MagiWrite: Towards Touchless Digit Entry Using 3D Space Around Mobile Devices

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ABSTRACT

In this work, we present a new approach for text (mainly digit) entry based on digit shaped gestures created in 3D space around a mobile device. Some new mobile devices such as Apple iPhone 3GS and Google Android are equipped with magnetic (compass) sensor. The main idea is to influence the magnetic sensor using a magnet taken in hand. The user draws (writes) digits in the 3D space around the device using the magnet taken in hand. Movement of the magnet changes temporal pattern of magnetic field around the device which is sensed and registered by the magnetic (compass) sensor. The registered pattern is then compared against already recorded templates for different digits. Such a text (digit) entry approach can be especially useful for small mobile devices in which it is hard to operate small buttons or touch screen. Using our technique, the text entry space extends beyond physical boundaries of the device. A demonstrator for this approach is implemented on Apple iPhone 3GS platform. It demonstrates registering a few templates for different digits, and recognizing digits written in the space around the device.

Categories and Subject Descriptors

I.5.4 [Computing Methodologies]: Pattern Recognition, Applications – Signal processing.

General Terms

Algorithms

Keywords

Touchless Text (Digit) Entry, Embedded Compass (Magnetic) Sensor, Mobile Devices, Around Device 3D Interaction, Properly Shaped Magnet.

1. INTRODUCTION

Mobile and tangible devices such as cell phones, wrist watches, headsets, and portable music players are being widely used during daily life. An important part of interaction with these devices
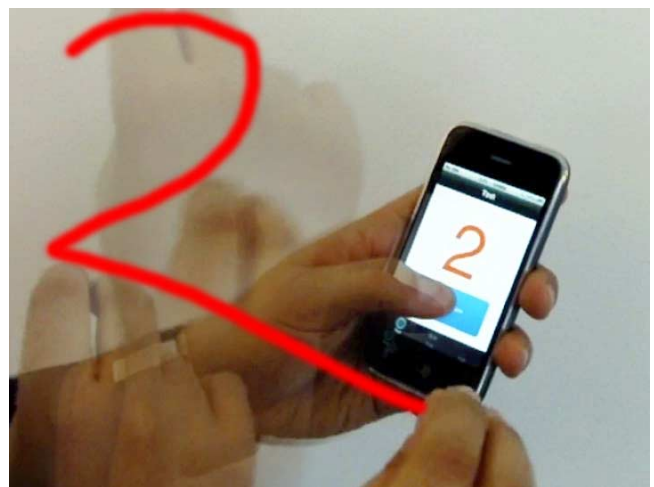
Figure 1. *MagiWrite:* **Entering text (digits) using space around the device. The user simply writes (draws) digits in air using a properly shaped magnet taken in hand! An iPhone based demo application recognizes the digit based on magnetic field interaction.**

involves entering textual data e.g. for sending a text message, dialing a number, choosing an album to be played, etc. The most common ways of text entry for mobile and tangible devices are via physical keypads or touch screens. However, considering small size of these devices, it is not usually comfortable to operate small buttons or touch screens for text entry.

In the current work, we propose a new technique for text (digit) entry which can overcome limits of existing touch pad and touch screen input utilities. Our method expands the text entry space beyond physical boundaries of a keypad or device, and uses the space around device for entering textual data. The basic idea is to draw gestures similar to characters (in terms of shape) in the 3D space around (or in front of) the device (Figure 1). The character shaped gestures are made using a properly shaped magnet taken in hand. Some mobile devices such as iPhone 3GS and Google Android are equipped with magnetic (compass) sensor which is originally used for navigation purposes. Movement of magnet in a shape similar to a certain character can change temporal pattern of

magnetic filed around the device, and can be sensed and registered using the internally embedded magnetic sensor. This pattern can be then matched against models created for each character. In this work, we mainly focus on entering digit data. However, the same methodology can be applied for entering other characters, symbols, or textual commands.

Since the proposed method can expand the interaction space to around device, the problem of small size keypads or touch screens for text entry can be partially addressed. Our method is only based on a very small and cheap magnetic sensor which can be internally embedded in the device (already embedded in some devices). Therefore, it does not impose major change in hardware or physical specifications of devices which can be an important issue in small mobile devices. Replacing keypads or touch screens with such a data entry technique in small mobile devices can allow saving cost, complexity and physical space in designing the device. Compared to keypad or touch screen, a magnetic sensor can be much simpler, smaller and cheaper, and can be internally embedded.

Since the interaction in this technique is based on magnetic field which can pass through many materials, the device does not need to be necessarily in the line of sight or in hand for entering textual data. Data entry can be potentially possible even if the device is in a pocket or bag. For instance, the user may be able to dial a number, enter a pin code, or select a certain album without taking the mobile device out of his pocket/bag.

We provide a user friendly demo application which demonstrates entering digits using the proposed technique. The demo application is implemented for Apple iPhone 3GS platform. The demo application allows a user to initially register one or a few templates for each digit. The user can then test the digit entry system by drawing digits in the space around the device. More detailed explanation of the demo application is given in Sections 4 and 5.

The paper is organized as follows: Section 2 provides more details on the novel approach, background and related techniques. Section 3 briefly presents processing of magnetic signals and recognition of digits drawn in the 3D space. Section 4 presents the user interaction with demonstrator application in more details. Section 5 explains technical requirements for presenting the demonstrator. Finally Section 6 provides a summary of the paper and future enhancement possibilities.

2. DIGIT ENTRY BASED ON AROUND DEVICE MAGNETIC INETARCTION

In this work, we propose a new text (digit) entry technique based on interaction with embedded magnetic sensor in mobile and tangible devices. In our method, a digit is entered by drawing its shape in 3D space around the device using a magnet. It can be especially useful for small mobile devices which size limits complicates designing or operating key pads or touch screens. The magnet which should be used for creating characters is a regular non-powered magnet in a proper shape such as rod, ring or pen. Movement of the magnet in a shape similar to a digit changes temporal pattern of magnetic field around the device. The magnetic field is sensed and registered by the internally embedded magnetic sensor. The user can register his personalized templates for different digits as a time sequence of signal samples captured by the magnetic sensor in a simple training phase. This

means that the method can allow learning handwriting of a person in the space around the device. During the actual text (digit) entry, a new digit sample drawn in the space around device is matched against available templates for different digits. As we discuss in Section 3, we have used Dynamic Time Warping (DTW) technique [1] to evaluate the match.

Such an approach open ups a new frame work for text entry, dialing a number, pin code entry, and textual item selection in very small mobile and handheld devices.

The idea is partly inspired by Around Device Interaction (ADI) framework which proposes using space around the device for interaction with the device. Around Device Interaction (ADI) has been investigated recently as an efficient interaction method for mobile and tangible devices. ADI techniques are based on using different sensory inputs such as camera [2], infrared distance sensors [3, 4, 5, 6], touch screen at the back of device [7], proximity sensor [8], electric field sensing [9, 10], etc. ADI concept can allow coarse movement-based gestures made in the 3D space around the device to be used for sending different interaction commands such as turning pages (in an e-book or calendar), controlling a portable music player (changing sound volume or music track), zooming, rotation, etc.

Considering our ADI technique based on magnetic interaction in the context of text (digit) entry, and compared to camera based techniques, getting useful information from magnetic sensor is algorithmically much simpler than implementing computer vision techniques. Our method does not impose major change in hardware specifications of mobile devices or installing many optical sensors e.g. in front, back or edges of the device. It is only based on a magnetic sensor which is internally embedded in some new mobile devices (phones). Optical sensor installation occupies certain physical space which can be critical in small devices. In our method, for mobile devices such as iPhone and G1/2 Android, it is only necessary to have a properly shaped magnet as an extra accessory. Our approach also does not suffer from illumination variation and occlusion problems. Optical interaction techniques can be limited when the senor is occluded by an object, including body of user. In our proposed method, the interaction is based on magnetic field which can pass though many different materials. Therefore, the device does not need to be necessarily in the line of sight for the interaction. The user can enter textual information or commands even if the device is covered (e.g. mobile device in a pocket or bag). This feature can be especially useful when operating headsets, wrist watches, etc.

Our technique can be even combined with regular text entry methods such as keypads or touch screens to provide more advanced data entry possibilities.

3. ANALYSIS OF MAGNETIC SIGNALS

We have used Apple iPhone 3GS in our studies. This device has an internally embedded magnetic sensor which is originally used for navigation purposes (compass application).

The embedded compass (magnetic) sensor provides a measure of magnetic field strength along x, y, and z directions. The values change over a range of -128 to 128.

The magnetic sensor can be also affected partly by some sources of magnetic noise, and mainly by Earth's magnetic field. In order
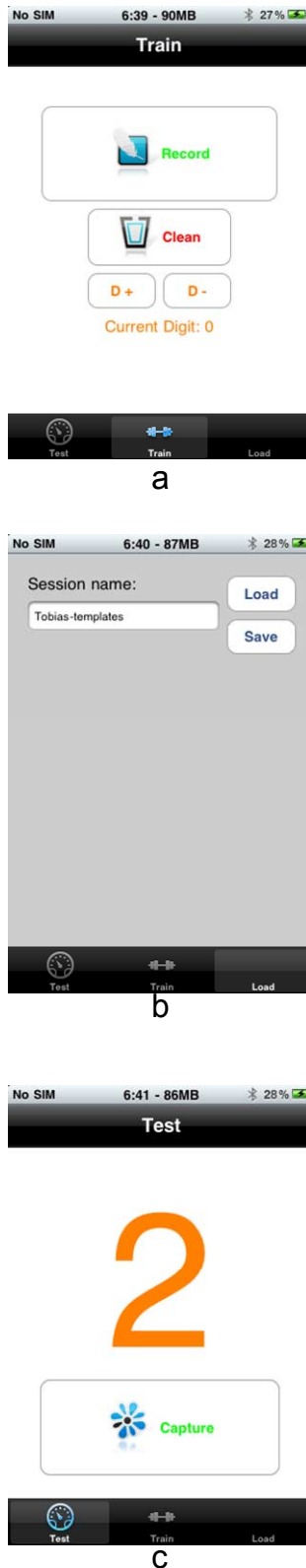
a

b

c

Figure 2. Different snapshots of demo application.

to cancel the effect of Earth's magnetic field, we apply a time derivative operator on the output signals of the magnetic sensor. In the rest of this section, whenever we refer to "magnetic signals", we simply mean time derivative of the output signals of the magnetic sensor.

In our current demo setup, the user should press a button during performing the text (digit) entry, in order to indicate the beginning and end of capturing magnetic signals. An alternative would be automatically detecting begin and end of the character by comparing Euclidian norm of magnetic field strength against a pre-defined threshold.

As explained before, the user has to register one or a few templates for digits in a training phase. The template for each digit is stored as a time sequence of magnetic signal samples along x, y, and z directions. During digit entry (testing the demo system), magnetic signals are captured and stored as a time sequence in a test buffer. The test buffer is then compared against registered templates available for different digits. The digit class which is showing a better match is selected as recognized digit and presented on the iPhone screen.

We have used Dynamic Time Warping (DTW) technique [1] to calculate the match between the test buffer and templates. Dynamic Time Warping is a technique for determining the level of similarity between two given sequences (series) which can vary in time or speed. In the other words, DTW is an approach for finding an optimal match between two given sequences (e.g. time series). The two series are "warped" non-linearly in the time dimension in order to acquire a measure of similarity between them. One should keep in mind that, the measure of similarity is independent of certain non-linear variations in the time dimension. We have used Euclidian distance to calculate the distance between a magnetic signal sample in the template and a magnetic signal sample in the test buffer. Our system can perform digit entry in a satisfactory way even using one template for each digit.

4. INTERACTION WITH THE DEMONSTRATOR APPLICATION

We have implemented a demo application called as *"MagiWrite"* based on the presented method for Apple iPhone 3GS platform. The application allows demonstrating the process of recognizing digits written (drawn) in the 3D space around the iPhone device. The demo application comes with 3 screens: The test screen allows users to draw digits in the space around the device and observe recognition result. The second screen is training screen. This screen allows the user to register one or a few templates for digits. The third screen is load/save screen which allows the user to store or re-store the registered templates for future experiments.

Training screen: A snapshot of this screen can be seen in Figure 2.a. As mentioned before, this screen allows users to register their own templates for different digits. The user simply holds the "Record" button on the screen and draws a certain digit as template using a magnet taken in hand in the space around the device. If the user feels that the template is not done appropriately, he can delete the last template using "Clean" button. The "Current Digit" item indicates the digit class for which the template is being registered. "D +" and "D-" buttons are used to either increase or decrease the current digit class to be registered.

Save/Load screen: This screen (Figure 2.b) allows the user to store the registered templates for future use. The user specifies a name for current experiments and presses "Save" button. This allows the personalized digit templates to be available next time when the user wants to use the demo application. In the next use, he simply enters the experiment name, and presses "Load" button, resulting in his personalized digits templates to be loaded for the ongoing experiment.

Test screen: This screen allows the user to try digit entry system in a live manner. The user simply presses "Capture" button and draws a digit using a magnet in 3D space around the device. The result of recognition is then immediately appears on the screen (Figure 2.c).

Although in this paper we mainly focus on digit entry, any other character can be simply registered and recognized using the demo application. The user can also simply come up with custom rules for entering more numerical information in a rapid way. For instance, the user can register templates for digits 0 to 9 in front of the device. Then, if he wants to enter a number like 11, 12, 15, etc., he simply can registers templates for digits 0-9 again, but this time using the space at the back or sides of the device. Obviously he should take care to increase the "Current Digit" item to 10, 11, 12, ... when registering the second round of digits. This simply results in being able to enter numbers up to 19 very quickly. During the test of the system, if the user draws a digit in front of the device, the same digit appears on the screen, but if the digits is drawn at sides or back of the device, a 10 is added to the recognition result, leading to have numbers between 10-19. The same effect can be also achieved by separately registering numbers from 0-9, and from 10-19 with two different polarities of the magnet. The user simply needs to take the magnet upside down when registering templates for numbers between 10-19.

5. REQUIREMENTS FOR PRESENTATION OF THE DEMONSTRATOR

The demonstrator is implemented as an iPhone based application. We provide visitors with an iPhone and a rod shaped magnet. Visitors can take the magnet in hand and write digits in the space around the device. Visitors can freely interact with different screens of the demonstrator, train new templates for digits, test digit recognition, and store/re-store the templates. Apart from the iPhone and the magnet, there is no other especial requirement for interaction with the demonstrator.

6. SUMMARY AND FUTURE WORK

We have presented a new approach for text (digit) entry, based on drawing (writing) digits in the space around the device using a magnet. The approach can be especially suitable for very small mobile and tangible devices. It can be used as replacement to keypads or touch screens for entering textual data such as dialing a number, entering a pin code, selecting a textual field, etc. Our method is based on influencing an internally embedded magnetic sensor with movements of a magnet in a shape similar to a digit, in the space around the device. The magnetic sensor is very small and cheap, therefore using such a technology can save complexity, space and cost in designing small handheld devices.

The data entry process can be done even if the device is not in the line of sight, or if it is in a pocket or bag.

The demo application based on the presented idea is developed for Apple iPhone 3GS platform. The application can demonstrate registering personalized digit templates, and then recognize the digits drawn in the space around the device.

As future plan, we will be working on extension of this work for entering more characters and symbols. This involves studying more sophisticated signal processing and template matching techniques.

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