

MOBILE PHONE INTERACTION TECHNIQUES FOR RURAL ECONOMY DEVELOPMENT – A REVIEW

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ABSTRACT

Rural communities, especially in developing countries, are often neglected in terms of facilities and services that aid their social and economic development. This is evident even in software development processes, in that these groups of users or potential users' are often not taken into consideration. The resultant effect is that they may not use it or use it sparingly. The objective of this study is to identify the various researches on interaction techniques and user interface design as a first step to the design of suitable mobile interactions and user interfaces for rural users. This research project is also aimed at socio-economic development and adding value to mobile phone users in Dwesa, a rural community in South Africa. This paper presents a literature survey of interaction techniques and user-interfaces. An analysis of the interaction techniques with respect to their suitability, availability of technologies, user capabilities for implementation in a rural context is discussed. Descriptive statistics of users' current phones interaction facilities in the rural community which briefly illustrates users' experiences and capabilities in different interaction modes is also presented.

KEY WORDS: Interaction Techniques, Mobile phone, User Interface, ICT, Rural Development.

1. INTRODUCTION

ICT plays a significant role in the social and economic development of a people. This can clearly be seen in the impact it has made all over the world and the increase of the use of ICT infrastructures and services e.g. internet, desktop computers, cell phones, and personal digital assistants (PDAs)). For mobile phones alone, the estimated global subscription rates were 4 billion in 2008 and a great percentage of the users were from developing countries (ITU, 2008). More people live in rural areas than urban centers in developing countries (IFAD, 2008). With the rapid spread of mobile phones in developing countries, rural areas are potential markets for ICT service providers to explore through services that will empower the people socially and economically. The rural communities are usually inhabited by poor and low literate people. There is also poor government presence in terms of social amenities, and a low level of ICT services. Much effort is needed in order to provide be ICT products and services that will help to improve the social and economic impact on this group of users.

Mobile phones and services are viable tool for social and economic development of rural people (Patel *et al.*, 2008). Software developers and service providers need to explore these potential markets to provide services that will enhance rural livelihood and local economy development for these diverse users. Mobile phone services are limited in use in rural communities, where most phone users only make and receive calls with their devices. This could be due to low literacy, technology illiteracy, applications not tailored to their needs, or poverty-related factors. It is therefore important for developers and service providers to

explore ways of addressing these problems, so as to increase mobile device usability in the rural areas. They need to provide user interactions and interfaces with applications that will be intuitive, localized and aimed at improving the rural quality of life.

Several interaction techniques have been designed and implemented on both the desktop PCs and mobile devices, with each trying to make the devices more efficient and usable. These interactions also attempt to take the forms applicable to human-to-human interactions, but the majorities are still focused on the urban users that are highly skilled and technology literate.

Our objective in this paper is to explore and identify the numerous efforts that have been made by researchers in mobile interaction techniques. This review is not exhaustive and is not limited to a single interaction technique. We will not completely ignore the interaction techniques on the desktop PC as some of them apply to and can be implemented on mobile platforms.

Reviews on interaction techniques had been done within different domains of interactions. Few reviews exist that cover a broad spectrum of interaction techniques on mobile devices. Some of these reviews include those that had been done on hand gesture (Pavlovic *et al.*, 1997) and taxonomy of gestures (karam and Schraelfel, 2007). Other researchers reviewed vision-based interaction technique and its application in different areas of computing, such as in human motion analysis (Gavrila, 1999 & Poppe, 2007), in motion estimation (Erol *et al.*, 2007), motion of the eyes

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(Duchowski, 2002), and facial expression analysis (Fasel and Luetin, 2003). A review of user interfaces for vision-based interactions is presented in Quek (1995), Kratz and Ballagras (2007). A review of speech-based interactions is presented in Potamianos *et al.*, (2004). In Jaimes and Sebe (2007) a review of the different developments in multimodal interaction techniques is presented, while Maquire (1999) surveyed the different guidelines used for user interface design.

The use of ICTs for social and economic development of the rural areas is receiving attention in the research community and government agencies. Mobile phone is affordable when compared to the desktop computer in rural areas. To this end, interaction techniques and user interfaces for such ICT products and services must be designed to use available facilities (e.g. mobile phones), meet users' interaction experiences, user capabilities and expectations. In this research, mobile interactions and user interfaces on a mobile commerce application will be developed. The aim of the review presented in this paper is to identify the different interaction techniques, analyze their suitability for implementation from the literature and a survey of the users' environment where this research is targeted. The objective of this research is to add value to mobile phone use, economic empowerment, and bring ICT closer to rural people.

2. Graphics User Interface (GUI)

The graphical user interface has dominated interface technology and interactions on the desktop and mobile systems for a long time now. The popularity of the GUI has made it the traditional medium for presentation of information within different computing platforms and applications. GUI is easy to understand and also helps to remove complexities during task performance. Most interaction techniques often use this medium to display information on the screen, while the interactions are performed using any of the interaction technique or a combination of techniques.

Keyboard interactions are usually the main modality of interaction on GUIs. Other modalities usually combine with the keyboard, such as the pen, stylus, touch screen, hand writing, for effective interactions. Different methods and models for GUI design have been presented by different authors. These include model-based design (Paterno and Santoro, 2003), unified interface design method (Savidis and Stephanidis, 2004), and pattern modeling (Nilson *et al.*, 2006). The small QWERTY keypad on mobile devices is mostly used for interactions on GUIs. Research efforts geared towards reducing key presses during tasks performance on GUI had recorded successes. They try to combine key presses with other modes of interaction in order to reduce the difficulty users may face during interactions. Benko *et al.*, (2006) describes a method where the finger is used for selection on a mobile device touch screen. Other examples include: finger touch interaction (Vogel and Baudisch, 2007), FluidT-mouse (Esenther and Ryall, 2006), "drag-and-pop and drag-and-pick" (Baudisch *et al.*, 2003). The above interfaces are graphical presentations.

With a GUI, Luoma, (2003) describes "the symbol creator" that enabled users to perform text entry with ease. In Balakrishnan *et al.*, (2008), the keypad is combined with a pen rolling technique to interact with a pen-based user interface. Some stylus-based interfaces that enable users enter text with ease and flexibility into their mobile devices include those discussed in Yatani and Truong, (2007), Glyph (Poirier, 2005), and Edgewrite (Wobbrock *et al.*, 2003). Other forms of interaction modalities that were integrated with the mobile keypad to give users intuitive interactions on GUIs are discussed (Rekimoto, 1996 & Widgor and Balakrishnan, 2003). Rekimoto, (1996) described a tilt interface that enables interactions on small screen devices. The user tilts the device to the direction of an item that needed to be selected on the screen, and performs an input operation through key press and selection. Widgor and Balakrishnan, (2003) presented a GUI that allows the user to tilt the mobile phone to the direction of a character on the keypad and the movement is indicated on the screen. The desired character is then selected by pressing the key on the keypad that contains that character in its combination.

GUIs are flexible and easy to use. This is demonstrated in Medhi *et al.*, (2006) where it was implemented and used to assist illiterate and semi-literate users to search for jobs that are available within their community on the Web. The users were able to use the application with ease. A GUI on any application for rural community people and with the appropriate symbols that reflect the social and cultural values of the people could help to improve usability of new technology within the community.

3. Vision-Based Interaction Technique

Advances in mobile technologies have brought about promising features and functionalities. This has increased the modalities of interaction and services available on mobile devices. Some of these improvements include high resolution cameras, and detachable memory cards. High resolution cameras available on mobile devices can capture images of objects and used for interaction on mobile devices.

Vision-based interaction technique performs just like human sight (Kjeldsen *et al.*, 2003) used for interaction with other humans or objects in our environment. This form of interaction on mobile devices is made possible through an interface provided on the device.

A vision-based interface that can detect head movement through a mobile phone camera is also described (Kjeldsen *et al.*, 2003). Vision-based interaction and interface were applied in a mobile game application in Capin *et al.* (2006), while Bucolo *et al.* (2005) describe two interfaces for tilt and translation interactions on a mobile phone that are used to play a ball in the maze game which is made possible by the camera interface. In Hannuksela *et al.* (2007) a vision-based interface that is combined with the camera of the mobile phone to capture and measure the motion of the phone when it is tilted or translated on the hand is described.

With the decrease in price of mobile phone devices and the increased distribution of camera equipped devices, the application of vision-based interactions and interfaces for low literate rural community people may be a possibility in the future. Vision-based interaction can be applied in traditional game applications that are localized to the rural people. This may provide the needed intuition and usefully add value to mobile phone usage within a low literate/community.

4. Gesture-Based Interaction Technique

Using gesture during oral communication is common among humans (Brewster *et al.*, 2003). It is most times performed using different parts of the body, such as the head, hand, mouth, or eyes. There exist applications and services that use gesture as a mode of interaction both on the desktop computers and on mobile devices. Some examples are interactive games Kratz and Ballagras (2007), Sato *et al.* (2006), consumer electronics Bretzner *et al.* (2002) and virtual environments Vatavu *et al.* (2005).

Gesture-based user interfaces that enable users to interact with the computing system are also available. An interface that accepts head gestures as input for menu selection is presented Brewster *et al.*, (2003). Wexelblat, (1995) used gestures as the modality of interaction on virtual reality systems, while Crossan and Murray-Smith (2004) incorporated an accelerometer in a gesture-based interface for interaction. In Long Jr. *et al.* (2000), a pen-based interface is combined with a gesture recognition module for user interactions. For mobile entertainment, Pirhonen *et al.* (2002) used gesture to control a mobile music player, and Crossan and Murray-Smith (2006) also describes how a song could be selected and filtered using gesture in a mobile phone music player that is attached with an accelerometer. On large display systems, Fohrnbach *et al.* (2008) describe the use of hand gesture for selecting items on the display through pointing of the finger on the target.

As a human form of communication that cuts across every society, this type of interaction can have some unique features among different groups. These gestures could be captured and used for interaction design for different mobile applications, but such facilities are not yet available in rural areas.

5. Point and Shoot Interaction Technique

Point and shoot interaction technique offers an intuitive method of interactions to the users. It is flexible and natural since as humans we also point to object we interact with. An interaction device is pointed to another object for interaction and exchange of information. Research work has been done in this regard such as discussed (Ballagas *et al.*, 2005), where a mobile phone's camera is pointed to a target item or position on a large display screen to perform item selection, rotation/drag with the phone's joystick. Another example of this technique is a tourist application (Madhavepeddy *et al.*, 2004) that allows mobile phone users to read the tags on a world map by pointing the camera on the tags

and then shoot to select the target. With the information they could locate a city/airport, book a flight, or view a city map.

In Rukzio *et al.* (2006), a mobile phone camera is used to pick images of smart objects with visual markers for identification and the information concerning the smart object is read. Also, optical beam attached to a mobile phone is used to read information from visual tags on a poster through pointing (Valkkynen *et al.*, 2003).

This type of interaction technique may still seem difficult to implement in a rural community due to the high technological requirements. But being an intuitive and easy form of interaction, it can be useful for wireless services like information boards where audio information can be transmitted to the user in his or her local language.

6. Touch-Based Interaction Technique

During interactions, we could touch other people or objects that are near to us. With mobile devices, this type of interaction has been demonstrated by researchers with objects like posters, maps with radio frequency identification (RFID) tags, information kiosks, public display systems, and near field communication (NFC) enabled mobile devices.

Touch-based interactions using mobile phones equipped with NFC/RFID tag readers can be used to interact with other objects at acceptable communication range as discussed (Hardy and Rukzio, 2008). Hannuksela *et al.* (2007) used a mobile phone to read information from a map-based tourist application in a large display system by touching the device on the display to get information from the map. In entertainment, Anokwa *et al.* (2007) describes the use of mobile phones enabled with NFC to interact with movie poster so as to enable the user book for the event. In Isomursu *et al.* (2008), a home care application where the elderly people could use NFC/RFID enabled mobile phones to order meals from a home care service provider by touching the phone on tags placed in their homes as a way of assisting them in their daily living is described. Rukzio *et al.* (2006) also used a mobile phone with RFID tag reader to browse information from a Web server by touching the device on an RFID tag. And in Hinckley *et al.* (2000), touch sensors attached to a mobile phone are used to send signals into the mobile phone when the user touch or pick the phone.

Touch-based interactions are easy to perform without requiring much assistance. In a rural community, this type of interaction technique could be useful since it does not require text commands. It could be implemented in mobile applications that provide community support services with user interface and requirements that meets the local needs of the people. Facilities for implementing this interaction technique in rural areas are not available yet.

7. Speech-Based Interaction Technique

Speech communication is a common, intuitive and natural way of interaction. Research efforts in speech technology had resulted in the development of

different speech recognition and synthesis systems, and applications that uses these systems to improve speech-enabled interactions. One prominent advantage of speech interactions is that it can accommodate a variety of users (Zhang *et al.*, 1999).

The Mandarin dialog system (Tsai, 2006) is a voiceXML interface that provides users access to Web services with Mandarin or English language voice commands via telephone lines. The application uses automatic speech recognition and text-to-speech systems to establish dialogs between the user and the Web service. WAP (wireless application protocol) integration with speech technology provides wireless access to users using speech interactions. In Lo and Meng (2002), users with WAP devices could interact with the Web server to retrieve information and services such as weather information, stock alert service, or sport news using voice commands. Also, Sodnik *et al.* (2008) describes a driving simulator with an auditory interface on a mobile device.

In database systems, speech technology has been used to perform database queries. This is discussed in (Arons 1999), where voice queries are used to manipulate the database using the mobile phone, while D'Haro *et al.* (2006) describes a Web-based database system that perform queries using voice commands.

Speech-based interfaces enable device users to simultaneously engage in more than one activity (Holland *et al.*, 2002). In rural communities, speech interactions on mobile devices may provide the desired intuition, flexibility and ease of use. An example is Sherwani *et al.* (2007), where a voice-enable application is used to assist a rural community in Pakistan to access health information from the Internet. Speech applications on mobile devices can be applied in any rural community provided the language of communication or interaction is localized.

7. Multi-Modal User Interface

Multimodal user interfaces combines two or more modality of interaction for user interactions. They can accommodate diverse users since they provide more than one modality of interaction to them. Multimodal interfaces can be implemented in different application areas.

Multimodal interfaces that combine speech and gestures interactions were implemented (Bolt, 1980, Ito, 2001, and Irawati *et al.*, 2006) for intuitive interactions in different applications. In Bolt (1980), speech and pointing gestures are used for positioning objects on a large display system, while Zhang, (1999) combined these two modalities of interaction to assist the visually impaired to control home appliances, and Irawati *et al.* (2006) applied speech and gesture interfaces in augmented reality environment to provide intuitive interactions to the user.

MUNDO (Hartl *et al.*, 2002) is a multimodal interface development tool for different applications on mobile devices. A multimodal user interface is a good candidate interface that can be used to improve mobile phone usability in any rural community in developing

countries. A combination of speech and GUI on an e-commerce application can assist low literate users to use the system effectively. This had been demonstrated and proven successful (Sherwani *et al.*, 2007).

9. Summary

The interaction techniques so far discussed are applicable on both desktop Pc; wireless and mobile devices. Some of the interactions are yet to receive wide acceptability on the mobile device due to the limited nature of the device and the wide use of mobile devices such as the mobile phone across different variety of users. These techniques have tried to take interactions design to higher level. Though they have all been describe to follow the natural ways of human interactions and also aimed at improving interactions and users' experiences with their devices. Much research work is still needed to evaluate their effectiveness and user satisfaction impact (Ji *et al.*, 2006 & Duh *et al.*, 2006). Although, research in user interface design is still faced with the problem of designing interfaces that can provide the needed satisfaction and the right context of use for every user (Cremers *et al.*, 2007) irrespective of their physical abilities, educational background and environment.

A summary of the different interaction techniques, the types of interaction, input and output mechanisms associated with the different techniques are presented below. We also mentioned the interaction suitability/non-suitability for implementation on mobile devices for rural mobile phone users taking into consideration factors such as low income, technology illiteracy, low literacy level, availability of facilities and user needs.

Touch-based interactions

Type of interaction: Instant or continuous touch on an interaction surface, e.g. a mobile device screen surface or on an interaction object for connection together. Some existing application areas: Mobile tourist guide, home care services, advertisements, museum guides, etc. Input mechanisms plus support facilities: Mobile devices enabled with NFC, RFID readers, Bluetooth, sleep/active mode display etc. Output mechanisms plus support facilities: Mobile device screen, large display system/dynamic display system etc. Suitability for use during movement: Not suitable for use during movement. Interactions are performed when stationary. User requirements (illiteracy; less training; intuitiveness "localization"): Less pre-knowledge of displayed options required; intuitive, difficult localization/personalization. Suitability in a rural community: Not yet Suitable for implementation in rural areas, due to none availability of facilities rural communities. It also requires some level of literacy and training.

Gesture-based interactions

Type of interactions: Movement of human body e.g. the arm, camera movement, image capturing on camera. Some existing application areas: Interactive games, virtual environments, control of music players, camera-based recognition systems etc. Input mechanisms plus

support facilities: Mobile device camera, sensor-enabled mobile device, accelerometer, etc. Output mechanisms plus support facilities: Mobile device screen, large display systems, virtual reality systems, etc. Suitability for use during movement: Interactions can be performed during movement. User requirements (illiteracy; less training; intuitiveness "localization"): Intuitive, unknown outcome of input; requires knowledge of possible input, difficult localization. Suitability in a rural community: Difficult and may not yet be suitable for implementation, facilities or devices may be too costly for rural people.

Vision-based interactions

Type of interactions: Instant or continuous movement of camera or objects, image capturing. Some existing application areas: Mobile games, tourist guide, advertisements, video mails, etc. Input mechanisms plus support facilities: Mobile device camera, data gloves, NFC/RFID reader, etc. Output mechanisms plus support facilities: Mobile device screen, virtual reality display systems. Suitability for use during movement: Interaction is not suitable during movement. User requirements (illiteracy; less training; intuitiveness "localization"): Unknown outcome of input; requires knowledge of possible input, difficult localization. Suitability in a rural community: Not suitable yet for implementation due to limited facilities and interaction complexity that will require training.

Point and Shoot interactions

Type of interactions: Instant shooting; mobile device is pointed to object of interaction, selection, clicking an item. Some existing application areas: Tourist guide, Web services, Advertisement, games, etc. Input mechanisms plus support facilities: Mobile device camera, optical beams/light beams, laser pointers, etc. Output mechanisms plus support facilities: Mobile device screen, large display systems, etc. Suitability for use during movement: Interactions not suitable during movement. User requirements (illiteracy; less training; intuitiveness "localization"): Unknown outcome of input; requires knowledge of possible input, difficult localization. Suitability in a rural community: Not suitable for implementation, devices are costly and unavailable in rural areas etc.

Speech-based interactions

Type of interactions: Spoken dialog and voice commands, and sometimes with key presses for interactions. Some existing application areas: Wide range of applications, games, Web services, database queries, tourist guide, etc. Input mechanisms plus support facilities: Mobile device microphone or mouth piece. Output mechanisms plus support facilities: Mobile device screen, speaker or earpiece. Suitability for use during movement: Suitable for use during movement. User requirements (illiteracy; less training; intuitiveness "localization"): Intuitive, low literacy level; linguistic localization. Suitability in a rural community: Suitable for implementation in rural areas.

Graphic User interface

Type of interactions: Keypad pressing, mouse pointer and button press with device movement, finger touch, stylus, pen interactions, etc. Some existing application areas: Wide range of applications, games, Web

services, database queries, tourist guide, etc. Input mechanisms plus support facilities: keypad, touch screen, stylus, pen, etc. Output mechanisms plus support facilities: Mobile device screen.

Suitability for use during movement: Cumbersome and not flexible enough for use during movement. Often used with conflicting attention. User requirements (illiteracy; less training; intuitiveness "localization"): Intuitive; low literacy, ease cultural localization. Suitability in a rural community: Suitable for implementation, but with minimal key presses.

Multimodal interactions

Type of interactions: Keypad/button pressing, voice/keypad, vision/gestures, pointer selection with narrator interaction, and other combination of interaction types. Some existing application areas: Wide range of applications, games, Web services, database queries, tourist guide, etc. Input mechanisms plus support facilities: keypad, touch screen, stylus, pen, help desk; narrator or screen navigator or drop down menu, etc. Output mechanisms plus support facilities: Mobile device screen; screen narrator, speaker, etc. Suitability for use during movement: Less conflicting attention with narrator. User requirements (illiteracy; less training; intuitiveness "localization"): Intuitive; low literacy, ease cultural localization. Suitability in a rural community: Suitable for use in a rural community.

8. Survey of Users' Phone Interaction Mode

We conducted a survey using structured questionnaire with the target users in the rural community to find out users' different modes of interacting with their devices, as a means of determining their capabilities and experience with mobile phone technology with respect to the different interaction techniques. This is part of the user and environmental analysis in our study. The result shows that among the 83 respondents, 78.13% owned mobile phones and interact with the primary keypad and screen. For additional phone facilities, 12.5% use touch screen, 6.25% use touch pen for interaction, 60.87% use camera on their device, and 12.5% also interact with soft keypad on their phone. The results are indications of the nature of phones, common interaction technologies used, and users' capabilities with phone technologies.

9. CONCLUSION

The rapid proliferation of mobile phones entails that new applications are required to take advantage of the new market. ICT can play a significant role in rural development by providing services that take into consideration the local economy of the people. The type of user interface and interaction technique used will play a vital role in this. We have presented a review of some of the existing research on interactions and interface design as part of our research work to design mobile interactions and user interface for ICT services for rural users.

Our future work is to design graphic and voice interfaces for mobile commerce services for rural users in Dwesa community of South Africa consisting of semi and illiterate mobile phone users, and subsistence

farmers. This is part of the Siyakhula Living Lab project, an ICT infrastructure that have been installed in Dwesa to provide Internet access and a platform for social research aimed at socio-economic enhancement of the community.

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