to the prior interaction model, a refine user engagement model is developed, as shown in Fig. 3. In conjunction with the proposed *Notify-and-Interact*, the engagement model can be categorized into 2 major phases:

- *Notification Phase*: A push notification is used to alert users to the interesting events around them, and trigger users for further action. Fig. 3 shows two types of notifications: A global notification serves as an announcement to announce the presence of the displays to their surroundings, whilst local notifications are personalized notifications that invites individual users for further interaction.

- *Interaction Phase*: Interaction describes a transition to a deeper level of engagement. Local interaction dictates an on-the-spot interaction, where users interact locally with the system, and the system is able to respond to users' interaction requests in real-time. Remote interaction describes how users interact with the system remotely to complete a conative task: placing a purchase online, sharing their interaction experiences using social networks, etc.

4.1. Evaluation Metrics

With reference to the 2 engagement phases described above, we are interested in investigating how the integration of *Notify-and-Interact* increases the attraction and finally leads users to interaction. Hence, two evaluation metrics are defined to evaluate the system performance:

- *Engagement Conversion Rate*: It is very subjective to determine if the users are engaged. To generalize, we assume that the users are engaged if they are attracted and started to spending quality time with the said system. For the case of *Notify-and-Interact*, the number of attracted users, N_a, can be estimated by counting the number of users who have responded to the general notification. By modifying the formula described in [15], the number of attracted users, N_a, can be estimated as below,

$$N_a = f(N_0, p_a), 0 \leq N_a \leq N_0 \quad (1)$$

where p_a is a set of parameters to be characterized by the attraction features. The engagement process is abstracted as a black box function $f(\cdot)$ with respect to the total number of passers by N_0 and a set of attraction parameter p_a.

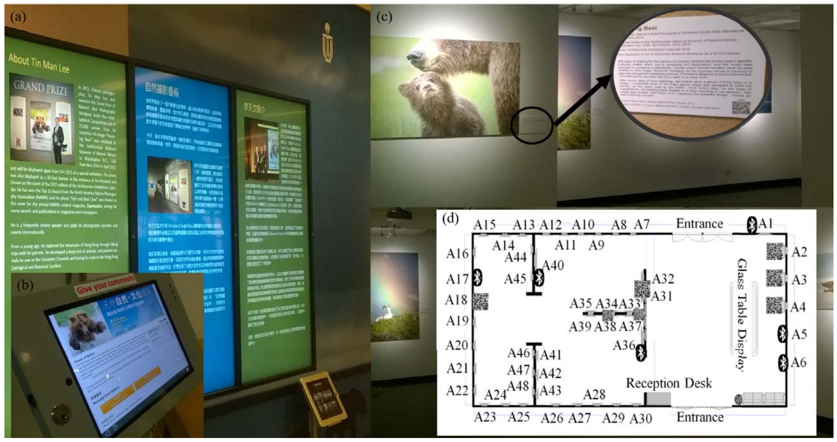

Fig. 4. The Gallery: (a) The digital information panel, (b) the embedded touch-screen devices, (c) the QR code, and (d) the gallery blueprint

Similarly, the number of interacted users, N_i, can be generalized as follows,

$$N_i = f(N_a, p_i), N_i \leq N_a \leq N_0 \tag{2}$$

where p_i is a set of parameters to be characterized by the interaction modalities.

Note that not every passers-by will be attracted, and not every attracted users will end up interacting with the system. Our design goal here is to increase engagement conversion rate, E.

$$E = \frac{N_i}{N_a}, 0 \leq E_t \leq 1 \tag{3}$$

Clearly, E is subject to the attraction rate ($\frac{N_a}{N_0}$). However, high attraction rate does not necessary indicate a high E, as stated in one of the discussed issue, those attracted users might not end up interact with the system due to the complicated interaction process.

- *Quality of Experience*: The quality of experience (QoE) to be examined in this paper is the user engagement during the interaction stage. The time users spent interacting can be a good indicator of QoE. However, the overhead induces during the interaction can cause frustration in users and degrade the engagement quality. Hence, it is imperative to investigate the interaction overhead at the interaction stage to ensure the QoE.

5. EXPERIMENTAL TESTBED

This section first discusses the deployment of the Ping Yuan and Kinmay W. Tang Gallery [1] and follows with a description of the evaluation methodologies.

[1]Natural World, Cultural Elegance: A Photography Exhibition by Tin Man Lee, "http://library.ust.hk/info/exhibit/tinman/tinman-intro-eng.html"

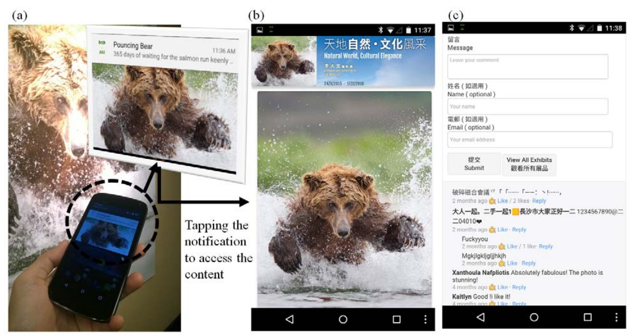

Fig. 5. Interactive gallery application: (a) Notification, (b) Content, and (c) Comment section

5.1. Gallery Deployment

Fig. 4(a) shows the 4 digital information panels installed at the entrance to the gallery. Fig. 4(b) shows the touch-screen devices installed at the gallery. A text description is pasted right next to the artwork. Fig. 4(c) shows the QR code found at the bottom of the text description.

In total, there are 48 artworks in the gallery: 7 artworks were embedded with a QR code, 6 were integrated with the proposed framework, and the rest are just non-interactive artworks. Besides that, there were also few touch-screen displays around the gallery.

5.2. Evaluation Methodologies

Notify-and-Interact is implemented in the said gallery. A smartphone is installed with the developed interactive applications. Fig. 5(a) shows the notification sent to users when they are near the artwork. Instructions attached to the notification is served to guide users for further interaction: preview artwork's (Fig. 5(b)), comments and reviews(Fig. 5(c)).

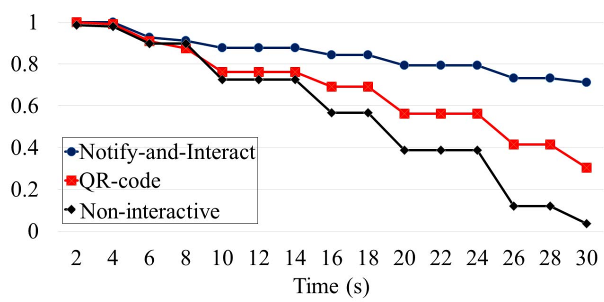

Fig. 6. The attraction ratio at different duration

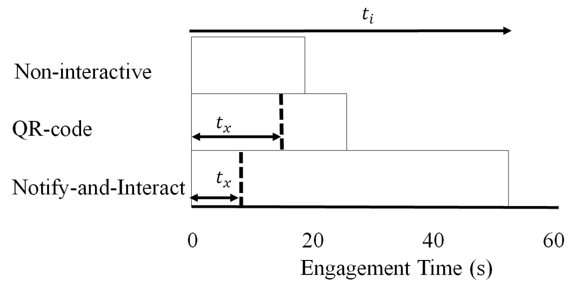

Fig. 7. Quality of engagement, Q_e

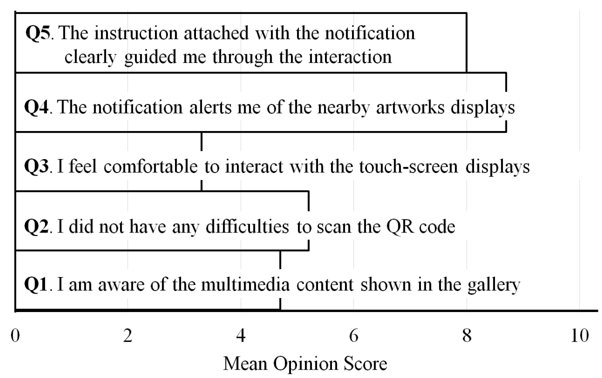

Fig. 8. The mean opinion score collected from likert assessment

Users were randomly invited on the spot to participate in the gallery tour. During the tour, users' behaviors and the time they spent on each artwork was observed and recorded. Likert assessments were carried out after the gallery tour, a total of 5 questions were asked. Each question is scaled from 0 to 10, with 10 signifies the highest satisfaction. Users were required to answer all the questions in less than 5 min such that the first impressions from the users can be captured without giving them the room for second thought.

6. EVALUATION RESULTS

This section evaluates the results collected from the experimental testbed. In total 30 users (16 Males and 14 Females, with ages ranging from 18 to 40) had participated in the interactive gallery tour.

6.1. Engagement Conversion Rate

Fig. 6 depicts the engagement conversion rate with respect to the attraction duration. The duration is calculated based on the average time all the 30 users had spent on each artwork. The graph shows that most of the users spent less than $8s$ on the artworks. Furthermore, the engagement conversion rate drops as time increases, which simply implies that the users lose their interests after certain duration. Overall, *Notify-and-Interact* achieves higher engagement conversion rate compared to the rest. In other words, we can said that *Notify-and-Interact* engages more users for further interaction, and users typically spent more time on the artwork which are installed with *Notify-and-Interact*.

6.2. Quality of Experience

The QoE is evaluated from 2 aspects; first we study the effects of interaction overhead on the quality of user engagement; second we investigate users' satisfaction through a MOS obtained from the Likert assessment.

- *Quality of User Engagement*: Fig. 7 shows the mean interaction time with induced overhead. Clearly, the overhead induced from QR code system (e.g., time taken to discover the QR code, open the App and scan) has degraded the quality of engagement. As for the *Notify-and-Interact*, the only overhead is the notification time. Regardless, the time spent reading the notification is comparatively short; furthermore, the aim of the notification is to drive users' attention back to the artwork.

- *Mean Opinion Score*: Fig. 8 shows the MOS for each of the assessment questions. It is not surprising to see that more than 50% were unaware of the multimedia content displayed in the gallery. 52% were aware of the QR code; however, most of them confessed that they were lazy to scan the QR code due to the cumbersome process. Only 33% felt comfortable interacting via the touch-screen displays, whereas many raised their privacy concerns interacting publicly. For the *Notify-and-Interact*, many agreed that the notification increased their awareness regarding the installed interaction modalities, with 87% complimented the simplicity and intuitiveness of the interaction process. Overall, *Notify-and-Interact* achieves high MOS score, with more than 80% satisfaction.

7. CONCLUSIONS

This work presents a novel interactive framework that encourages an active notification and intuitive interaction by keeping the complicated technologies in the background. The implementation of *Notify-and-Interact* in a gallery application has proven its feasibility. The activeness of *Notify-and-Interact* has increased the engagement conversion rate, and the intuitive interaction modality has enhanced the QoE. Experiment has proven that the private notifications are more efficient in increasing users' awareness compared to public notifications. And, private interactions have received higher user acceptance compared to public interactions. To conclude, *Notify-and-Interact* is a promising interactive framework with high user engagement. And the deployment possibilities of *Notify-and-Interact* are beyond imagination.

8. ACKNOWLEDGMENTS

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9. REFERENCES

[1] Fernando Reinaldo Ribeiro and José Metrôlho, "Context-aware information systems for public spaces: The public and private dichotomy. overview, challenges, and experiments," *International Journal of Multimedia and Ubiquitous Engineering*, vol. 11, no. 3, pp. 11–22, 2016.

[2] Jörg Müller, Dennis Wilmsmann, Juliane Exeler, Markus Buzeck, Albrecht Schmidt, Tim Jay, and Antonio Krüger, "Display blindness: The effect of expectations on attention towards digital signage," in *Pervasive Computing*, pp. 1–8. Springer, 2009.

[3] Roy Want and Bill N Schilit, "Interactive digital signage," *Computer*, , no. 5, pp. 21–24, 2012.

[4] Sarah Clinch, "Smartphones and pervasive public displays," *IEEE Pervasive Computing*, , no. 1, pp. 92–95, 2013.

[5] Svebor Karaman, Andrew D Bagdanov, Lea Landucci, Gianpaolo DAmico, Andrea Ferracani, Daniele Pezzatini, and Alberto Del Bimbo, "Personalized multimedia content delivery on an interactive table by passive observation of museum visitors," *Multimedia Tools and Applications*, vol. 75, no. 7, pp. 3787–3811, 2016.

[6] Hannu Kukka, Jorge Goncalves, Kai Wang, Tommi Puolamaa, Julien Louis, Mounib Mazouzi, and Leire Roa Barco, "Utilizing audio cues to raise awareness and entice interaction on public displays," in *Proceedings of the 2016 ACM Conference on Designing Interactive Systems*. ACM, 2016, pp. 807–811.

[7] Peter Peltonen, Esko Kurvinen, Antti Salovaara, Giulio Jacucci, Tommi Ilmonen, John Evans, Antti Oulasvirta, and Petri Saarikko, "It's mine, don't touch!: Interactions at a large multi-touch display in a city centre," in *Proceedings of the SIGCHI conference on human factors in computing systems*. ACM, 2008, pp. 1285–1294.

[8] Ivan Elhart, Federico Scacchi, Evangelos Niforatos, and Marc Langheinrich, "Shadowtouch: A multi-user application selection interface for interactive public displays," in *Proceedings of the 4th International Symposium on Pervasive Displays*. ACM, 2015, pp. 209–216.

[9] Yi-Ta Hsieh, Antti Jylhä, Valeria Orso, Luciano Gamberini, and Giulio Jacucci, "Designing a willing-to-use-in-public hand gestural interaction technique for smart glasses," in *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems*. ACM, 2016, pp. 4203–4215.

[10] Gregor Broll, Eduard Vodicka, and Sebastian Boring, "Exploring multi-user interactions with dynamic nfc-displays," *Pervasive and Mobile Computing*, vol. 9, no. 2, pp. 242–257, 2013.

[11] Matthias Baldauf and Peter Fröhlich, "The augmented video wall: multi-user ar interaction with public displays," in *CHI'13 Extended Abstracts on Human Factors in Computing Systems*. ACM, 2013, pp. 3015–3018.

[12] Tim Weißker, Andreas Berst, Johannes Hartmann, and Florian Echtler, "Mmm ball: Showcasing the massive mobile multiuser framework," in *Proceedings of the 2016 CHI Conference Extended Abstracts on Human Factors in Computing Systems*. ACM, 2016, pp. 3796–3799.

[13] Gregor Broll, Roman Graebsch, Maximilian Scherr, Sebastian Boring, Paul Holleis, and Matthias Wagner, "Touch to play–exploring touch-based mobile interaction with public displays," in *Near Field Communication (NFC), 2011 3rd International Workshop on*. IEEE, 2011, pp. 15–20.

[14] Andrea Bellucci, Paloma Diaz, and Ignacio Aedo, "A see-through display for interactive museum showcases," in *Proceedings of the 2015 International Conference on Interactive Tabletops & Surfaces*. ACM, 2015, pp. 301–306.

[15] James She, Jon Crowcroft, Hao Fu, and Flora Li, "Convergence of interactive displays with smart mobile devices for effective advertising: A survey," *ACM Transactions on Multimedia Computing, Communications, and Applications (TOMM)*, vol. 10, no. 2, pp. 17, 2014.