Cross-Display Pointing and Content Transfer Techniques

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ABSTRACT

Devices such as smartphones are becoming more and more ubiquitous in our life. Not only are they growing in number but also in type. One can now commonly have a smartphone, a laptop, a family PC, maybe even a tablet. In addition to these private devices we also encounter more and more public displays. In order to be able to interact with such public displays and therefore to improve their usefulness several methods for cross-display pointing have already been proposed to allow the control of a cursor on a device from another one. Moreover users, in situation of collaborated work or when sharing files (music, pictures...) with friends, need transparent way to achieve content transfer. However in both those domains there are still research to do in order to desing system that are efficient and adopted by end users. Here we first introduce different techniques that exist in both Cross Display Pointing and Content Transfer field and then review some applications that can leverage them. Finally we present the challenges and the new opportunities that arise with the development of these techniques.

Keywords

Multi-device interaction, Cross Display Pointing, Content Transfer, Public Displays

1. INTRODUCTION

As public displays become more affordable they are more and more present in public spaces. Researcher are investigating effective way to interact with them and studies reveal different methods for Cross Display Pointing. Some techniques enable users to remotely interact with distant screens. It is achieved either by making use of laser-pointer-equipped mobile phones or by leveraging sensing capabilities of smartphones to control a distant cursor. Some studies are also investigating how gaze can be tracked to determine wich area of the distant screen the user is interested in. Another technique using Near Field Communication enable users to point at a specific item of a screen by directly touching it. These techniques can be applied in different applications such as collaborative work, interaction with public displays, multi-users gaming or file sharing.

Once an item of interest for the user has been recognized on a distant display it is natural to be able to share informations between the distant and the nearby device. Thus, in addition to cross-display pointing, efficient content transfer between devices is needed. Here the methods used focus on either using the embedded phone camera to recognize area of interest for the user or using optical projection. These techniques can be applied for exchange of content between public and personal devices but also for exchange of content between mutliple private phones.

Review of Cross-Display Pointing and Content Transfer Techniques '14 Passau, Germany

2. CROSS-DISPLAY POINTING

Cross-Display Pointing mean the ability of poiting an aera of interest on a distant displays by using another device. Distant displays can refer to public displays such as the ones we can find in shopping galleries or to large screens in a meeting room. Since people now have almost all personal phones it is an obvious choice when wondering what device should be used for pointing.

2.1 Techniques

Below is a review of techniques that has been investigated and whose purpose is to enable pointing on distant displays via private phones. First techniques allow to control a cursor remotly whereas the last one require the user to touch the screen in order to point to an item of interest.

2.1.1 Mouse-Like Phone

The first technique is inspired by traditional mouses with personal PCs where the cursor on the PC follow the same movements than those of the mouse. For Cross Display Pointing the paradigm is extended by enabling cursors on remote displays to be controlled by the movements of the personal users phones. It leverages phones sensing capabilities (accelerometers) to continuously controlling the users pointer on public displays. Following this paradigm different methods have been investigated. For instance Sebastian Boring et al. [9] presented three different methods called Scrolling, Tilting and Moving. The simplest, Scrolling, only map key press on the user phone with cursor movement on the distant screen but Tilting solution enable the cursor to be controlled by the way users tilt their phones. If the phone is tilted to the left cursor will go the left, if the cursor is tilted up the cursor will go up and so on. The more the phone is

tilted in a certain direction the faster the pointer. The last technique, called Move, map the phone's movement linearly to the pointer's movement. The idea of using the personal phone as a mouse have also been investigated in [4] where the *Sweep* technique use optical flow image processing to determine the relative motion of the phone and to enable the control of a distant cursor.

2.1.2 Live Video

When interacting with public displays which are likely to be used by a great number of user at the same time Mouse-like techniques may not be the best choice since it would involve a substantial amount of pointers displayed on the public screen which could be confusing for the users. Moreover one might want to interact privately with the screen and not show its actions to other peoples around. Techniques using live video allow this scheme by enabling users to interact with the displays via live video on their personal devices. It has been investigated for different tasks in several works [23] [26].

Specifically Sebastian Boring et al. [8] presented a systen where users aim their devices at the facade and observe it in live video. They can interact with it through the display that is a touch input on the personal device is interpreted as if the user was touching the facade. Since no visible pointer is visible on the media facade it allow multiple users to interact simultaneously and transparently on it.

Simiraly Touch Projector [7] is a system that enable users to manipulate and transfer content between large displays through live video. Users aim their personal device to a display and is able to see the content of the display on its device thanks to live video. Then users select an item of interest by touching their device. In order to better select the item the user has the possibility to freeze the video. After that users move their devices off-screen, keeping their finger on the interested object, reach the destination display and transfer it by releasing the finger.

2.1.3 Laser Pointing

A last technique for remotly pointing to a distant screen is to use phones provided with a laser. The user can then easily and intituively point to the region of interest in the distant screen. A camera aimed at the remote display record what is happening on the screen and via basic image processig can detect the presence of a laser pointer and therefore the area of interest for the user. This approach has been investigated for some time now [44] [15] and has been specifically studied in the context of collaborative gaming [45] or file sharing [38].

2.1.4 Touch and Interact

An other way to interact with large displays is by directly touching the screen for instance to select an object of interest. This way of doing has the benefit to be rather direct and instinctive for the end users. However for public displays it might not be always possible to use it due to protecting reasons (against vandalism for example).

Direct pointing can be achieved via Near Field Communication (NFC). It is a radio-based technology for short-range data exchange between reading devices. It require a server that manage the logic of the application and is linked to a projector in order to project the user interface. The physical UI is composed of a grid of NFC tag. By touching a tag with a NFC-enabled personal device we can return the position of the tag to the server which update the interface accordingly.

This technique has been used by Broll, G. et al. all [10] to implement the Whack-a-Mole game for multiple users. Touch and Interact [24] enable a user to select an item on a display and push it to its phone or inversely to select the item on its phone and drop it to the display. Hardy R. et al. [25] have developed a tourist guide prototype leveraging NFC and focus in their study on the feasability, performance and usability of their prototype.

2.1.5 Eye Gaze

Yet an other way to point at a remote screen consist to keep track of the position of the gaze on a screen which enable to point specific object in it. Combined with touch input it allow to transfer content from a public display to a private phone. It is used by Jayson Turner et al. [41] [42] to acquire content from the display and transfer it to its personal device. Ken Pfeuffer et al. [32] investigated a novel method for gaze calibration as existing ones can be difficult and tedious. One major drawback of eye pointing is the necessary deployement of an eye tracking system which prevent it to be, at least in a near futur, used in a large scale.

2.2 Applications

2.2.1 Collaborative Work

A very common situation is a modern meeting room with a large screen and several users attending to the meeting. In this situation a person often has to refer to the content of the remote screen and efficient pointing techniques that would help him to point at informations of interest can help everyone to quickly understand the subject of its thinking. In order to illustrate how cross display poiting can be used Julian Seifert et al. [38] designed and implemented a collaborative presentation system that supports users in a meeting scenario.

2.2.2 Interaction with Public Displays

Cross Display Pointing have been heavily investigated to enable users interaction with public displays. Different use cases have been studied. A common situation is when a public screen is displaying information relevant to us and we would like to select such item either to view it privately on our phone or even transfering it definetily on it [3] [24] [41] [42]. In order to be able to achieve this task the remote display has to be aware of the item of interest and thus the need for efficient poiting system. In the study realised by Matthias Baldauf et al. [3] live video is used to allow user to see privately content exposed on public displays. Specifically the public display offer several choices of video and each user aiming at the display with its phone is able to chose the one he is interested in and viewing it privately. Other use cases include print media like posters [17], e.g., for gaming [20, 22] or touristic map applications [21]. Web-based tracking systems have been explored as well for print media [31]. However, there is a need for stable tracking technologies as otherwise the user experience might suffer [29].

2.2.3 Multi-User Gaming

Yet another applications is to enable muliple players to

play a common game on a large screen. For example Florian Vogt et al. [45] use laser pointers to allow several participants to play to a game. Each participant has to complete a maze and the winner is the one that find the shortest path.

2.2.4 File Sharing

Laser poiting have been used by Julian Seifert et al. [38] to facilitate file sharing between a distant screen and personal phones. When transfering a file from the phone to the screen the pointing is needed to identify into which distant screen and which area in this screen the file has to be transfered. When transfering from the screen to the mobile phone poiting is needed to identify which item on the distant screen the user is interested in. File sharing between distant and personal phone has also been investigated with live video technique [26] [39].

2.3 Challenges and Opportunities

Early public displays was essentially showing static content and was mainly used for marketing purpose and to control the consumer behaviour. Thanks to great advances in technology public displays are now available at affordable prices [2] and are becoming more and more interactive. Therefore they are more and more ubiquitous in public place and we can now run into them at cultural site like museums or art galleries, in a shop center, at some university or in a meeting room. They are being used to display cultural content, for social interaction between remote communities, or for entertaining purpose [40]. Some innovative proposals that envision new interaction possibilities have also been investigated. Alexander et al. [1] introduce displays that extend beyond the traditional rigid, flat surfaces and that user can deform. Schneegass et al. [37] explore the concept of free-floating public displays and Buxton and all [11] studied 3D displays.

Regarding gaze pointing techniques for public displays its adoption has been slowed by the time consuming and cumbersome calibration needed to perform eye tracking. [27]. But as more sophisticated calibration-free eye tracking methods arise [46] [43] these problems might be overcome and gaze interaction could become more frequent.

3. CONTENT TRANSFER

Good pointing techniques are required to interact with distant displays but in order to push the interaction further it is not sufficient and we need to be able to transfer informations between the distant device and the personal phone. Also content transfer has been investigated to exchange informations either between multiple phones belonging to different users or between heterogeneous devices (smartwatch, smartphones, laptop...) belonging to the same user.

3.1 Techniques

The techniques reviewed here discern between two main methods. The first one make use of the built-in camera phone to take into picture an area of a distant screen with relevant informations for the user. The second technique rely on optical projection where the content of the personal device is projected using a projector.

3.1.1 Phone Camera

Using phone camera for transfering content broadly involve three steps. First the user take a picture of the area he is interested in. Next its picture is transfered to a server which is able to identify to which region of the remote screen it corresponds. Lastly informations in this regions are stored on a web server that the user can access to retrieve the informations.

Content transfer via the phone camera has notably been investigated by Shoot and Copy [6] and Deep Shot [12]. The first system, Shoot & Copy, allow users to take pictures of the informations of interest and retrieve those informations later on their personal PC. To achieve this the picture taken by the user of the display is send to the display's host computer which is able to identify to which region of its screen it corresponds. The informations at the center of this region (images, music, text files...) are transmitted to a web server and the url to retrieve them is communicated to the user phone. Users have now the posibility to downoald the content whenever they want on their PC. An alternative would be to send directly to the user phone the files instead of the url to retrieve them.

The second system, Deep Shot, use similar technique to allow tasks migration between devices. The system recognize the application the user has taken into picture and enable him to transfer not only documents but also the application state.

3.1.2 Optical Projection

Optical projetion rely on the capacity of a phone to project its content on a surface along with its ability to recognize operations made on its projected display. Early systems were using stationary projectors with tracked mobile device to simulate mobile projection. With Hotaru system [28] the phone is connected to a server and the image captured by its camera is sent to the server. In response the server send to the phone the operations made on the projected display. Using this system file sharing between two phones has been achieved. Each phone project its display on a surface and recognize operations conducted on its own projected display. So by dragging an item from a projected display to another users can intituively exchange the item. Nowadays picoprojectors can be embedded in handled as explored by Baur et al. [5] but with their system a central server is still needed to manage all the connections between the handhelds and secondary displays. Conversely Negulescu et al. [30] studied a decentralized architecture for scalable mobile sharing.

3.1.3 Communication protocol

The Hermes system developed by Keith Cheverst et al. [14] support content transfer between public displays and private phones by making use of bluetooth technology. Through this work researchers implemented a system enabling users to both send pictures to a public display and receive from it. Advantages of Bluetooth is that it is a well establish standard and most users can benefit from this technique. However, as reported by the authors, a problem encountered by this system is the reliability of the Bluetooth discovery process which can lead to user frustration. Other emerging wireless technologies that can compet with bluetooth are UWB, ZigBee and NFC [36].

3.2 Applications

3.2.1 File Sharing

Situations where we are surrounded with several people

and we would like to share documents from our phone is very common. it might be at the terrace of a cafe with friends where we want to share pictures of the last evening or at home with relatives to share pictures of the last holidays. In this situations pictures typically are on our phones and ideally we would like everyone to be able to see it at the same time. Moreover if someone is interested by a picture we would like to be able to transfer it to him intuitively without having to search in our phone settings for the bluetooth section, finding its device, pairing the two devices and so on. Content Projection techniques described earlier would be one way to enable the vizualization of the picture by everyone and to allow intuitive transfer of the picture.

Sharing pictures between friends and relatives is not the only moment where we would like to enable easy document vizualtion and sharing between multi devices. In situation of collaborated work it might be very convenient to be able to easily share documents.

3.2.2 Tasks Migrations between Devices

With the increasing number of devices (tablets, smartphone, PC ...) researchers have noticed that one is often brought to continue a task started on a other device. For example one might be reading an article in a newspaper on its desktop PC but is forced to stop because for some reasons he has to go somewhere else. So he takes the bus and once sitted he would like to continue its reading where he left it. A commmon source of frustration then is the need to repeat the steps made on the first device in order to recover the same state on the second device. In the case of reading newspaper it might be pretty straightforward bur for more complex tasks it can be very troublesome. So a better way to do would be to automatically migrate the task between the two devices. In Deep Shot [12] it is achieved thanks to mobile phone cameras which allow to take a picture of a screen, then recognize the application on it and automaticaly migrat the application state onto the mobile phone.

3.2.3 Content Projection

Content Projection can be used to overcome the limited output capabilities of small devices such as smartphones. It is also a way to easily share, let's say pictures, between friends. Indeed a common situation in our life is when we show pictures to our friends or relative. If the number of people exceed four or five people it might be difficult for everyone to see the picture at the same time. But this problem can be easily resolved if we are able to project the content of our phone on a bigger surface.

Yet an other application relying on optical project is art projection. For instance MobiSpray [35] is a tool that allow anyone to use its mobile phone as a virtual spray to paint anything anywhere.

3.3 Challenges and Opportunities

The emergence of smartwatch, eyeglass or smartphones in our every day life is changing the way we are performing our activities. For example one might use a smartwatch to monitor its vital signs when jogging and at the end of its run visualize the results directly on its smartphone then store the informations on its laptop for later comparison between its different runs. An other example would be downloading an album music from its desktop PC to listen to it inside your home where you have good speakers but then you realize you have to make some urgent shooping outside. So you synchronize the downloaded music with your smartphone to continue the listening outside. Once you are outside you use your smartwatch to navigate into your playlist and change the current song. Dearman et al. [16] have confirmed that users tend to use many devices when performing a single activity. They also report that the greatest complaint from user about using multiple devices is the diffusion of information across them.

As noted by Pierce et al. [33] a problem is that most applications created today still assume the applications will be used on a single device. This fact is due in part to the difficulty of creating new functionalities such as identifying, connecting to, and communicating with other devices. Therefore they introduce an infrastructure based on instant messaging that simplifies adding these additional functionalities to applications.

MultiFi [18] is a platform for implementing user interface widgets across multiple displays with different fidelities for input and output. It enable better interaction between display devices on and around the body such as smartwatches, tablets or head-mounted displays. Also Duet [13] is a system that explores a design space of interactions between a smart phone and a smart watch. However, several technological and social challenges exists for mobile multi-display devices [19, 34].

4. CONCLUSION

In this review we have shown different techniques to point to distant displays. Those techniques either enable to point to a screen remotly or by touching it. In the range of remote techniques mouse-like technique extend the paradigm of standard mouse to personal phones. Movements by personal phones are tracked and used to controle a remote cursor. Live video, used for instance by Touch projector, is another technqiue that enable cross display pointing via live video where touching its phone is sensed as if we were touching the remote screen. LumiPoint or PointerPhone, use laser embedded on the mobile phone to point to the screen. As for poiting by directly touching the screen systems that rely on Near Field Communication have been investigated. These techniques find many applications especially to interact with public displays but also when doing collaborative work where multiple users interacting with a single screen is a common situation.

To complement Cross Display Pointing efficient Content Transfer techniques is required. One trend is this domain is to rely on camera embedded in the personal phones to let user take into pictures the area in the distant screen they are interested in. Then by recognizing which region of the screen is concerned informations can be exchanged as shown in Deep Shot. An other way of achieve intuitive content transfer in to use optical projection and enabling phones to detect operations performed on their projected display as demonstrated in Hotaru. Techniques for efficient content transfer cover a broad range of applications. It can be used for intuitive file sharing between friends, co-workers or relatives, to easily switch of devices while keep performing the same task or to project content from its personal phones for a better visualization.

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