

Review on Interaction Design for Social Context in Public Spaces

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Abstract. This paper presents a structured literature review on interaction design for social contexts in public spaces, especially the research on designing for public interactive facilities, such as public displays, interactive installations and media façades, aiming to gain a holistic understanding on current research. A framework is also introduced to help summarize current research focuses, considering interaction process, social impacts and spatial factors as three main layers of it. Based on the framed results, the paper discusses possible design opportunities and challenges, bringing new perspectives into interaction design in public spaces.

Keywords: Public space · Social context · Interaction design

1 Introduction

Public spaces, generally considered as places where “civic, cultural and social activities occur”, play an important role for public life, promoting the sense of community, enhancing the connection between people and place, and helping create a sense of belonging. It provides citizens with spaces and opportunities to exchange information and communicate on local issues, enjoying the gathered experiences with others [1].

In recent years, driven by technical and societal development in smart cities, such as the construction of sensing networks and intelligent systems, and the growth of mobile networks and the Internet of Things [2], public spaces gradually become interactive and responsive [3] both in providing basic public services and in improving urban social life. The continuously lowered cost and the increasing number of interactive facilities in public space, like public displays [4, 5], digitally augment and transform the traditional existences in urban space, such as buildings, bridges, and public statues, into public media where the social interactive experience can be sculptured with the public participation [6–8].

Meanwhile, the maturity of social networks and mobile service largely increases the means of social interaction, generally popularizes the information posting and sharing behaviour, and partially merges online activities into real spaces. Daily activities and life styles of people are changing quickly along with the technical developments, including the attitude towards online and offline social interactivity, as well as the way the space is used, which may bring new challenges to interaction design.

In this paper, we present a literature review of current research on interaction design in public spaces, especially for social contexts, through an iterated searching process and a framed analysis. Research topics mentioned frequently in research are recorded to present a general state of focuses and challenges. The findings are summarized into an initial framework, considering the interaction process, social impacts and spatial factors as three main layers of it. The derivation of this framework indicates the design possibilities in multi-place contexts that are less mentioned in reviewed papers, and brings new perspectives into interaction design in public spaces.

2 Review on Current Research

So far, there has been a large amount of research on both specific design contexts and the strategy level (e.g. research on urban interaction design [9] and smart city platform [10]) for interaction design in cities. In this paper, the search focused more on studies starting with concrete design contexts, while the potentials of interdisciplinary cooperation will also be discussed as extension.

Researchers and practitioners are taking up the challenges, exploring the potentials of interaction design for social contexts in urban space, including the research on media facades (e.g. Aarhus by Light and The Climate Wall [11]), public screens (e.g. Outdoor UBI hotspots in Oulu [12] and The Wray Photo Display [13]), mobile applications (e.g. Tiramisu [14]), and interactive art installations of which the contents and final forms may be co-created by the crowd (e.g. public art installation for Taicang [6]). Most of the research, if not all, seems to focus on concrete interaction (e.g. the form of manipulation and the material for embodiment), effects on social behaviour among citizens (e.g. the research on engagement), and spatial factors of public space.

2.1 Structured Review Searching

The review mainly went through three steps: (1) a review of related workshop paper collections; (2) a general searching and filtering with web searching tools; (3) a focused review on highly related and updated conference papers. Keywords were revised according to the results during the iterating process, except the main keywords of “public space”, “interaction”, “social” and “social interaction”.

The review started with summarizing of position papers from CHI Workshop 2013, of which the theme was “experiencing the interactivity in public space (EIPS)” [15], gaining an initial knowledge on recent research interests and design concepts.

The second step was to conduct a general searching with keywords mentioned above via Google Scholar. The initial results were filtered again according to the titles and abstracts, as well as the re-checking of the keywords.

The last step ended with a searching for main and influential conference papers, using the same keywords and similar filtering methods, while this time the search was mainly focused on the research papers in recent five years (2010–2014).

According to the relevance of the content and citations of the paper, 77 papers were selected from the 164 searched pieces (Table 1) for the further review in detail.

Table 1. Searching results in total

CHI	PerDIS	DIS	CSCW	TEI	MobileHCI	UbiComp	Others	Total
63	16	9	7	7	7	12	43	164

*Others include: MAB, INTERACT, NordiCHI, OZCHI, Digital Creativity, MUM, AVI, and ICEGOV etc.

2.2 Summary of the Results

Tables 2 and 3 present the highly mentioned topics, which are discussed as research content and methods respectively. The numbers represent a count for papers that relatively consider the topics as main focuses or important content in their studies, while not suggesting that the rest of reviewed papers would be absolutely irrelative to

Table 2. Research topics mentioned in relatively high frequency

Themes	Sub-categories	Research topics under themes	Papers
Concrete Interaction Design	Input Mainly focusing on modality and human manipulation	Whole body interaction	12
		Extra tools input (e.g. mobile device)	11
		Touch (multi-user contexts)	9
		Urban sensing (e.g. camera)	8
	Output Mainly focusing on presentation and interface highly combined with physical environment	Public display	26
		Interactive installation	14
		Media facade	12
		Personal mobile device	12
Social Impacts of Interaction	Human Behaviour	Service system	12
		Communication & Share	32
		Collaboration	14
	Cognition & Perception	Performativity & stage metaphor impact	6
		Enhance user engagement	16
		Increase motivation or attention	10
Spatial Factors	Mainly focusing on spatial factors that influence on social behaviour	Social acceptance on interaction or social behaviour	10
		Spatial influences from layouts and surroundings (Mainly in co-located contexts)	17
		Societal function influence and situated factors	6

Table 3. Research types and evaluation methods mainly discussed in studies

Themes	Research topics under themes	Papers
Research	Practice (introducing experiments, field trials or case studies)	46
	Exploring design methods, frameworks or patterns	21
	Theoretical analysis and deduction	18
Evaluation	Observation	11
	Interview	7
	Questionnaire	5
	Data log in system	3

the topics. Although this record is not a precise statistics, it is helpful enough to give indications on current distribution of research attentions and trends.

Summary of research contents. As showed in record (Table 2), there are three major themes in search results: (1) concrete interaction design; (2) social impacts brought by the interaction; (3) spatial factors influencing the interaction and social behaviour. The topics are not separated from each other, but inter-connected in practice to reach specific design and research objectives. Usually, the study questions can be raised as exploring the behavioural and social impacts of specific interaction process, or discussing possibilities in interaction and space design to facilitate social experience.

Concrete interaction design is the first theme with the most-frequently mentioned topics in record, including studies like designing specific manipulation and exploring new modalities as potential interfaces. According to the basic interaction framework introduced by Abowd and Beale [16], topics are categorized by “input” and “output” process.

Research on input pays much attention to the multi-user context, and often focuses on exploring manipulations and input modalities, including gestures [15, 17] (ranging from hand gesture to whole body interaction), touch [15, 18], portable devices (e.g. smart phones), urban sensors (e.g. surveillance camera), and even sound interfaces (SI) [15]. And studies on output usually discuss about materials, platforms and technical solutions for presentation. Public display [19] is most often used in research. Media façades [11] and interactive public installations [20] are increasingly employed in large-scale design, while personal devices are popular in providing customized services. Participatory performance is also mentioned for research on human behaviour in social context [15, 21].

Social impacts of interaction look into the influence of interaction on people’s behaviour and cognition. Main objectives of research include summarizing behaviour patterns and exploring how people understand, feel or get reflection on specific interaction or social relationship they are involved in.

Behavioural influences are usually studied through the observation on how specific interaction facilitates the communication between people in public spaces, including the studies on sharing, cooperating and competing behaviour, as well as the research on people's observing and reacting behaviour during the interaction (e.g. the transformation between the role of spectator and actor [22]). This research often deploys in two directions: (1) improving manipulation, modalities or tools to lower thresholds for people joining the activities; (2) improving content design or user task setting to facilitate social behaviour naturally [23].

Reviewed studies concerning the social impacts on cognition mainly discuss enticing or enhancing the user engagement [23], facilitating the feeling of connection, and exploring the range of social acceptance [15].

Spatial factors in review mainly discuss the influences brought by physical and societal features of public space on interaction process and human behaviour.

Research on physical features can be seen in the design of space layouts and surrounding environment to influence people's behaviour, including two major contexts - co-located interaction and remote interaction [24]. Combination with digitally augmented layers is also tried to enhance the spatial influence on human behaviour [15].

Societal features of different public spaces influence social behaviour of people and design of the facilities, like open space is generally used for large-scale design and short-term interaction, while indoor spaces are often used for detailed interaction or immersive experience.

Summary of research methods. Table 3 presents research types and evaluation methods used in practice, which indicates that most of the studies are based on practical design projects. There are some studies considering design methods and guidelines as major output, while fewer mainly conduct theoretical analysis or deduction, since design for interaction in public space always meets situations that cannot be foreseen or controlled in laboratory environment. The working prototypes and field trials of design play a significant role in research, especially in evaluation, which leads to a result that currently the observation (watching or video recording) combined with structured interview (with questionnaire) is considered as most feasible and practical evaluation method for user testing in wild [18].

2.3 Design Challenges in Current Reviewed Research

Being in the public spaces challenges interaction design with situations that can hardly be simulated in laboratory environment. The design can hardly be addressed specifically for certain group of regular users, and is usually defined as intuitive usage or needs to be "obtainable without prerequisites" [25]. Furthermore, there are also challenges in facilitating aesthetic communication and user experience, as well as in "utilizing the inherent qualities of public spaces to their full potential" [25].

Challenges in Design. The challenges summarized in this review paper can be discussed as dealing with the balances between several groups of trade-off relationship.

The first is to reach the balance between the single-user and multi-user context, which includes three sub-relationships: the individual operation versus the collective

operation, the customized service versus the common use, and the privacy of users versus the publicity of the interaction [23].

The second important challenge is the conflict between the stable existence of the facilities and the continuous interest of people. How to keep people continuously interested in and engaged with the design is a great challenge for public space context.

The third one is to deal with the conflicts in manipulation design, including the balance between the artificial interaction and natural movements, and the combination of digital content and physical environment. The most common design question is how to design novel interaction form with appropriate affordance to entice users' intuitive manipulation.

And the last challenge is to balance the relationship between entertainment and functionality. It always requires a compromise to keep the design both entertaining and functional in use, as well as both precise and inclusive in manipulation.

Challenges in evaluation. As discussed in reviewed papers, some parameters can hardly be measured in laboratory environment, such as "effectiveness, social effects, audience behavior, and privacy implications" [5, 26]. Therefore, field studies are necessary in research to explore different design conditions, "gaining insights into relevant design parameters while still ensuring a high ecologic validity for the data" [27].

Currently, most of the evaluation is deployed as the combination of interview (questionnaire) and observation, while with technical development and changes in people's usage of public media, there is a potential to design new methods that are more efficient and suitable for evaluation in future user contexts, such as collecting feedbacks through the social media or information shared through the interaction.

3 Framed Analysis and Exploration

Base on the findings, an initial framework is introduced, showing the three layers of main reviewed factors for interaction design in public space, and aiming to gain a better understanding on the summarization of review. The framework is inspired from a progressive combination of the basic interaction framework [16], the tangible interaction framework according to Hornecker and Buur [28], and the review finding in this paper.

The basic structure of interaction from HCI perspective, introduced by Abowd and Beale [16], can be considered as a circle of four elements: user, input, system and output (Fig. 1). This structure may become more user-centered with partially considering spatial and social factors (Fig. 2), when located into physical media to enhance the connection between people and the real place, such as in tangible interaction design [28].

When designing for interaction in public space, the social and spatial factors appearing in field context become increasingly important. The studies need to not only take the original interaction structure into consideration, but also treat the social relationship and spatial influences at almost the same hierarchy. Thus, the design and research practice need to tackle a three-layer relationship, which is also indicated in review findings (Fig. 3): the interaction layer, the social layer and the spatial layer.

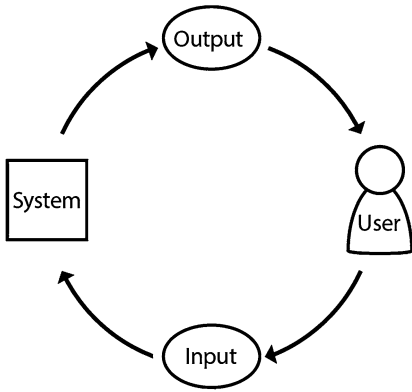


Fig. 1. Basic structure of interaction

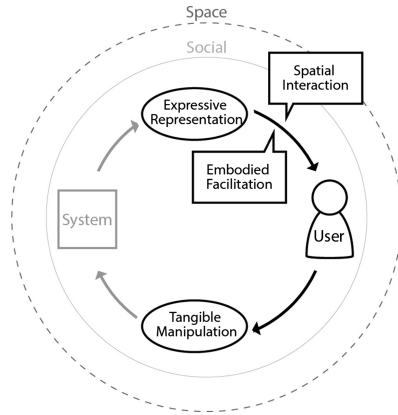


Fig. 2. Structure of tangible interaction introduced by Hornecker and Buur.

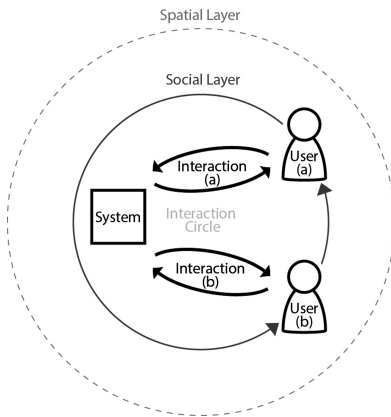


Fig. 3. Three-layer framework summarized from review findings.

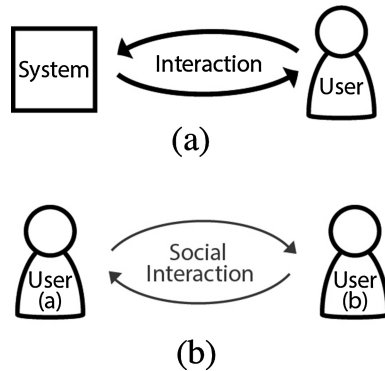


Fig. 4. Contexts that do not belong to the interaction discussed in this paper.

The interaction layer is the core of the framework. It matches the first theme in the summarization of review, and is also a basic premise of research in our review. The design without interaction, or the purely social interaction between people without interaction design intervention or mediation (Fig. 4b), may not belong to our research scope. In this circle, current research is making efforts to explore the new forms, materials and modalities of input manipulation and output presentation through the interaction process.

The social layer matches the second theme in review. It considers with the social interaction between people in the contexts (impacts on behaviour), and looks into the influences on people’s thinking and feeling (impacts on cognition). When put into the public spaces, the interaction between human and interactive facilities (Fig. 4a) usually

transforms into a social behaviour, due to the sociality embedded in the basic feature of public space. For instance, according to the explanation of the spectator-actor relationship, an individual usually holds an idea of being watched by the public or someone, even if he (or she) is the only person in front of the facility in public.

The spatial layer, matching third theme in review, refers to the consideration on spatial factors like the layouts of surrounding areas (no matter natural or digitally augmented) and the societal functions of different types of public spaces. As mentioned in review, these factors may have important influences on manipulation and presentation design of the interaction, as well as on people’s social behaviour.

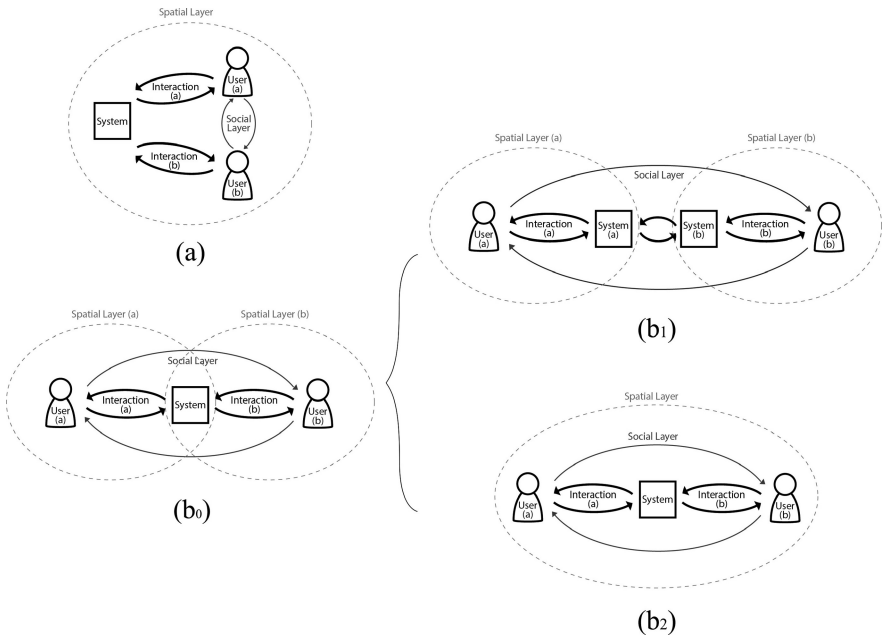


Fig. 5. Extended framework of interaction in social contexts in public space

Most of the research in review can be analyzed with this initial framework. However, differences between some contexts are not presented very clearly, for instance, the distinction between co-located situation and remote interaction context. Based on this consideration, an extension of the framework with derived contexts is employed, making it more detailed in interpretation of interaction design for social context in public space (Fig. 5).

The first context (Fig. 5a) represents one part of the basic co-located situation in public space. The users interact with the system (the public interactive facilities), and socially interact with other users during the interaction. This can be seen in many studies, especially those that focus on facilitating users’ cooperation or competition behaviour through the interaction.

The second context (Fig. 5b₂) shows the other part of the co-located situation, in which the users interact with the system and socially interact with other users through the system without face-to-face social interaction between each other. This context can usually be seen in projects with large group of participators, such as interacting with a public screen by sending comments through mobile phones at a event [15].

The third context (Fig. 5b₁) describes the multi-place situation, which is rarely discussed in reviewed studies. In this context, users interact with the co-located facilities while socially interact with other users at different places through the system. It presents a situation of connecting two or more places together for interaction, which is little mentioned in current design concepts. A limited number of examples can be found in research on remote social interaction, such as *Telemurals* [24] and remote sports game *Breakout for Two* [29].

Matching design focuses and challenges to this framework, it indicates that the contexts in real environment usually present as combinations of the basic contexts in the framework and may dynamically transform between different contexts during the interaction. It also shows that current studies are usually focused on co-located contexts. Few trials and experiments are conducted in multi-place situations. At the same time, design focuses and challenges are often focusing on the problems within one layer or the relationship between two layers.

There is still a large design space for multi-place interaction, which calls for exploration to design and organize the factors in three layers together. It can be deployed through a structural thinking that is flexible and responsive to the real-time changes. The linear structure (e.g. timeline) may no longer be a dominant reference for structuring, while spatial factors like location can be involved in design process.

This discussion on potential possibilities indicates to organize the factors in the framework at a structural level, helping the whole interaction dynamically unfold in public spaces, in order to enhance the connection between digital content and physical space, as well as bring new experience into interaction design.

4 Conclusion

In this paper, we present a structured literature review for current research on interaction design for social contexts in public space. The main objective of the review is to help designers and researchers gain a holistic understanding on current research stage and explore for further possibilities, based on the summarized design focuses and challenges.

An initial three-layer framework is presented for structured analysis on review content, considering the inter-relationship between interaction process, social influences and spatial factors. The derivation of the framework helps discussing potential design opportunities in multi-place contexts, which are less mentioned in the review.

The discussion suggests organizing the factors in the three layers of the framework through a structural thinking to help the interaction unfold in multi-place situations. Although there may be new challenges coming along with the further research, the

framework and its derived discussion in potentials are considered to be helpful in finding opportunities for novel interaction and user experience design. Future work on refining the framework is needed, as well as summarizing theoretical guidelines or patterns for more appropriate guidance on design practice.

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