

# Public displays for public participation in urban settings: a survey

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## ABSTRACT

Public displays can be used to support public participation in urban settings. This article provides a survey of the use of public displays for public participation in an urban context, covering articles on this topic published between 2012 and 2016. 36 papers were selected and analysed along eight dimensions: type of political context, type of scientific contribution, standalone displays vs displays with a device, single vs multi-purpose displays, shape of displays, lab vs field study, deployment in public vs semi-public space, and the level of public participation addressed. Our analysis revealed a number of trends regarding public displays and public participation in urban settings. Inspecting these articles also led to the observation that current research on public displays is mainly targeting lower levels of public participation and that the evaluation of public displays for public participation in urban settings remains a challenge.

## ACM Classification Keywords

H.5.2. User Interfaces: Theory and Method

## Author Keywords

Public display; citizen engagement; public participation; urban setting.

## INTRODUCTION

Nowadays a wide range of online technologies are available for public participation, such as e-mail, web forums, chat rooms and bulletin boards [14]. However, due to the private nature of these tools, parts of the population may become marginalized if facts and informations about urban life were only delivered through these channels. Public displays are a technology that has the potential to transform our urban environments and to dramatically change current city life [28, 41]. Specifically, they can be used to encourage local participation by informing citizens about available opportunities – in their immediate vicinity – to contribute to the urban life. As Goncalves *et al.* [19] pointed out, public displays are useful in generating interest in a particular topic, and in channeling respondents to other mediums. There is already some research exploring

a variety of ways to stimulate public participation amongst certain communities, e.g., through a sentiment dashboard that gives citizens the opportunity to express their mood about local challenges [6], by collecting citizens' feedback via voting systems [11, 35] or by using tangible interaction to explore different forms of community engagement [12]. Public displays as pervasive technologies have the potential to reach a broader group of stakeholders. The well-known honeypot effect [9] is one factor that public displays can use to draw more attention from potential participants. However, up to now there has been comparatively little research looking into how public displays are used for public participation in urban settings. This is the main motivation for the present work as it reports on a systematic literature survey on this topic.

Public participation can be defined in different ways. Throughout this article, we will use the definition from the European Institute for Public Participation [16], which defines public participation as: “the deliberative process by which interested or affected citizens, civil society organisations, and government actors are involved in policy-making before a political decision is taken. By deliberation we mean a process of thoughtful discussion based on the giving and taking of reasons for choices”. This definition emphasizes the involvement of stakeholders to come to a shared understanding of issues and solutions. While public participation can bring great value to all stakeholders, more efforts are needed to facilitate public participation and realize its full potential. Developing and emerging information technologies have great potential to support citizen participation in decision-making processes [20]. As one kind of information technology, public displays have proven to be able to facilitate participation opportunities for citizens through interactions such as questionnaires, voting, and discussion via simple text entry [23, 37, 6].

In this paper, we report on a survey on the current development of public displays for supporting public participation in urban environments. We focus on studies published on the ACM digital library between 2012 to 2016, and try to give a thorough analysis of the papers surveyed to give some inspiration for future research on public displays in this context. Our contribution is two-fold. First, we provide a review of recent research progress of using public displays for public participation in urban settings by analysing various research dimensions of public displays in these papers. Second, we summarise the challenges and opportunities for future studies on achieving higher levels of public participation by using public displays.

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The paper is organized as follows. We first briefly review related work on surveying research in the public display field. We then describe our data collection process in detail, including the inclusion criteria we used for selecting papers from ACM digital library. The main part of the paper reports on the analysis of the collected papers, points out current research trends, challenges and opportunities, and reflects on the limitations of our work. The paper concludes by briefly summarizing our main contributions.

## RELATED WORK

An early survey<sup>1</sup> on large high-resolution displays was carried out by [38]. The survey covered aspects such as hardware configurations, rendering, steaming, as well as application areas of large high-resolution displays. Ni *et al.* [38] mentioned several challenges with respect to research on large displays. These included overcoming variations of color and luminosity which may easily break the illusion of a single seamless display; building large-scale, high-resolution head-tracked stereoscopic displays; creating displays that can easily be reconfigured and support diverse form factors (e.g., flat, curved); the development of effective interaction techniques for large public displays; and presenting empirical evidence as to the benefits and limitations of large high resolution for a range of tasks.

Surveys focusing specifically on interaction techniques for large displays were presented in [7, 26]. In his article, Bierz [7] discussed gaze tracking, head tracking, body tracking and gesture interfaces as possible interaction techniques. Khan [26] listed at least four means of conveying information to, and receiving information from a large display: speech, tracking, gestures and haptics.

Ardito *et al.*'s comprehensive survey [3] was concerned with the evolution of the use of interactive large displays over the years. Ardito *et al.* proposed five classification dimensions for previous research on public display: visualization technology (e.g., projection or monitor), display setup (e.g., horizontal, vertical, diagonal, or floor display), interaction modality (e.g., external devices, touch or other body movements), application purpose (e.g., productivity, entertainment, social interaction, gaming and advertising), and location (e.g., city, office, university/school, conference).

According to their findings, before 2004, both projections and monitors were used. Since 2004, however, projections have been more frequent than monitors. In addition, the vertical setup is still the most popular and currently trailed by the horizontal setup. There are commercial solutions available for the vertical and horizontal setup, but all other setups are still in an experimental phase. As for interaction modalities, touch-based interaction is the oldest and still most used modality, but there is a growing number of systems tracking the users' body movements to realize interaction with large displays. Most public displays are designed to provide a specific utility to their users (i.e., they are designed for productivity). Regarding

<sup>1</sup>'Survey' in this section refers to academic writings on public displays (i.e., overview of work done in the field), not to survey research (i.e., data collection about a group of people through interviews or questionnaires).



Figure 1. Author keywords of relevant papers from PerDis on public participation in an urban context.

location, installations of displays in offices prevailed in the earlier years. However, as Ardito *et al.* [3] observed, systems are increasingly installed in cities, universities, schools, and sites of cultural interest in recent years. Challenges for large displays that were mentioned in [3] include blended interaction in ubiquitous environments, better understanding the potential of large displays to foster collaboration, making public displays accessible to disabled people, and the evaluation of public display research.

As this section illustrates, previous surveys looked at various aspects, produced a set of different insights and identified a series of challenges revolving around public displays research. None of them has however specifically looked at the benefits and challenges of utilizing public displays for public participation in urban settings. This paper aims to fill that gap.

## DATA COLLECTION

In order to ensure the analysis of relevant papers in our survey, we organized the selection process by steps as described in this section. At the beginning, we defined inclusion criteria of the papers to be surveyed: the main criteria for including a paper in our survey were (a) the paper uses public displays as an object of study; (b) the paper is related to public participation; and (c) the context of the paper is related to urban space. Next, keywords were selected.

We screened all the papers from the PerDis conference from 2012 to 2016 manually. We read all the papers' abstracts, the introduction and conclusion, while applying our inclusion criteria. After this step, 12 papers were selected. After reading these 12 papers carefully, 10 papers were kept which really fit our purpose. We analysed the author keywords of these

10 papers using Wordclouds<sup>2</sup>. It turned out that authors publishing at PerDis use the keyword "engagement" (instead of "participation") as Figure 1 shows. Based on this, we used two groups of keywords to search for relevant papers in the ACM digital library: (public display, urban, participation) and (public display, urban, engagement). The time frame was limited to 2012-2016 to catch the most recent trends since the PerDis conference series started. The search on the ACM digital library was performed in January 2017.

This keyword searches returned 40 papers from various outlets as raw materials for our review. After a thorough reading, a total of 36 papers were identified as falling within the scope of the study, namely using public displays in urban settings for public participation (or citizen engagement). In Table 1, we sketch the distribution of all the papers over conferences and journals. Additionally, we built an online repository that is publicly available<sup>3</sup> and also contains the meta-data of the selected papers. The meta-data includes the paper title, publication year, and the conference or journal informations. The data collected was organized along the following dimensions:

**Type of political context:** as indicated in [16], "any approach to understand the use of public participation must take into account the cultural and political context". Therefore, special attention was given to the countries where the studies presented in the papers surveyed were conducted.

**Type of scientific contribution:** Wobbrock [42] proposed seven research contribution for the field of Human Computer Interaction (HCI) which are re-used in this article. These are (1) empirical (i.e., they provide new knowledge through findings based on observation and data gathering), (2) artifact (i.e., prototypes which reveal new possibilities and facilitate new insights), (3) methodological (new knowledge that informs how research is carried out), (4) theoretical (i.e., improved concepts, definitions, models, principles, or frameworks), (5) dataset (i.e., useful corpora for the research community), (6) surveys (i.e., synthesis of work done on a research topic with the goal of exposing trends and gaps), and (7) opinion (i.e., essays which seek to change the mind of the reader through persuasion).

**Type of public display:** Buerger [10] distinguished between two types of interactive public displays: "standalone public display" (where no additional device is required to interact with the screen) and "public displays in combination with mobile devices" (where mobile phones are used to interact with the display). This distinction, with some slight change, was adopted for the classification. Instead of "public displays in combination with mobile devices" (which is restricted to mobile phones), "public displays in combination with additional devices" was chosen as a dimension to include devices such as tablets, physical pushbuttons, physical cursors, microphones, tangible user interfaces and mouse devices.

**Single-purpose vs multi-purpose displays:** according to previous work [25], if a public display just provides one single

"application" or interface, it can be understood as a single-purpose display. In contrast, a multi-purpose public display is a display that provides multiple types of applications or services (e.g., information browsing, games, galleries, and polls) concurrently [25]. The essential difference between single-purpose and multi-purpose public displays is the number of applications on public displays [28].

**Shape of the display:** the shape of a public display can vary between the most common shape (a single rectangular and flat shape) to unconventional shapes (e.g. circular or 3D displays). The display shape can influence the design of interaction and visualization methods of a public display.

**Type of space where the display has been deployed:** two types of spaces are considered, namely public and semi-public. Semi-public spaces are defined after [8] as "spaces that are owned and controlled by a private entity or institution, but open for the public (e.g., a café, a train, a movie theatre)". Public spaces are in contrast, owned and controlled by the government or local authorities.

**Lab study vs field study:** to denote whether the study was conducted in a laboratory or in the real world. In the context of public participation, there is arguably a very big difference in terms of ecological validity between the two options.

**Level of public participation addressed:** While Arnstein's eight rungs on the ladder of citizen participation [4] are a common approach to describe the levels of citizens engagement, this paper uses the International Association for Public Participation (IPA2)'s Public Participation Spectrum<sup>4</sup>. This spectrum defines five types of engagement with stakeholders and communities: *inform*, *consult*, *involve*, *collaborate*, and *empower*. The spectrum has been developed from the perspective of the government, and the five types of participations should be considered from that perspective. According to the IPA2, *inform* refers to transmitting information from the government to the public; *consult* means giving the public the possibility to give feedback on the information provided; *involve* denotes working directly with the public throughout the decision process to ensure that public concerns and aspirations are consistently understood and considered; *collaborate* refers to partnering with the public in each aspect of a decision, including the development of alternatives and the identification of a preferred position; and *empower* means that the government places the final decision-making into the hands of the public.

## ANALYSIS

Using the dimensions detailed in the previous section, we analysed the papers we collected to gather insights on the topic of this survey, i.e. public displays for public participation in urban settings. This analysis yielded a number of insights and trends that we report on in the following.

**Type of political context:** as Figure 2 illustrates, the overwhelming majority of the papers surveyed report on research done in developed regions of the world (i.e., Europe, North America, Australia). Lessons learned about deployments of public displays in other regions of the world, e.g., Asia and

<sup>2</sup><http://www.wordclouds.com/> (last accessed: February 2, 2017).

<sup>3</sup><https://github.com/robinhood747/Papers-list>

<sup>4</sup><http://bit.ly/2kkPFAM> (last accessed: January 31, 2017).

<i>Outlets</i>	<i>Frequency</i>	<i>Percentage</i>
ACM International Symposium on Pervasive Displays (PerDis)	11	30.5%
ACM CHI Conference on Human Factors in Computing Systems (CHI)	5	13.9%
Media Architecture Biennale (MAB)	4	11.1%
ACM Conference on Computer-Supported Cooperative Work and Social Computing (CSCW)	2	5.5%
ACM International Joint Conference on Pervasive and Ubiquitous Computing (UbiComp)	2	5.5%
International Conference on Communities and Technologies (C&T)	2	5.5%
International Conference on Mobile and Ubiquitous Multimedia (MUM)	2	5.5%
Nordic Conference on Human-Computer Interaction (NordiCHI)	2	5.5%
ACM International Conference on Interactive Surfaces and Spaces (ACM ISS)	1	2.8%
Australian Conference on Human-Computer Interaction (OzCHI)	1	2.8%
British Human Computer Interaction Conference (British HCI)	1	2.8%
Conference on Human-Computer Interaction with Mobile Devices and Services (MobileHCI)	1	2.8%
Participatory Design Conference (PDC)	1	2.8%
Personal and Ubiquitous Computing (JPUC)	1	2.8%
<b>Total</b>	<b>36</b>	<b>99.8%</b>

Table 1. Selected outlets and paper frequencies

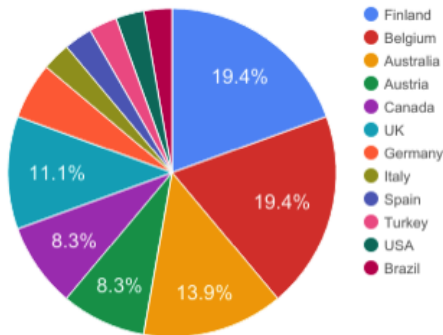


Figure 2. Distribution of the studies according to countries.

Africa, are rare. This suggests that research on public displays for public participation still needs to expand to embrace a wider audience, and a greater diversity of political contexts. HCI4D (HCI for development, see [15]) already has documented studies in Asia, Africa, as well as Central and South America.

**Type of scientific contribution:** The main contributions of the surveyed papers are summarised in Table 2. The collected papers show the fundamental role of empirical studies for the topic of interest in this paper. HCI as a research field has an inclination towards empirical contributions (see for example [33]), and research on public displays for public participation seems to be no exception. In order to broaden the existing body of knowledge, it would be desirable to see more theoretical, methodological, artifact, opinion and survey contributions. In addition, though artifacts are "often accompanied by empirical studies but do not have to be, and sometimes should not be" [42], there seems to be a close association between artifact and empirical contributions with respect to public participation.

**Type of public display:** among the 36 papers surveyed, three were about exploring people's awareness of public displays, about their use for e-participation through a workshop [40],

about presenting arguments by analyzing works empirically grounded in field observations and design research [18], and about focusing on describing certain participatory design methods [5]. Since these did not specifically study public display as artifact, they are not included in the current discussion. In the remaining 33 papers, the number of studies on the two types of public displays (standalone and with device) were approximately equal. This may indicate that both types are equally relevant for public participation. The dataset did not allow to infer clear trends over time in this respect. In addition, touch, air gestures and body gestures were the most common interaction methods used for standalone public displays. Different kinds of physical buttons and handheld devices were the most common additional devices that were combined with public displays.

**Single vs multi-purpose displays:** Table 3 shows that there is currently little research on multi-purpose public displays. Compared to public displays with a single purpose (e.g., supporting citizen voting in [35]), few papers dealt with multi-purpose public displays. A notable exception is Jurmu *et al.* [24], who implemented two different services for different purposes. One service is a slot machine application, which provides shopping information, while the other one displays recent tweets around the display in a map-based view. Hosio *et al.* [23] pointed out that multi-purpose public displays (MPDs) – which can be "customized to offer something for everyone" – are envisioned to be popular in the future. The potential of MPDs is to "offer something for everyone", which could be an attractive feature in an urban context. They can indeed be calibrated to offer participation opportunities to diverse user groups. Deploying MPDs for public participation might come at a price though: as [22] observed, popular applications on MPDs proportionately attract fewer targeted users. The data collected (Table 3) does not give enough evidence to claim that the apparent tension between popularity and target users' attraction is the reason for the very low number of studies on MDPs for public participation. It rather suggests that this tension could benefit from further investigations. Future studies should also shed light on the respective effectiveness of

<i>Main research contribution (s)</i>	(1)	(1) & (2)	(1) & (3)	(1) & (4)	(3)
<i>Frequency</i>	18	13	2	2	1
<i>Percentage</i>	50.0%	36.1%	5.6%	5.6%	2.7%

Table 2. Types of the main research contributions of the papers surveyed.

both types of displays (single and multi-purpose) for citizen engagement.

**Shape of the display:** according to our analysis, most previous studies (25) have dealt with public displays with rectangular shape. Still, there were a few unconventional shapes such as different appearances of lightings [21], chained public displays [36], or a large multi-dimensional media facade [6]. Ten Koppel *et al.* [39] performed a field study comparing three types of chained displays: flat, concave, and hexagonal. They observed that flat displays created the strongest honey-pot effect and attributed this to the users being able to see manipulations and effects of actions at the same time.

**Type of space:** Table 3 shows that several investigations were conducted in public spaces while few studies took place in semi-public spaces or in both places together. For instance, one paper [31] reported two field studies conducted in a main library and the center of the city at the same time. Another group [27] deployed their voting system in coffee shops but visualized the voting results outside the shops. According to Fortin *et al.* [17], the type of space can invite different degrees of public participation. We analyzed the numbers of participants involved, and the duration of studies in the different types of space. The majority of field studies in public spaces lasted more than 5 working days (sometimes up to 12 weeks) while most of field studies in semi-public spaces took less than 5 days. The small sample of papers arguably puts some limits on generalizability, but this observation remains a trend to watch out for in the future. In addition, the number of participants involved in the majority of studies in public spaces was bigger than the number of participants involved in studies in semi-public space. This trend also needs further confirmation through larger sample sizes.

**Lab vs field study:** the data collected shows that nearly all papers used field studies to test their ideas. Only one paper [29] mentioned the use of laboratory studies, but did not provide enough detail as to the why, the benefits and the drawbacks. Our survey provides additional evidence for the point that ecological validity is being prioritized over internal and external validity [1]. In addition, few papers [12, 13] emphasized using "controlled in-the-wild studies" as a viable alternative in evaluating more complex interaction methods in public spaces. The controlled in-the-wild study could be valuable if researchers want to reduce the practical effort of involving participants in real-life contexts while preserving some features of the field study. Furthermore, the deployment duration of public displays in the field varies from study to study, and no specific pattern (e.g., a recurrent minimum/maximum/average field study duration) emerged from the papers we examined.

**Level of public participation addressed:** most of the research emphasized community awareness, interaction, discussion for the purpose of citizen engagement or public partic-

ipation in urban environments. Voting applications, mainly related to local issues, were also common. Comparing the focus of selected studies to the level of public participation as defined above, we found that most studies address the level of *inform*. At this level, there is no expectation of receiving feedback from the citizens (and of course the level of the public impact is rather low). The studies surveyed used different kinds of visualizations on public displays (e.g., lights, text, picture or voice) to show information to communities, and explore how community awareness should be enacted. Besides, there are few papers which focus on deploying voting applications on public displays and on providing real-time voting results. Overall, very few projects currently address the level of *consult* and even fewer operate on the *collaborate* level. This was the case for the work presented by Mahyar *et al.* [29] who worked towards engaging citizens and professionals in the complex process of collaborative urban design. *Empower* was not tackled by any of the papers examined.

## Discussion

Based on the results reported on in the previous section, we identified two key challenges/opportunities for future research in using public displays for public participation in urban contexts. In the following we discuss those and also briefly reflect on limitations of our study.

**Current research on public displays is targeting low levels of public participation.** As mentioned above, current research has, by and large, addressed the *inform* level of the IPA2's public participation spectrum. Involving citizens at higher levels of participation has so far received little attention. Moving up on the spectrum of public participation is challenging, but is generally desirable and also constitutes a research opportunity. Higher levels of public participation mean greater involvement of the public in public decision making processes. As Milakovich [32] indicated: "efforts to increase citizen participation result in better governmental decisions that involve larger numbers of citizens and are, therefore, more acceptable and legitimate to the majority of people".

Achieving higher levels of public participation is challenging for several reasons. Considering urban planning as one example area where this would be desirable, Rittel [34] indicated that it is "a field with confronting social problems that needs to balance the concerns of a wide range of stakeholders to reach solutions". This applies to other application areas for public participation in urban context as well. Current research has mainly focused on citizens. Embracing additional stakeholders such as civil society organisations and governments actors poses the question of designing displays which supports smooth communication between the different parties. For example, future research may put a focus on visualizing different kinds of urban planning information in a way which could be easily understood by regular citizens. Also designing

<i>Dimension</i>	<i>2012</i>	<i>2013</i>	<i>2014</i>	<i>2015</i>	<i>2016</i>	<i>Total</i>
Standalone	3	5	3	4	1	16
With a device	1	3	5	4	4	17
Public space	2	7	6	6	3	24
Semi-public space	0	1	2	1	1	5
Semi-public & public space	2	0	0	1	0	3
Semi-public & Lab space	0	0	0	0	1	1
Multi-purpose	1	1	0	0	0	2
Single-purpose	3	7	8	8	5	31

**Table 3.** Papers surveyed according to the types of public displays examined, their purpose, and the type of space where they are studied.

new interactions for and with such urban planning information offers interesting avenues for future work.

**Evaluating public displays for public participation is a challenge.** This applies both to the evaluation methods to use as well as to evaluating various aspects of relevance in this context. As we mentioned above, the types of space where public displays are deployed can invite different degrees of public participation. Here, it would be desirable to establish both methods to evaluate these aspects and a basic understanding of the relationship between space and participation. Similar research questions emerge in relationship to the impact of different interaction techniques on citizen engagement and the influence of the type of public display (standalone, with device, single purpose, multi-purpose) on public participation. Finally, a central open question is: how to evaluate the effectiveness of public displays in supporting higher levels of public participation in general? This calls for an evaluation framework which helps to assess public displays with respect to their achievements regarding higher levels of public participation.

**Limitations of the study:** Since 36 is a relatively small number of papers to analyze, this limits the generalisability of the results of our survey. Moreover, the keywords used might have limited the number of papers retrieved. For example, some additional keywords (e.g., community involvement, urban screens or public screens) might have produced a larger set of papers to analyze. Besides, the focus of the survey was on recent trends (i.e., 2012 onwards), but it is worth mentioning that there is a rich history before 2012 on exploring the use of public displays for community interaction in different settings, e.g., BigBoard [30] deployed for sharing informations within communities in a township in a developing world; TexTales [2] collecting public expressions in different developed countries; and the Urban Screens conferences which began to explore the potential use of screens for urban society in 2005.

The study is also limited by the number of outlets that we considered. The ACM digital library indexes many important outlets in the HCI field (including the PerDis proceedings) and we therefore considered it to be a suitable source to collect relevant papers from. By extending the survey to include other electronic libraries (e.g., Science Direct, IEEE Xplore Digital Library, ISIWeb of Knowledge and Springer Link), a more comprehensive overview of work done on public displays for public participation could have been produced. In addition, "increasing citizen participation" was essentially discussed through the lens of reaching higher levels of the IPA2's public participation spectrum. Increasing citizen participation might

involve further aspects. For instance, exploring alternative ways of enabling participation (e.g., art, play) and promoting them might also contribute to pushing current public participation forward. Finally, though we carried out a thorough analysis, we did not contact the authors of the surveyed papers directly regarding the characteristics of their work. It is thus possible that our study might have misrepresented some aspects as the classification of the papers is based on our understanding of what the authors did. Consequently, future work could include data from additional outlets and involve authors in the classification process of their papers along the dimensions introduced we proposed.

## CONCLUSION

In this paper we reported on a study exploring the use of public displays for supporting public participation in urban settings. We presented a snapshot of research done from 2012 to 2016 based on papers indexed in the ACM digital library and analyzed current trends regarding different dimensions: political contexts, scientific contribution, type of public displays, single purpose vs multi-purpose displays, shape of public displays, lab vs field study, type of space, the levels of public participation addressed. We observed that the current research on public displays lacks diversity of political contexts and that beyond empirical contributions more types of scientific contributions would be desirable to add diversity to the existing body of knowledge. We also identified a gap of research regarding the respective effectiveness of single purpose displays and multi-purpose displays in achieving public participation. Rectangular shapes of displays were most common, and most research emphasized community awareness, interaction and discussion for the purpose of public participation. Finally, we identified two challenges/opportunities: designing public displays which support higher levels of public participation and evaluating them in the context of public participation.

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