



# An Enhanced Mobile Phone Dialler Application for Blind and Visually Impaired People

Rana Yousef\*, Omar Adwan, Murad Abu-Leil

Computer Information Systems department, KASIT  
The University of Jordan, Amman-Jordan

\*Corresponding author E-mail: rana.yousef@ju.edu.jo

---

## Abstract

This paper presents the development of a new mobile phone dialler application which is designed to help blind and visually impaired people make phone calls. The new mobile phone dialler application is developed as a windows phone application to facilitate entering information to touch screen mobile phones by blind people. This application is advantageous through its innovative concept, its simplicity and its availability at an affordable cost. Feedback from users showed that this new application is easy to use and solves many problems of voice recognition applications such as inaccuracy, slowness and interpretation of unusual voices. In addition, this application has increased the users' ability to dial phone numbers more independently and less stressfully.

**Keywords:** Touch screen Mobile phones, smartphones, voice recognition, windows phone application, visually impaired people, phone dialler, visual studio

---

## 1 Introduction

Blind and visually impaired people require built-in accessibility functionalities to help them use mobile phones. When mobile phones started to emerge on the market, blind people only had to memorise the layout of the phone's keypad, which was similar to regular phones with two extra keys, send and cancel. Accordingly, dialling numbers was not a complex task for blind or visually impaired people. However, mobile phones started to become more advanced and started to run operating systems, where users were able to use them similarly to a regular computer. At this point, it became necessary to develop screen readers which could be used on the mobile phones similarly to how blind people use the computer.

The emergence of touch screens made the situation much more difficult. Before, all input was done through a keyboard or keypad, which is the ideal situation for blind people. However, with touch screen mobile phones, even if blind people had a screen reader to use, it became increasingly difficult for them to enter information, and interact with their phone [7].

Manufacturers started to build voice recognition into their phones but could only provide limited functionalities. In addition, voice recognition applications undergo some drawbacks. Although voice recognition software may interpret the spoken words correctly the majority of the time, the user might still need to make corrections and repeat information he/she already entered. Additionally, some people with unusual or especially thick accents may be unable to achieve the accuracy figures claimed by some voice recognition programs. Also, using voice recognition software, one may find himself speaking more loudly than in normal conversations. Although there is no definite scientific link established between the use of voice recognition software and damage to the voice, talking loudly for extended periods always carries the possibility of causing strain and hoarseness. Another drawback of voice recognition applications is that the ideal environment should be a quiet one. In a loud environment, voice recognition software may fail to recognise the voice.

In this paper, we provide a novel solution to the problem of entering information to touch screen mobile phones for blind or visually impaired people. Specifically, our application facilitates dialling phone numbers using simple mobile phone applications that requires no extra cost to be burdened by the user. Feedback on the new application has been collected from blind and visually impaired people to figure out the degree of simplicity and usefulness of our application.

Section 2 presents background knowledge and research related to our work. Section 3 describes the enhanced mobile phone dialler application. Section 4 evaluates the application and analyses results obtained from users who used the application. Finally, section 5 concludes the paper and presents future work.

## 2 Background and related work

One of the general obligations specified by the united nations about the rights of persons with disabilities is: “To undertake or promote research and development of, and to promote the availability and use of new technologies, including information and communications technologies, mobility aids, devices and assistive technologies, suitable for persons with disabilities, giving priority to technologies at an affordable cost” [11].

Mobile phones have revolutionised life for most people, but for blind and visually impaired people, finding a mobile phone that they can use is nearly impossible. For example, features that can be identified by touch, displays that can be read by people with limited vision and phones with speech output for people who cannot read the phone's display are not widely available. Many mobile phone manufacturers are not taking seriously their accessibility obligation [1].

Many researchers have proposed new applications to help blind and visually impaired people access and use mobile phones. Most of these applications were based upon previous researches whose goal is to use and enter information to mobile phones or other devices by the use of eye-free techniques. For example, Zhao et al. [14] presented the design and evaluation of earPod which is an eyes free menu technique using touch input and reactive auditory feedback. They have indicated that earPod is potentially a reasonable eyes free menu technique for general use, and is a particularly exciting technique for use in mobile device interfaces.

Wobbrock *et al.*[13] proposed EdgeWrite which is a unistroke text entry method for handheld devices designed to provide high accuracy and stability of motion for people with motor impairments. It is also effective for able-bodied people. Users can enter text by traversing the edges and diagonals of a square hole imposed over the usual text input area. Gesture recognition is accomplished through the sequence of corners that are hit. This means that the full stroke path is unimportant and recognition is highly deterministic. The authors' results indicated that EdgeWrite have better accuracy compared to other techniques at the time. Also, Wobbrock et al. [12] have presented a gestural text entry method for mobiles phones. In their method, instead of entering text to mobile phones by repeatedly pressing buttons, users can use an isometric joystick and the EdgeWrite alphabet to allow them to write by making letter-like pressure strokes. And this could be used eyes-free at about 80 % of the speed of normal use.

The following researches have mainly focused their goals on developing applications to help blind and visually impaired people use mobile phones. For example, Narasimhan et al [6] described developing cost effective assistive technologies for the visually impaired, with a focus on using commercial off-the-shelf technologies as much as possible. Their work involves three specific technologies; the grocery shopping assistant, the currency identifier and the transportation assistant. These technologies are supported on standard mobile phones with text-to-speech and commonly used by the visually impaired.

Li *et. al.*, [3] have proposed a prototype application called blindSight to replace the traditionally visual in-call menu of a mobile phone. Users can interact using the phone keypad without looking at the screen. The application responds with auditory feedback. This feedback is heard only by the user, not by the person on the other end of the line.

Sánchez and de Togores [8] introduced the concept of “Low Vision Mobile App Portal”, which provides a way to access mobile apps specifically designed for visually impaired users. Kane *et. al.*, [2] argue that touch screens are still largely inaccessible to blind people because they require the user to visually locate objects on the screen. The authors have addressed this problem by developing an application called Slide Rule that uses audio output and gesture input to enable blind people to interact with touch screens.

Most of techniques and methods described above are used to help blind and visually impaired people obtain information from mobile phones. The other techniques which focuses on helping blind people entering information to mobile phones are the either expensive, complicated or relays on voice recognition techniques which we have previously mentioned have many drawbacks, such as inaccuracy, slowness and interpretation of unusual voices. The application described in this paper helps blind and visually impaired people use their mobile phones to dial phone numbers, the application is advantageous through its innovative concept, its simplicity and more importantly, its availability at an affordable cost. It accordingly does not depend on voice recognition techniques or complicated techniques as will be seen in the following section.

### 3 The enhanced mobile phone dialler application

As a first step and before designing our dialler application, interviews with blind and visually impaired people were conducted to understand how they use mobile phones to dial phone numbers, and to figure out the difficulties they face while making phone calls.

The interviews took place in Dubai; the interviewees' replies were relatively similar. Almost all of them used mobile phones with additional assisting software's that had to be installed to help them use these phones. However, a number of the interviewees would have preferred to switch to other branded mobile phones but, unfortunately, they had to purchase assisting software's such as Talks, Ebser, and Nateeq which are highly priced and were expensive to purchase. The software price ranged between AED 1000- AED 1500. This is equivalent to the price of any branded mobile phone. In addition, interviewees had problems in having to deal with complicated assisting software and they all agreed that their ideal phone is a user-friendly one.

Accordingly, our goal was to develop an easy to use phone dialler application that enables blind and visually impaired people dial their phone numbers using a touch screen mobile phone with a minimum cost. Consequently, the new phone dialler application was developed as a windows phone application using Microsoft visual studio [4] and is based on a simple algorithm which we have named the Nodes-Based Dialler (NBD) algorithm. In future, more functionality will be added to touch screen mobile phones and to be run on different platforms such as android and IOS.

In the following subsections we describe the design and development of the enhanced mobile phone Dialler application

#### 3.1 Windows phone application

Mobile applications which are developed to run on smart phones became an extremely competitive field of software production.

Our new mobile phone dialler application is developed using Windows Phone 7 which is a mobile operating system from Microsoft [5]. Windows Phone 7 development is done using the .NET framework, the .NET framework is a software framework created by Microsoft for use in creating Windows applications.

Our application is developed using visual Studio 2010 express for windows Phone and a windows phone SDK which is available free on the msdn website. The design is simple and easy to Implement.

User Interface design is the first phase of developing a mobile application. The goal of user interface design is to make the user's interaction as simple and efficient as possible, in terms of accomplishing user goals. User interface design requires a good understanding of user needs. In our application, the users are either blind or visually impaired. This necessitates designing a simple interface to facilitate the phone number dialling process as will be discussed in the following subsection.

There are two development platforms in Windows Phone 7, Silverlight and XNA. Silverlight is used in line business applications while XNA is used in games and Xbox applications [9]. The Silverlight platform was used to develop our mobile phone dialler application. We wrote the core functionality in the .cs file.

When the application has been demonstrated to provide the required capabilities, the application can be provisionally accepted and the process can be started. We tested the application in many ways so that it doesn't crash anywhere during run time [9]. An emulator can be used to see exactly how the developed application can be on original device. We get the emulator by default when we install the Visual Studio.

#### 3.2 The enhanced mobile phone dialler application's user interface

Figure 1, represents part of the state machine model representing events exposed by the user [10].

The state machine in Figure 1 shows four nodes representing the mobile states: Locked, Normal mode, Dialling mode and In-call mode. While in the Normal mode, choosing the NBD application first opens the user interface shown in Figure 2 (a) which should also be read to the user using an output audio; at this point the mobile phone state is moved to the Dialling mode. The Dialling mode state displays 6 nodes to the user as shown in Figure 2(b) and then the NBD algorithm is called. The nodes are simply represented as circles; no complicated controls were used, so that our target users, who are blind and visually impaired, will not find the interface difficult to learn and use. Pressing the Dial button moves the mobile phone state to the In-call mode to set up the connection with the dialled phone number, and pressing the Cancel button returns the mobile phone state to the Normal state.

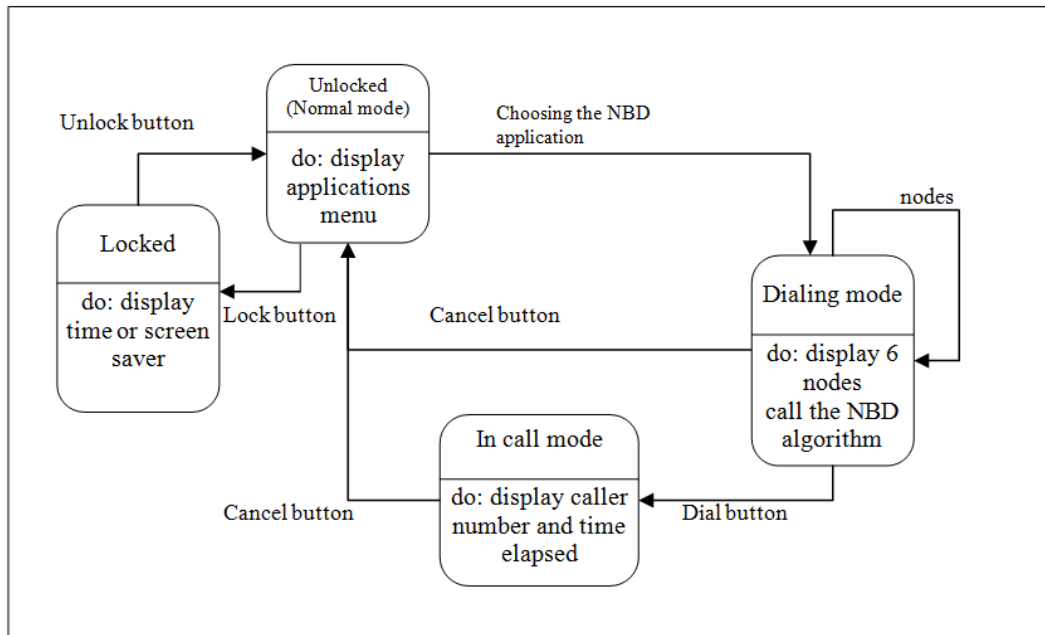


Fig 1: Part of the state machine model representing the behaviour of the mobile phone in response to events exposed by the user

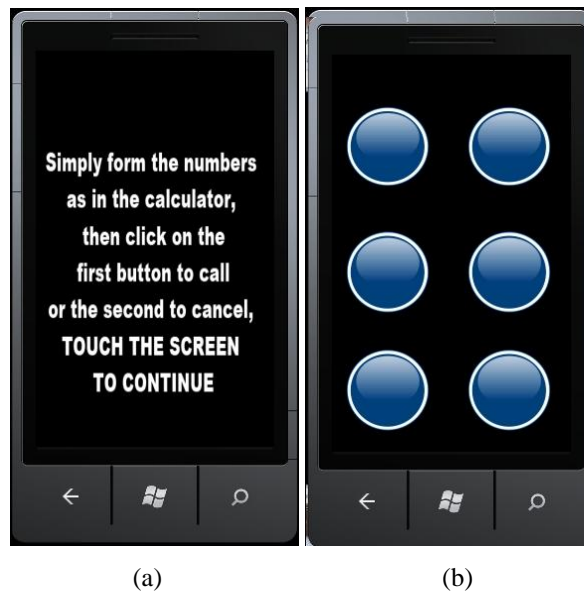


Fig 2: (a) The first screen opened to the user when the NBD application is chosen. (b)The nodes displayed to the user when the NBD application starts

### 3.3 The nodes-based dialler (NBD) algorithm

The following algorithm presents the new mobile phone dialler application algorithm, which we have implemented to be used on touch screen mobile phones.

**The NBD Algorithm: The Nodes-Based Dialler Algorithm**

**Input:** A set of six nodes,  $n = \{n_1, n_2, n_3, n_4, n_5, n_6\}$ , representing digit points which formulate a digit from 0 to 9 if visited according to one of the sequences,  $seq(d) = \{seq_1, \dots, seq_i, \dots, seq_j\}$ ,  $0 \leq d \leq 9$ ,  $seq_i = \{n_p, n_p, \dots, n_q\}$ , where  $1 \leq i \leq 6$ ,  $1 \leq p \leq 6$ ,  $1 \leq q \leq 6$ .

**Output:** a set of digits,  $dig$ , representing the phone number to be dialled:  $dig = \{dig_1, dig_1, \dots, dig_k, \dots, dig_m\}$ ,  $1 \leq k \leq m$ . Or perform an emergency call dial.

**Begin**

Set the mobile phone mode to dialling

While user has not pressed the dial button or the cancel button, do

If the starting node  $\in \{n1, n2\}$  then

for each node  $n_p$  visited by the user, where  $1 \leq p \leq 6$ , do

add  $n_p$  to seq

if seq =  $\{n1, n4, n5\}$  then

output audio: "emergency call dialling"

Ask user to confirm the dial

if user confirmed, then dial the emergency number specified

else If seq  $\in$  seq( $d$ ), where  $0 \leq d \leq 9$

output audio: the digit,  $d$ .

Add  $d$  to dig,

Else

Delete all nodes from seq

ask user to re-enter a digit

end if

end for each node

else

ask user to re-enter the digit

end if the starting node

end while

if user pressed the dial button

ask user to confirm dialling the number

if user confirmed then perform the call dial

else if the user pressed the cancel button

set the mobile mode to normal

end if

**End**

The NBD algorithm starts with a set of 6 nodes representing digit points from which a digit from 0 to 9 can be formulated by touching the screen and sliding over these points. A number of design decisions were made to make this application suitable for blind and visually impaired people.

Design decisions:

1. A surface-raised dot is required on the first two nodes, to allow the user recognise where to start sliding his/her finger.
2. Each digit should have one or more starting nodes specified.
3. Once the nodes are visited in one of the recognised sequences, the digit is read by the application and saved as one of the phone number digits; this makes the application more reliable and makes the user more confident during the dialling process.

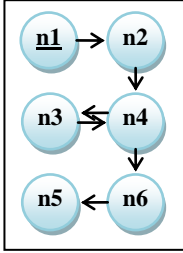
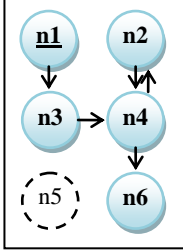
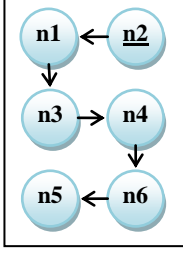
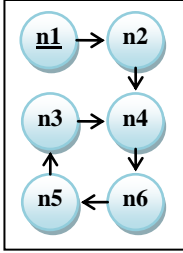
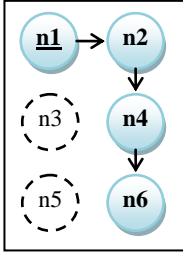
4. According to design decisions 2 and 3, no sequence of nodes can be a subset of another sequence if both have the same starting node.
5. The user should not remove his finger before he finishes formulating the digit and if the user removed his finger before formulating a recognised sequence of nodes, the user will be asked to re-enter that digit.
6. According to design decision 5, a node can be revisited while formulating a digit.
7. The digits 0, 1 have two sequences of nodes to formulate them. In future, all possible sequences can be implemented and added to the set of allowed sequences to be visited to formulate a digit.
8. The nodes sequence {n1, n4, n5} allows the user to immediately make an emergency call.

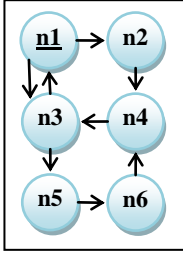
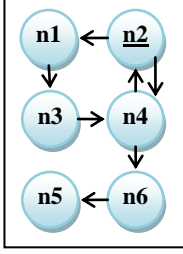
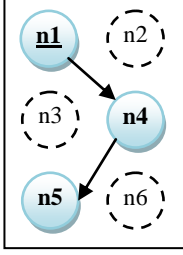
The algorithm should first check out the starting node which should be one of the two nodes: n1, n2. If the starting node is correct then, while the user slides his/her finger over the nodes, the sequence of nodes is saved into a string variable. If this sequence of nodes is one of the allowed sequences for any of the digits from 0 to 9, the digit is read by the application and is saved as one of the phone number digits to be dialled. However, if the sequence was not recognised, then the user is asked to re-enter a digit. After entering all digits the user dial his/her number after a confirmation message. At any time, the user can cancel the dialling process by clicking the cancel button.

Table 1 lists the allowed sequences of nodes that can be visited by user to formulate a digit. The third column in table 1 shows the digits representation formulated using the 6 nodes. These are represented as shaded nodes with arrows connecting them; the underlined node number indicates the starting node that the user should begin sliding his/her finger. The dashed circles should not be visited while formulating a digit.

Table 1: Allowed sequences of nodes to formulate digits

Digit	Set of accepted sequences of nodes to represent the digit	Digit representation
0	{n1, n2, n4, n6, n5, n3, n1}, {n2, n4, n6, n5, n3, n1, n2}	
1	{n1, n3, n5} {n2, n4, n6}	
2	{n1, n2, n4, n3, n5, n6}	

<p>3</p>	<p>{n1, n2, n4, n3, n4, n6, n5}</p>	
<p>4</p>	<p>{n1, n3, n4, n2, n4, n6}</p>	
<p>5</p>	<p>{n2, n1, n3, n4, n6, n5}</p>	
<p>6</p>	<p>{n1, n2, n4, n6, n5, n3, n4}</p>	
<p>7</p>	<p>{n1, n2, n4, n6}</p>	

8	{n1, n2, n4, n3, n1, n3, n5, n6, n4}	
9	{n2, n1, n3, n4, n2, n4, n6, n5}	
Emergency call	{n1, n4, n5}	

## 4 Evaluating the nodes-based mobile phone dialler application

We evaluated our new nodes-based mobile phone dialler application by conducting user studies with 10 blind people. Evaluation was performed in two phases. In the first phase, our goal was to measure the degree of correctness of formulating the phone number digits using the nodes. In the second phase, we focused the evaluation on getting feedback about the simplicity and user friendliness of the application and how it would affect the sense of independence for the user.

### 4.1 Phase I: Evaluating the Degree of Correctness of Formulating Digits

In this phase, we have explained to participants how to formulate each digit (from 0-9) and explained the alternative sequences of each, if available. Then, we asked each participant to formulate each digit from 0-9 as well as the emergency phone number sequence. Figure 3 shows the results of testing the digit formulation process by each blind participant in two consecutive trials. A correct formulation is when the user enters the correct sequence of nodes to formulate the given digit and hears back the corresponding digit. A wrong formulation of digits is when the application asks the user to re-enter a digit, this means that he/she either left up his/her finger before finishing the digit formulation, or that the user has entered a wrong sequence of nodes, which is not recognised as one of the acceptable sequences to formulate a digit or an emergency call.

As can be seen from Figure 3, the digits: 0, 1, 5, 6, 7 and the emergency number sequence were the easiest to memorise by participants, where all participants were able to correctly formulate them in both trials. Digits 2 and 3 were also simple to formulate by users. However, only 10% of participants in the first trial forgot where start, where they have

started with node 2 instead of node 1. In the second trail they were able to avoid this mistake. Digits 2 and 4, caused 20% of participants to make incorrect formulation, and that was because they forgot to revisit a node, so they left up their fingers instead. This of course resulted in wrong digit formulation. Again, these mistakes were avoided in trail 2. Digit 8 was the only one which didn't result in 100% correct formulation in the second trial compared to other digits. This was because there's only one sequence of nodes to formulate it and the starting point should be node 1. As digit 8's sequence of nodes was the longest, it seems that it was relatively more complicated than other digits to memorise. However, we believe that another trail could have resulted in 100% correct digits formulation for all digits.

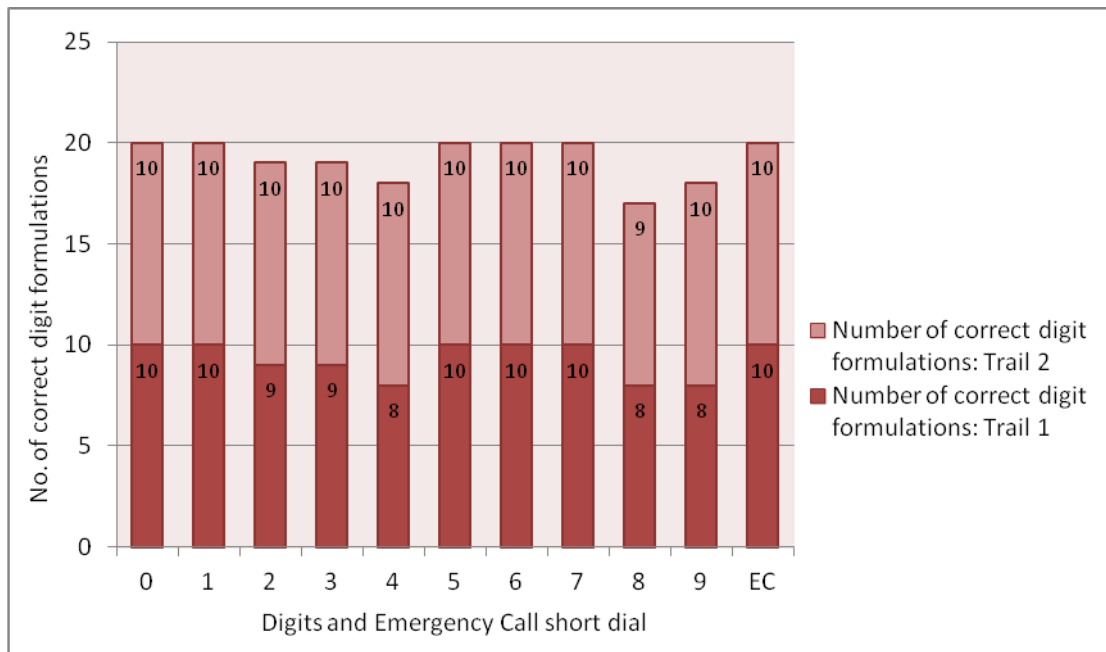


Fig 3: Results of testing the digit formulation process by each blind participant in two consecutive trials

From these results, we observe that it only took one trial to increase the digit formulation correctness from 92.7% in trail 1 to 99.1% in trial 2. Which means that digit formulation by blind people using our approach is simple and easy to learn and use.

#### 4.2 Phase II: Evaluating the simplicity and user friendliness of the application

After briefly explaining the phone dialler application to the users, we asked participants to dial a phone number using the application, and then we conducted a 15-minute semi-structured interview.

Table 2 shows user satisfaction questions and mean answers after using the mobile phone dialler application by 10 blind people. Participants were asked two groups of questions, the first group measures the degree of simplicity and usefulness of our dialler application, the second group of questions aimed to measure the degree of correctness of our design decisions to enable users feel independent while using their mobile phones to dial phone numbers. The participants were asked to answer with numbers ranging from 1 to 5 to indicate their agreement to the statements appearing in part 1 of the table for the first group of questions, (1= Strongly disagree, 5=Strongly agree), and to indicate the importance of the design decisions which appear in part 2 of the table (1 = irrelevant, 5 = critically important).

Analysing participants' answers it was found that all participants were able to make phone calls easily. Participants found the interface easy to use and fast to learn. As can be seen from Table 2, satisfaction with the dialler application was high. All participants found the application useful, easy to use and learn and they can be confident that they are dialling the correct phone number. The majority of the participants found the application faster than using voice recognition software, and enabled them to use the mobile phones more independently and less stressfully.

Regarding our design decisions, all participants found it important to have a starting node to begin sliding and formulating the digits, also it was important to have the application read the recognised digit. Most of the participants found having a special sequence of nodes to make an emergency call important and they appreciated having different sequences of nodes to formulate the same digit.

Table 2: User satisfaction questions and mean answers after using the mobile phone dialler application by 10 blind people

Part1: Describe how you feel about each statement. 1 = strongly disagree, 2 = somewhat disagree, 3 = neutral, 4 = somewhat agree, 5 = strongly agree		
Number	Statement	Mean answers
1.1	The application would provide me with useful Functionality	5
1.2	dialling phone numbers using the application would be faster than using voice recognition software	4.6
1.3	I would prefer to ask someone to dial me a phone number than to use the application	1
1.4	I feel that the application would enable me to use my mobile more independently	4.1
1.5	Using the application would make my phone call dialling less stressful	4.6
1.6	The system was difficult to use	1
1.7	It was easy to learn how to use the system	5
1.8	I can trust that I'm dialling the correct phone number	5
1.9	I prefer to have this application installed on other mobile phones brands	4
Part 2: How important was each of the following design decisions for enabling you to feel independent while using the phone dialler application? 1 = irrelevant, 2 = not important, 3 = neutral 4 = important, 5 = critically important.		
Number	Design Decision	Mean answers
2.1	Having a starting node specified when formulating a digit	5
2.2	The presence of a surface-raised dot on the first four nodes	5
2.3	Having the digit read once the digit was formulated	5
2.4	Not allowing the user to remove his finger before he finishes formulating the digit	2.4
2.5	Having some digits different sequences to formulate them	4.1
2.6	Having the sequence {n1, n4, n5}to allow the user immediately make an emergency call	4.5

## 5 Conclusion and future work

In this paper we have identified key values that are important to blind and visually impaired people when using touch screen mobile phones, specifically when dialling numbers and making phone calls.

Most of the applications proposed in literature have focused on helping blind and visually impaired people obtain information from mobile phones. Other applications which focus on helping blind people entering information to mobile phones are either expensive, complicated or relays on voice recognition techniques which have many

drawbacks, such as inaccuracy, slowness and interpretation of unusual voices. The application described in this paper is advantageous through its innovative concept, its simplicity and more importantly, its availability at an affordable cost.

Accordingly, our main goal was to develop a simple application that is easy to use by blind people with the minimum cost. The developed application is based on sliding the user's finger over 6 nodes displayed on the screen to formulate the digits of a phone number. A new algorithm, the Nodes-based dialler (NBD) algorithm was presented and implemented as a windows phone application to achieve our goals. Evaluation was performed in two phases; the first phase included evaluating the degree correctness of formulating the digits from 0-9 as well as the emergency call sequence of nodes by 10 participants who were blind. Results showed that 92.7% of participants were able to formulate the correct sequence of nodes of the digits from the first trial. Then the percentage has increased to 99.1% in the second trail. From these result we concluded that the application was simple and easy to learn and use. The second phase of the evaluation included getting feedback from users about the simplicity and user friendliness of the application and how it would affect the sense of independence for the user. Feedback results showed that the application is easy to use and learn and it makes users more confident and independent when making phone calls using touch screen mobile phones.

For future work, the application will be enhanced to be available for installation on any platform. Also the application will be enhanced to include other functionalities required to enter information to the mobile phone by blind and visually impaired people, for example to dial a phone number saved into the mobile's phone book, a similar application can be developed to allow the user enter the first letter of the name, then an algorithm similar to the one described in this paper can recognise a letter and then asks either to enter a second letter if the number of contacts were more than three, for example, or the application will read the names and allows the user to choose one of them.

## References

- [1] American Foundation for the Blind. Cell Phone Accessibility. <http://www.afb.org/section.aspx?FolderID=2&SectionID=4&TopicID=327>, 2012. Accessed October 2012.
- [2] S. Kane, J. Bigham and J. Wobbrock. "Fully Accessible Touch Screens For The Blind And Visually Impaired", 2011.
- [3] K.A. Li, P. Baudisch, and K. Hinckley, BlindSight: Eyes-Free Access to Mobile Phones. *Computer Human Interaction - CHI*, 2008. 1389-1398.
- [4] Microsoft. <http://www.microsoft.com/visualstudio>, 2012. Accessed October 2012.
- [5] Microsoft. Windows PhonePage, <http://www.microsoft.com/windowsphone/en-us/default.aspx>, 2012. Accessed October 2012.
- [6] P. Narasimhan, R. Gandhi, and D. Rossi, Smartphone-based assistive technologies for the blind. *Proc. CASES*. New York: ACM Press, 2009, 223-232.
- [7] J. Oliveira, T. Guerreiro, H. Nicolau, J. Jorge and D. Goncalves, Blind People and Mobile Touch-based Text-Entry: Acknowledging the Need for Different Flavors. *ASSETS'11*, Dundee, Scotland, UK, 2011.
- [8] J. Sánchez and J. de Togores, Designing Mobile Apps for Visually Impaired and Blind Users-Using touch screen based mobile devices: iPhone/iPad. *The Fifth International Conference on Advances in Computer-Human Interactions*, 2012.
- [9] B. Sandeep and N. Cholli, Application Development on Windows Phone 7, *International Journal of Computer Science and Technology*, 31(2), 2012.
- [10] I. Sommerville. *Software engineering*. 9th ed. Reading, MA: Addison-Wesley, 2010.
- [11] United Nations. *Convention on the Rights of Persons with Disabilities*. <http://www.un.org/disabilities/convention/conventionfull.shtml>, 2006. Accessed October 2012.
- [12] J. O. Wobbrock, D. H. Chau, and B. A. Myers, An alternative to push, press, and tap-tap-tap: gesturing on an isometric joystick for mobile phone text entry. *Proc. CHI'07*, 2007, 667-676
- [13] J.O. Wobbrock, B.A. Myers, and J.A. Kembel, Edge-Write: a stylus-based text entry method designed for high accuracy and stability of motion. *Proc. UIST'03*, 2003, 61-70.
- [14] S. Zhao, P. Dragicevic, M. Chignell, R. Balakrishnan, and P. Baudisch, Earpod: eyes-free menu selection using touch input and reactive audio feedback. *Proc. CHI'07*, 2007, 1395-1404.