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John P. T. Moore
University of West London
London, W5 5RF
moorejo@uwl.ac.uk

Ryan Younger
University of West London
London, W5 5RF
21264807@student.uwl.ac.uk

Jose Abdelnour-Nocera
University of West London
London, W5 5RF
abdejos@uwl.ac.uk

ABSTRACT

In this paper we introduce the concept of a low-cost, offline information kiosk that is controlled through a sound-based interface. More specifically, we will describe how we use a mobile phone to control a kiosk by communicating DTMF phone tones. Our main use-case is deployment within developing countries where we intend to examine issues related to cross-cultural interface design.

Author Keywords

Kiosk interaction, sound-based interface, cross-cultural design

ACM Classification Keywords

H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous

INTRODUCTION

There are economic, political and technical reasons that some regions in the world still lack adequate information technology. Although there might be a lack of communications infrastructure in some regions of the world, we believe there is still potential to provide services to local communities through information kiosks which can operate without the need for an Internet connection. Typically in these communities people walk distances up to several miles to a local community centre where they can access a limited range of technology. We intend to supplement this technology with an interactive kiosk that could provide valuable information to community members. For example, we could provide a specific information service providing agricultural information to local farmers or provide a more general solution such as a medical information for the community.

In this paper, we will describe how we will try and overcome some of these challenges by designing a solution designed to work from low-cost existing technology. In addition to these challenges, we are also keen to design solutions which take into account the diverse range of cultures that exist within this domain. Therefore, we will follow a socio-technical approach to designing an information kiosk to provide a service in the rural communities of Kenya where we have gained previous experience [3].

RELATED WORK

Information kiosks provide information to a wide cross-section of users with diverse cultural backgrounds and varying degrees of computer literacy. Therefore it is vital that information kiosks are easy to use and take full advantage of current technologies in order to make the user experience as enjoyable as possible for the end user. Most kiosks in public service currently utilise a touch-based approach, however a body of research has been growing in the area of alternative kiosk interaction methods, including a multimodal approach that makes use of multiple inputs and outputs for a richer user experience.

Kiosks can be categorised depending on their intended purpose. Borchers et al. [2] defines four different categories of information kiosk, these are information kiosks, advertising kiosks, service kiosks and entertainment kiosks. Although touch screens are typically used for each of these purposes other more novel interaction methods have proven useful to end-users.

Bergweiler et al. [1] describe Calisto a system that enables users to connect their mobile devices to a large public terminal and share interesting facts and media via an intuitive multimodal interaction. This seamless combination of a touch- screen kiosk and mobile device (a ubiquitous device in both developed and developing countries) presents a novel approach to the traditional kiosk interaction paradigm. In addition to touch and gesture based interaction users are able to interact with the Calisto system via natural language. Using their personal mobile device users can utilise speech commands combined with optional deictic pointing gestures to media objects on the large screen.

Lee MK et al. [4] explored the effectiveness of channelling visitors interactions with the kiosk through an interactive robot, based on the belief that this would create a more social narrative for interactions with the system, thereby resulting in more relational conversational strategies such as polite- ness and self-disclosure as well as fewer negative behaviours. Their findings suggest that peoples initial words in an interaction can predict their schematic orientation to an agent, meaning that agents can be designed to adapt to individuals during interaction in an attempt to

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elicit their cooperation. The author notes that it would be interesting to assess the effectiveness of utilising an adaptive agent within a culturally adaptive interface (as described by Reinecke et al. [6]).

Rehg JM et al. [5] describes a Smart Kiosk that utilises a graphical speaking agent for output, however rather than using keyboard input (as used by Lee MK et al. [4]) they pro- pose a novel vision-based human sensing system. This kiosk interface supports public interaction with multiple users and is able to actively initiate and terminate interactions as well as manage an uncertain and dynamically changing user population. Computer vision techniques differ greatly from current immersive VR interfaces as well as traditional touch based systems. Rehg JM et al. found that the key to an effective kiosk is natural communication with end users within the context of their environment; to that end their future research plans include the addition of other input modalities such as speech to provide a more holistic approach.

Rather than assuming that a single international definition of usability holds true, Reinecke et al. [6] investigated how a user's cultural background impacts what they perceive as beautiful and usable. They argue that it is simply not feasible to design a single interface that appeals to all users of a global audience. They describe a culturally adaptive system, a system that automatically generates personalised interfaces based on cultural preferences. Results showed that users were 22% faster using these culturally adapted interfaces, needed fewer clicks, made fewer errors and reported greater overall satisfaction with the system.

ARCHITECTURE

Figure 1 provides a very high-level view of our kiosk design. A mobile phone is required to interact with the kiosk. Al- though this may appear a limitation, we believe that by sup- porting low-end mobile phone hardware we are providing a tool which is common place within rural communities. To interact with our kiosk the mobile phone does not need any network connectivity. Instead it emits a series of DTMF tones which are received and interpreted by the kiosk as menu selections.

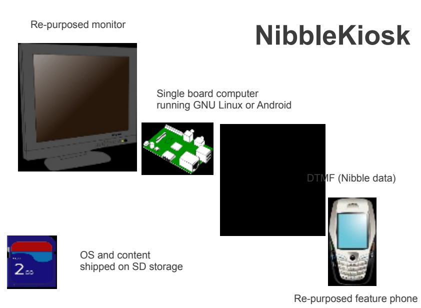

Figure 1: Kiosk architecture

DTMF

Dual-tone multi-frequency signalling (DTMF) was designed to support in-band signalling over analogue phone lines. They are typically used to allow a user to signal information across a phone line to an automated service such as a cinema reservation system by simply selecting the corresponding keys on a numeric keypad when instructed. In this scenario the rate of data transfer is extremely low yet effective. If the speed at which the tones were generated is increased we could transfer data at a higher rate. If the receiver is able to receive a number of tones in a defined unit of time and decode those tones into meaningful information we have invented a practical data communication system. As there are exactly 16 different tones available we can encode exactly 4 bits of data (or a nibble of data) per tone. Thus to transfer 1 byte of data we must generate two tones. Governed by the DTMF standard we should be able to transfer data across these tones at a rate approaching 5 bytes/second. Our system operates by sending a series of 13 tones per interaction as depicted in figure 2. The first tone, indicated by an asterisk, is used to wake up

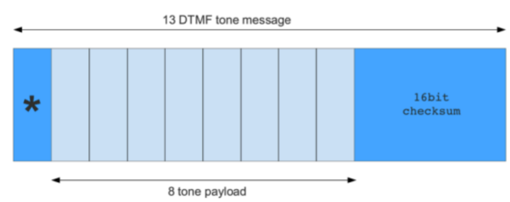

Figure 2: Nibble DTMF message format

the receiving kiosk application. The next 8 tones contain the 32bit payload or data and the final 4 tones provide a check- sum to test whether the message was received. As there are 8 tones to represent data we can represent 32bits of information per exchange or map to 232 different messages. By mapping these unique sequences to actions, a user is able to make a selection on their phone which will emit the corresponding tones to the kiosk which in turn reacts to the user's choice. Manually managing the mapping of tone sequences to actions would be a tedious process and would not scale well. For this reason we intend to provide a much more high-level approach where each 8 tone message corresponds directly to a valid XML message predefined within an XML Schema. Not only will the XML Schema govern the communication it will also provide support for dynamically rendering the GUI on our kiosk computer. To support this design we will use the Packedobjects[1] XML compression tool.

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[1] http://packedobjects.org

Packedobjects

The Packedobjects tool uses a subset of XML Schema that is well suited for low-bandwidth communication. However, we will restrict this further by using an even more limited Schema language which provides suitable data types for only creating menu driven applications. This restricted format will allow us to pre-generate compressed XML on the kiosk computer for all the possible user choices and store these results in a hash table where each encoded selection can be retrieved with a key corresponding to one of the 8 tone sequences. This 32bit key is generated by hashing the encoded XML. A user with a mobile phone will make a menu selection which will result in generating some encoded XML which will be hashed to a matching 32bit key or 8 tone sequence to be sent to the kiosk. Therefore, to the kiosk developer we have created a system that appears to allow XML to pass across DTMF phone tones.

The kiosk

The main design brief for the kiosk is to be low-cost and where possible re-use existing equipment that might be avail- able through donations. For this reason, we intend to support a range of display types such as LCD monitors to CRT monitors. To drive these displays we require a simple embedded computer capable of running either GNU Linux or Android. This computer will need to be equipped with a microphone so that it can receive and process DTMF phone tones. We have already developed software capable of carrying out the required signal processing on board embedded devices and can successfully transmit and receive 32bit messages. A video exists demonstrating the software running between mobile phones[2].

One of the challenges we face of operating an off-line sys- tem is keeping the kiosk up-to-date. To help solve this we will design a system that works entirely from SD card. Both the content and operating system will reside on this storage. Therefore, updating will require replacing this card and re- booting the device. The client-side mobile phone provides other technical challenges.

The mobile phone

Similar to the kiosk hardware, we want to use low-cost hard- ware that is in widespread use or is provided through donation. Our software is written to be highly portable and runs on a range of embedded devices including both MIPS and ARM architectures. If we assume an Internet connection is always available, we could simply build a web-based application that did not need deploying on the device. However, we must assume the software resides on device. This limits our development to feature phones that provide an SDK such as those that run the Symbian OS. We can also support any modern smartphone such as those running Android. We will need to work out a software deployment strategy for these phones and how they will be updated. This will likely take place within the community centres within the towns and villages.

[2] http://nibble.io/video/nibblepin.mp4

CURRENT STATUS AND CHALLENGES

The main area we need to focus on next is the kiosk application. There are a number of GUI technologies we could employ to provide offline access to content. Ideally we will reuse as much existing open source software as possible and most likely build a web-based interface to the local content. However, running Android on the kiosk computer provides another interesting option where we could use its SDK to develop a rich native application.

There are a number of technical challenges to overcome and improve on. We need to improve the performance of the signal processing code to handle receiving tones in noisy environments. Deploying the application will allow us to collect suitable data to help tune our audio processing. However, once these technical challenges have been overcome we need to focus our design towards the user and examine our over- riding goal of providing a solution which can be adapted to support different cultures within our developing world con- text. We hope to build systems that allow us to capture and study user interaction to lead us towards this goal.

CONCLUSION

In this paper we have described work-in-progress towards building an information kiosk which can be controlled using DTMF tones emitted from a mobile phone. The purpose of the project is to build a low-cost, sustainable solution that could be deployed in areas that lack network connectivity. We aim to utilise existing widespread technologies to build a system which is localised to its environment. To help achieve this we aim to study user interaction with the kiosk through deployment in specific developing countries. We face a number of technical challenges in our design but also do not underestimate the importance of the social-technical design of the system.

REFERENCES

1. Bergweiler, S., Deru, M., and Porta, D. Integrating a multitouch kiosk system with mobile devices and multimodal interaction. In *ACM International Conference on Interactive Tabletops and Surfaces,* ITS ’10, ACM (New York, NY, USA, 2010), 245–246.
2. Borchers, J., Deussen, O., and Knorzer, C. Getting it across: Layout issues for kiosk systems. *SIGCHI Bull. 27,* 4 (Oct. 1995), 68–74.
3. Camara, S., Shrestha, S., Abdelnour-Nocera, J., and Moore, J. Village elearning: An offline mobile solution to rural communities? knowledge requirement. In *Proceedings of the 24th BCS Interaction Specialist Group Conference,* BCS ’10, British Computer Society (Swinton, UK, UK, 2010), 463–467.

4. Lee, M. K., Kiesler, S., and Forlizzi, J. Receptionist or information kiosk: How do people talk with a robot? In *Proceedings of the 2010 ACM Conference on Computer Supported Cooperative Work,* CSCW '10, ACM (New York, NY, USA, 2010), 31–40.
5. Rehg, J., Loughlin, M., and Waters, K. Vision for a smart kiosk. In *Computer Vision and Pattern Recognition, 1997. Proceedings., 1997 IEEE Computer Society Conference on* (Jun 1997), 690–696.
6. Reinecke, K., and Bernstein, A. Improving performance, perceived usability, and aesthetics with culturally adaptive user interfaces. *ACM Trans. Comput.-Hum. Interact. 18,* 2 (July 2011), 8:1–8:29.