Exploring the role of data-supported social interaction manifested through public displays

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Abstract
This paper presents the early findings of studies in the role of data informing the interaction between the user, public and public display. It focuses on exploring how different strategies amplify and stimulate these data-supported interactions. Building on the work by Tomisch et al (13), we establish a taxonomy for data-based features under the category of key elements in urban visualisations: 1) addressed topics, 2) input technologies, and 3) visualisation output. We analyse how these factors facilitate social interactions meaningfully through case studies of previous projects developed and implemented by Media Architecture research community. We suggest that data properties and manifestation play a significant role in 1) sustaining attraction to passers-by 2) enriching public understandings of display, and 3) encouraging diverse participation.

Author Keywords
public displays, data property and manifestation, social interaction, perceptional and behavioural changes.

ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous; See http://acm.org/about/class/1998 for the full list of ACM classifiers. This section is required.

Introduction
The urban environment is increasingly mediated through the pervasive and emerging HCI technologies. Within the context of interactive public displays, researchers have provided rich insights in revealing how featured display configurations support social relationship, yet the relationship data itself on shared experiences between participants and the public still need to be clarified. In this paper, we aim to address 1) what is the factors that influence the social interactions and 2) how these factors support different types of

social interaction meaningfully. In order to explore these questions, we conducted a literature review to confirm the key factors, and case studies in several relevant projects to identify the perceptional and behavioural influence on participation. We explore the data properties and manifestation in framing and supporting public engagement. In particular, the criteria will be structured through existing bodies of ambient display taxonomies proposed by Pousman and Stasko (12), and Tomitsch et al (13), with a specific perspective in the input and display of information. We focus on 1) the taxonomy of data-related features in ambient display (information capacity, localness, and etc.) and 2) the type of augmented public interaction. Our findings are discussed in regard to social relationships and stress the perceptional and behavioural aspects of interaction.

Background Research

In the light of data contribution, Koeman (6) defined three key elements of information visualisations: 1) addressed topics 2) input technologies and 3) visualisation output. Under these the category, we identify and categorise the data-related features based on the previous study.

Extensive research has carried out to build a taxonomy of various features in ambient display. Matthew et al (7) firstly proposed three key characteristics of ambient display with a focus on the "peripherality", namely: *abstraction of data, selection of notification levels,* and *transitions between notification levels.* Based on the pioneering work, Pousman and Stasko (12) emphasise on the display of information and add "information capacity", "aesthetic emphasis" to the design dimensions of the display. They plot each dimension with five modes from "high" to "low". Tomitsch et al (13) further expand these dimensions into a more specific taxonomy with nine characteristics in the matter of data manifestation.

Several projects contributed to identifying the data attributes that influence social interaction. Netto et al proposed three layers of information-*physical, semantic* and *enacted*, according to their description, physical information represents the facts of environment, after interpretation it transfers into the semantic content, and enacted information play as the consequence for direct public use (9). In other aspects, Cleas and Vande Moore (3), and Wouters et al (17) outline that hyperlocality of information have an impact on public awareness and participation. The more relevant of the topic within the situated context, the more attention and understandings will be gained from public.

Framework of the Criteria

Based on previous studies (7)(12)(13), we build on previous work and suggest a taxonomy of key features in an interactive public display regarding to their correlation with data:

Addressed topics

1. Information content- The meaningfulness of input data: physical, semantic and customised. The definition of first two layers is similar to Netto et al (9), and customised information refers to free content created by participants.
2. Hyperlocality of topic- Social relevance between the topic and the situated context. Metrics: irrelevant, communal, hyperlocal.

Input Technologies

1. Input action- Input mechanism and behaviour of participants to submit the data.

2.User interface- Type of tangible user interface. Metrics is based on the work by Hespanhol and Tomitsch (4) and Behrens et al (2) as: Mobile interface, performative interface, allotted interfaces, and responsive ambient interface.

Visualisation Output

1. Modality- Type of visualisation. Metrics: visual, tactile, olfactory, and auditory.

2.Information capacity- The number of information sources that ambient display can present. Metrics: low, medium, high.

3. Visual dynamics- The rate at which data and visuals changes. Metrics: low, medium, high.

Data-triggered Social Interaction

Social interaction in public display has been explored extensively，while only several studies emphasise on the impact of data properties and manifestation on public experience. Based on the previous work (5)(11)(14)(18), the following lists main social phenomena evoked by displayed information. The influence is partitioned into two mingled aspects as "perceptional" and "behavioural" changes.

Perceptional changes

Before participation, people are motivated through the changes of their perception to display: Curiosity and incentives for engagement, collaboration, or competition. In "Honey-pot effect", arising curiosity from spectators plays as a key factor to maintain "action loop". According to Wouters et al (18), The effect is often related to the visibility of input actions and visualisation output. Exaggerative movement and vivid representation have more chances to attract public attention by its clash with surroundings (8)(10). While the incentives for competition, based on the work from Valkanova et al (15), is mainly motivated by visualisation result. These are feedforward under the influence. However, during participation, chances are there to raise "social awkwardness" due to the fear of submitting inappropriate data. According to Valkanova et al (14), this feeling could be amplified by the identifiable personal visualisation.

Behavioural changes

Behavioural changes usually happen during the shift of roles between passers-by, spectators and participators (18). "Honey-pot effect" keeps the cycle of three roles and stimulate both active and passive engagement in the display (11). The passers-by turn into spectators by noticing the interactivity, and the spectators transfer to participators through input actions. After they quit interaction, they may have a discussion with new curious spectators about interaction rules (18). Although some audience are out of "action loop", they might get involved in the social discourse when the addressed topic is hyperlocal or there are discrepancies in understanding the projected information. "Social comparison" often happens between participators and spectators. It is more related to the type of data and visualisation style. Usually, physical and semantic data are more likely to trigger discourse as they are often related to a common issue or experience.

Case studies

To explore how these features in taxonomy support social interaction, we analysed existing projects that we identified as good examples. Drawing on the literature

Figure 1: During participation, People decided to put photos on the tile after submitting his opinion in "My Position". (http://www.rwalter.de)

Figure 3: In "Reveal-it!", people submit data of individual energy consumption and average community usage through public input entry. (https://ai2-s2-public.s3.amazonaws.com/figures/2017-08-08/cfc5d97e1209bc4757ef9ebb881108a425448b97/5-Figure3-1.png)

that outlines the project that we selected, we are able to gain an intensive understanding in its social effects. In the following section, we explain briefly the project component and highlight the corresponding changes on passers-by.

My Position

"My Position" is a large interactive poll visualisation aimed to support situated deliberation of citizen opinions. The visualisation is made of a series of square tiles, and each represents the opinion submitted by single participator. According to Valkanova et al (14), several goals have been achieved during projection: 1) Low barrier entry (simple gestures and guidance texts) and playful input action (Kinect sensed movements and options for photo taken) encouraged all participation and 2) it succeed at raising awareness of public opinions and sparking social debates.

Features	Component	Perceptional changes	Behavioral changes
Info	Semantic	Understanding	Discourse, Spectating, Participating
Hyper-locality	Hyperlocal	Understanding Social Awkwardness	
Input	Gestures	-	Spectating, Participating
User interface	Performative	Curiosity	
Modality	Colored Tiles	-	Discourse, Comparison, Spectating, Participating
Info capacity	High-cumulative	Incentives for competition	
Visual dynamics	Medium	Curiosity	

Table 1: The analysis of perceptional and behavioral changes triggered by data-supported features in "My Position".

Reveal-it!

"Reveal-it!" is an interactive public projection supporting comparison between energy consumptions of individuals and community averages (15). This project explores how communal data visualisation influence the user awareness, participation and discourse of differentiated understandings to the display. Valkanova et al concluded it successful in raising public awareness and stimuli discussion (14), yet, they also emphasized that there are difficulties in visualizing aggregated data as it may decrease public trust to projected information and lead to false input.

Features	Component	Perceptional changes	Behavioral changes
Info	Physical	Understanding	Discourse, Comparison, Spectating, Participating
Hyper-locality	Communal	Curiosity Social Awkwardness	
Input	Online Form	-	Participating
User interface	Mobile	-	
Modality	Polar diagram	Incentives for competition	Discourse, Comparison, Spectating, Participating
Info capacity	High-cumulative	Incentives for competition, Decreased trust	
Visual dynamics	Low to medium	-	

Figure 3: In "Solstice LAMP", people play with their avatar-like representation solely or collaboratively. Shapes of polygon change with user movement and merge into bigger one when people get close. (http://www.martintomitsch.com)

Figure 4: In "Shadowing", people submit playful movement under street lights embedded with motion-capture sensors. Sometimes they play with their shadows after submission. (https://www.playablecity.com)

Table 2: The analysis of perceptional and behavioral changes triggered by data-supported features in "Reveal-it!".

Solstice LAMP

"Solstice LAMP" is an interactive installation deployed in Vivid Sydney 2013. The display enables passers-by to generate their own avatar animation and sounds that travel up to building facades by peculiar sonic and visual technologies. Based on the field study conducted by Hespanhol and Tomitsch (4), vivid projection attracts much public attention, and intuitive input actions in allotted interface enabled quick understandings and participation from spectators. According to their observation (4), multi-use mode in the display to some extent encouraged negotiations or further collective activities between strangers.

Features	Component	Perceptional changes	Behavioral changes
Info	Customised	Curiosity	Spectating, Participating
Hyper-locality	Irrelevant	-	
Input	Full-body movement	Curiosity	Discussion, Spectating, Participating
User interface	Allotted	-	
Modality	Flexible polygons	Curiosity	Discussion Spectating, Participating
Info capacity	High-Real-time	Incentives for collaboration	
Visual dynamics	High	Curiosity	

Table 3: The analysis of perceptional and behavioral changes triggered by data-supported features in "Solstice LAMP".

Shadowing

Shadowing is an interactive lighting installation published by Chomko and Rosier. It gives memory to city street lights, enabling them to record and play back the shadows of pedestrians who passed underneath. According to the study from Anton (1), it succeeds at using simple input entry to attract diverse participation, and dynamic shadow encourages creative contributions. Based on the recordings from Chomko and Rosier (1), during display, passers-by are paused to watch playful shadows contributed by last user, further many of them participate in creating new shadows. The observation indicates that some users tend to play with their own shadows and make repetitive submission.

Features	Component	Perceptional changes	Behavioral changes
Info	Customised	Curiosity	Discussion Spectating, Participating
Hyper-locality	Irrelevant	-	
Input	Full-body movement	-	Spectating, Participating
User interface	Performative	Incentives for participation	
Modality	Shadows movement	Curiosity	Discussion, Spectating, Participating
Info capacity	Low-Temporary	Incentives for participation	
Visual dynamics	Medium	-	

Table 4: The analysis of perceptional and behavioral changes triggered by data-supported features in "Shadowing".

Findings and Discussion

The main findings of the case studies indicate that, different data-based features supporting different social experiences:

The rising of perceptional changes is mainly evoked by displayed content and data manifestation. Physical and semantic information could be easily accepted and understood by the public, while the customised content arises more curiosities. The more pedestrians are related to topic, the more concerns they show to the display. However, it may lead to the negative effect "Social awkwardness"- Since content is shared with local community or large audience, some potential participators are held back by the fear of submitting inappropriate data in front of public (14). Visualisation output stimulates perceptional changes by information capacity and temporality. In "My position" and "Reveal it!", the accumulated projection of personal information leads to comparison between participators, and to some extent, it also motivates spectators to join the competition (16). While for customised display, people are encouraged to crate identifiable content instead of setting up competition. Besides, the dynamic projection maintains sustainable attractions to spectators.

According to the analysis, perceptional changes evoked by data-based features further encourage different behavioural changes. In "Reveal it!", accumulative projection of personal data causes differentiated understandings which leads to social comparison and discourse (15). While the curiosity for customised content has more chances to raise social talk or discussion, as shown in "Solstice LAMP" (4). Input technologies trigger curiosity and participation through exaggerative input actions or the real-time interactivity between user input and interfaces. Compared with mobile or distributed devices, Public interfaces or screens with interfaces embedded could acknowledge the public of interactivity easily. For display output, rich visual style of aggregated information incentivizes competition or collaboration, while real-time display attracts more curiosity and casual participation.

Conclusion

In this paper, we explored the role of data in the ambient display and its impact on social interactions. The results suggest, the addressed topic not only defines the main content of display, but also has a great influence on maintaining the spectator curiosities. due to its social relevance of topic. Input technology plays a significant role in supporting pedestrians' notice of display interactivity and further participation. For output, besides attracting attention, it also affects public understandings of display. Further studies need to be carried out in uncovering connections between data-supported experience and contextual factors. In particular, we want to know under different context, how data-related features influence social interaction.

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