Touch & Interact: Touch-based Interaction with a Tourist Application

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ABSTRACT
Touch & Interact is an interaction technique which combines mobile phones and public displays. The motivation for the project is to overcome the intrinsic output limitations of mobile phones. Touch & Interact extends the phone output to a public display allowing both screens to share the display space. This concept is especially useful for separating public and private data – only showing private data on the phone display. During interaction, the phone is used as a stylus for the public display and can touch the display at any location. The phone also lends additional capabilities to interactions by providing storage capabilities, additional feedback (e.g. audio and haptic) and input modalities (e.g. keypad and joystick). The underlying technology supporting Touch & Interact is Near Field Communication (NFC); the dynamic display includes a mesh of NFC tags which can be interacted with using an NFC phone. A tourist map application was used to explore and test Touch & Interact in an environment with rich functionality.

Categories and Subject Descriptors
H.5.2 [**Information Interfaces and Presentation**]: User Interfaces – *Input devices and strategies; Prototyping.* H.1.2 [**Models and Principles**]: User/Machine Systems – *Human Factors.*

General Terms
Design, Experimentation, Human Factors.

Keywords
Touch & Interact, mobile interaction, dynamic display.

1. INTRODUCTION
Mobile phones are fast becoming more versatile and are incorporating increasing connectivity and sensing capabilities. These emerging capabilities provide a broader range of opportunities to developers. However, the limited screen size of current phones can still restrict developers as user's are still unable to view and manage a large amount of information at once [1].

The combination of public displays with mobile phones is seen as a promising future potential [2; 3; 4; 5]. There is significant interest in using public displays due to falling prices and remarkable improvement in size and resolution. Because of these factors, they are becoming increasingly deployed in office environments, airports, train stations, subways and homes.

There have been numerous mobile technologies developed which support mobile interaction (direct and indirect) with passive and dynamic displays [6; 7]. Examples of such passive displays include paper maps, food menus and posters. Alternately, dynamic displays may take the form of public screens or remote PCs. Fitzmaurice was one of the first who designed and discussed applications where a mobile device was used to interact with dynamic information displays [8]. C-Blink is an implementation which shares a similar concept to Touch & Interact since the phone is also used as a pointing device [9]. However, in the C-Blink system, the phone interaction is indirect as the phone controls a mouse curser on the display. Reilly et al. were the first ones who developed and evaluated a system in which a mobile device can touch and select options on a passive display [10]. A paper map was used for the passive display which was augmented with a set of RFID tags representing the touchable options. A mobile device (connected to a RFID reader) was used to read these tags in order select various objects on the map.

Using Touch & Interact, a large display is used to overcome the phone's output limitations whilst using the phone itself as a smart pointing device for intuitive interaction. The phone interaction is comparable to touch screen interaction, except a mobile phone replaces the finger.

The underlying technology supporting phone interaction with a public screen is NFC. Touch & Interact uses a mesh of NFC tags which form the display. In the tip of the phone (Nokia 6131) is an NFC reader which reads data from a tag when in close proximity (~3cm). Tag reading/writing uses inductive coupling so the tags require no power source other than that provided by the phone reader. With the ability to communicate with tags, the phone can interact with the display at any position by touching any of the tags in the mesh. A video projection on the tag mesh provides dynamic feedback from tag interactions. This feedback is supported by various forms of feedback from the phone (visual, haptic or audio).

The next section of this paper describes Touch & Interact in more detail including the advantages and challenges of the interaction technique. Following is an overview of the infrastructure supporting Touch & Interact including a basic implementation of a prototype. This leads onto a section describing a map application which was used to testing Touch & Interact. The subsequent section provides a description of the system demo and the paper finishes with a closing conclusion.

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2. TOUCH & INTERACT

Figure 1 shows a visualization of Touch & Interact and its use for panning a map on a display. It shows a vision of the interaction technique whereby expressive gestures can be used to interact with the display by touching the phone on the display at any position. In response to touch interactions, visual feedback from the large display is combined with feedback from the phone (e.g. visual, haptic or audio). In the example shown in Figure 1, whilst the user pans the map, the phone display may be used to show the distance panned or the touched map coordinates.

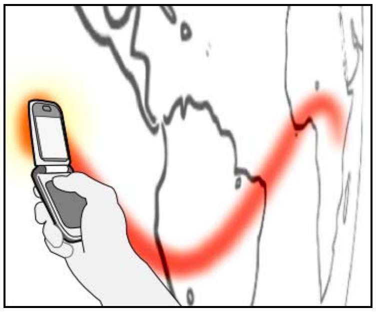

Figure 1: Touch & Interact used for map panning

Touch & Interact could be deployed for a broad range of uses. It could be used for interaction with public screens, picture boards, electronic paper, LCD screens or shop windows. There are numerous suitable applications for Touch & Interact, especially in the public sector. Some large display examples include transport timetables or public picture boards.

There are several advantages to the Touch & Interact approach:

- The combining the phone and large display creates new potential for feedback. The large display provides overview and spatial awareness. The phone screen can be used to show private (e.g. credit card or address details) and contextual information (e.g. details of a hotel in a map application).
- The phone can provide audio and haptic feedback which provides assertive response to user interactions.
- Input modalities on the phone such as the joystick and keypad can be combined with tag interactions. This functionality could be used to provide shortcuts for experienced users and reduce time spent by selecting options using menus.
- The storage capabilities of the phone allow data to be brought to and from the display. Using this concept, a pick-and-drop variation of drag-and-drop can be explored where the phone can pick up objects on the display and drop them elsewhere on the display. The phone's (Subscriber Identity Module) SIM could also be used for identification and authentication in a multi-user environment.

There are also technical challenges associated with Touch & Interact which are explained in the following implementation section.

3. IMPLEMENTATION

The hardware configuration supporting Touch & Interact (Figure 2a) uses:

1. A Nokia 6131 NFC phone.
2. A dynamic display.
3. A laptop (acting as a server).

The dynamic display consists of a 10x10 mesh of NFC tags (Trikker BL38 from toptunniste.fi). The tags are covered by an A2 paper sheet which is projected onto using a video projector. The number of tags corresponds to the input resolution of the system, in this prototype, a 10x10 resolution. This configuration should not be considered the maximum input resolution possible but a preliminary resolution to test various interactions.

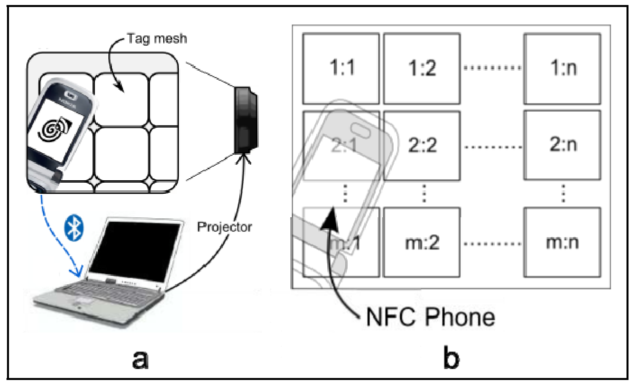

Figure 2: a - Emulation of a touchable dynamic display, b - NFC phone touches mesh of NFC tags.

The tags require no power source; have a size of ~4cm^2 and a read range of ~3cm. The tags can store 512 bytes of data, and in the case of the prototype, each tag in the mesh stores a string. The string is used to indicate each tag's position on the display (Figure 2b) when read by the phone (e.g. 1:2). The cumulative size of the tag mesh is 50cm^2 including tag spacing.

Java ME (CLDC 1.1 / MIDP 2.0) was used to implement the mobile phone client. The Contactless Communication API (JSR 257) was used for accessing the NFC tags and Java APIs for Bluetooth (JSR 82) were used for the communication between the phone and the laptop. The server application (running on the laptop) was implemented in Java SE. The Bluecove API was used for communication with the phone.

When selecting a tag, the phone needed to the moved within range of the tag. Once in range, the phone reads the coordinates from the tag and sends a notification (via Bluetooth) to the server. This notification contains the tag coordinates along with identification of a possible phone key (pressed in conjunction with the tag read). On receipt of a notification from the phone, the server fires an event which is handled by the appropriate listener depending on server state. The server responds to the event by updating the necessary server state and showing the resulting visual feedback on the large display.

The hardware configuration used for the prototype has an input resolution of 10x10 NFC tags. Although in reality most touch screens in the public sector have a target sizes greater than 2.6cm [11], it would still be beneficial to explore ways to improve the granularity issues. A possible area of interest is a reduction in tag size [12].

4. TOURIST APPLICATION

A tourist guide application (Figure 4) was implemented to explore and test a range of Touch & Interact interactions. The public display is used to show a Google map of the local area. The map features Google map markers which represent hotels, restaurants and events. The application would ideally be deployed in a tourist office, train station or city centre. The application allows a user with an NFC phone to browse the nearby markers, zoom and pan the map and ultimately build an itinerary (representing an ordered list of markers) for the day.

There was a collection of interactions which were explored in the early stages of the application consisting of:

- **Hovering** – Using the hovering technique, the phone can be moved within read range of a tag and additional information regarding the marker is displayed on the phone screen (e.g. name, price and rating of a particular hotel)
- **Single Selection/De-selection** – When a tag is hovered, the user can press a specified key on the phone to select/de-select the tag. Markers contained within the area of a tag are also selected. Selected markers are then 'picked up' onto the phone and displayed as a list of marker names on the phone display.
- **Multi-selection/de-selection** – If the user holds the key, they are able to select/deselect multiple tags.
- **Polygon-select** – Polygon points can be plotted by holding a specified key and touching the appropriate tags. When the key is released the tags within the polygon area are selected.
- **Pick-and-drop** – Selected markers that have been 'picked up' using the phone can be dropped in the itinerary.
- **Context menu** –The context menu is displayed on the phone. Using the phone's directional keys different options can be selected. Showing the menu on the phone avoids possible occlusion of the main screen options and interaction is very similar to menus on typical phones. The context menu for a marker can be accessed once it is hovered. The context menu allows the user to find out more information about the marker, receive contact details (a VCard) for the marker or to find the distance between two markers. These options are shown in Figure 3.
- **Remote Clear –** This interaction de-selects any currently selected tags remotely. Incorporating remote interactions into the prototype reduces arm fatigue which builds with prolonged use of pointing interactions.

Figure 3: The phone context menu

Figure 4a shows a screenshot of the public display interface. On the left-hand side of the display is a side menu which can be toggled on/off remotely using Bluetooth. The menu provides several options for the user: option (i) provides a map key when hovered by the phone.

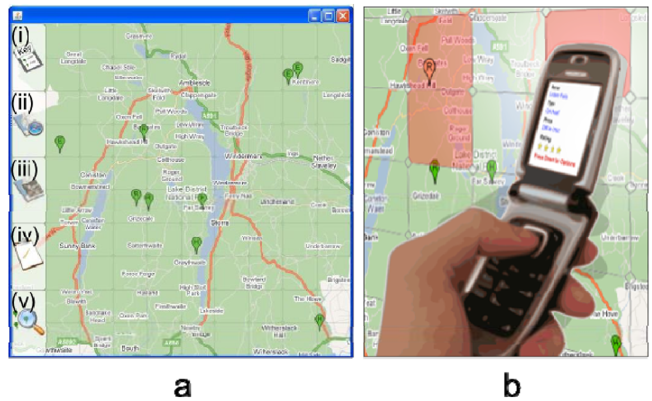

Figure 4: The tourist guide prototype, a - information showed on the public display, b - mobile phone selecting point of interest.

The key is used to convey what the marker icons on the map represent. The next option (ii) switches the application to view mode. In this mode the phone changes role from selecting markers to panning/zooming the map using tag interactions. The phone displays a satellite view on its display to provide an overview map with a rectangular graphic indicating the user's purview. In addition, the map can be panned remotely using the phone keypad and satellite view. This allows the user to step away from the map for easier viewing at a distance. Option (iii) switches the map to a satellite overlay to provide information which may be missing from the representational overlay. Markers can be picked from the map and dropped into an itinerary (iv). The itinerary can be viewed on the phone or on the public display. If viewed publicly, the screen shown in Figure 5 is displayed. This screen shows a list of markers which have been dropped into the itinerary. These markers can be reordered or removed from the list using tag interactions. The map shows another view of the marker ordering whilst providing the user with a spatial awareness of the markers. The itinerary and map side menu show the tags adopting list and button roles in addition to their map area roles.

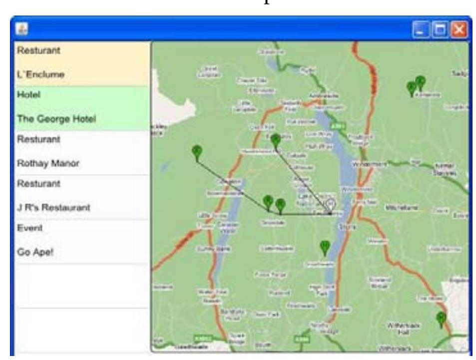

Figure 5: The itinerary screen

5. DEMO DESCRIPTION

The demonstration will begin with: an overview of the hardware, a description of the basic workings of the implementation, a brief motivation for the project and a concise description of the tourist guide application. Simple interactions will be demonstrated (listed in section 4), starting with the hovering interaction and finishing with the polygon-select shown in Figure 6.

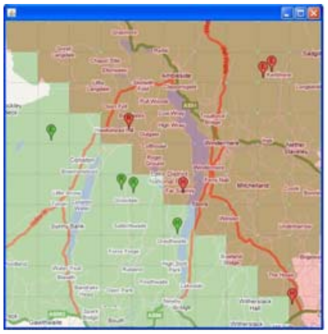

Figure 6: Polygon-select interaction

Once the basic interactions have been demonstrated, interactions will be concatenated. For example: hovering a tag which contains a marker, entering a context menu for the marker and selecting an option from the menu. The feedback from the example action is shown on the large display (Figure 7a).

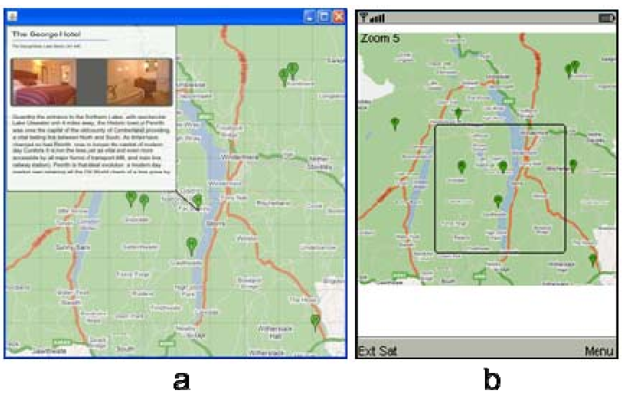

Figure 7: a - Marker information, b - Phone satellite view

Following the interactions is an explanation of the tag input resolution issues along with a demonstration of the tag enlargement method which enlarges one tag into nine on the large display.

The map side-menu will be shown with a run-through of the menu options. When the view mode option is selected, the use of the satellite view (Figure 7b) will be demonstrated when zooming or panning the map. Panning will be demonstrated using both tag interactions and remote phone-key interactions. Markers will be selected using the phone and dropped into the itinerary via the itinerary menu option. Once populated, the itinerary will be viewed publicly on the large screen. A subset of markers in the itinerary list will be reordered and removed.

Throughout the demonstration of the system will be points raised on how the phone capabilities complement interactions along with suggestions for alternate application of the features demonstrated.

6. CONCLUSION

Touch & Interact is an interaction technique which encompasses both public displays and mobile phones; in doing so, the advantages of both are utilized. The large display area of the public screen is used to overcome the output limitations of the phone and the phone is used to enhance user interaction through its input modalities, additional feedback, display and storage capabilities. Moreover, with the interplay of two displays, richer interaction techniques such as pick-and-drop can be explored. The pick-and-drop concept could be explored further by using the phone to pick-and-drop data between different systems or using to phone to drop contextual data to the public display. The latter would support user-generated content which is increasingly prevailing in the location-awareness field.

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