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An infrared-based touchless screen mobile device

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ABSTRACT

A touchless screen phone design has been presented in this work such that, users won't have to make any form of contact with the phone screen or make use of any keypad in initiating any input to the device. The design model was achieved by combining infrared optics technology with embedded computer chip by programming the chip with the popular C language and then designing and producing a printed circuit board for the entire design. The final outcome will enable the phone operator or users make voice calls, receive voice calls, send SMS messages and perform simple arithmetic calculations by pointing to buttons above the phone screen and also get real time and date updates.

Keywords: Consumer Electronics, Embedded System, Infrared Optics, Touchless Screen

1. INTRODUCTION

The world advances, various revolutionary technologies have emerged and transformed the world. In the category of the user interface technologies, it all started from switches to buttons, to keypads and Keyboards, to joysticks for gaming, then in 1984 the mouse came along and changed the entire computer industry (Mace, 1984). Since then we have witnessed the rising of some touch based control interface technologies which cover innovations like stylus, touchpad and touchscreen which is found in many advanced consumer electronics products.

The most recent kind of this technology is the touchless input method, also known as gesture control interface or gesture recognition system (Ishikawa et al., 2005). This technology enables users to control devices or equipment without having to make any form of contact or touch with the control interface.

Mobile phones are much more complex and capable than they were back in the early days. As an example, in the early days, a standard phone didn't have internet capability, wasn't portable, and to dial numbers, users had to spin rotating discs. But now we see phones that are even more powerful than standard computers featuring touchscreens, LCD, keypads and even touchless input technology. In this work, we will focus on the input methods based on a finger, this implies that input methods like voice or eye control are not included. Phones have transformed from rotating discs, to keypads, touchpads, touchscreens and now the world is currently exploring the possibilities of touchless input methods.

Even though this is not the first time an attempt has been made to explore the methods of designing touchless input systems. It will soon be clear that the approach taken in this work is unique and worthy of development.

In time past, the camera and capacitive approach were used in designing touchless input systems. The camera method was used in developing the kind of touchless input system found in the Samsung galaxy S4 (Samsung, 2013; Leong-Hoi et al., 2020). It features a small camera on top of the phone viewing the surface of the screen. This camera is activated whenever the screen puts up a user interface that only needs movement from left to right or top to bottom, and as the finger moves above the screen, image processing software running in the background of the phone tracks the human finger continuously and sends the tracking results to the operating system of the phone. The capacitive method was used in developing the kind of touchless input system found in the Sony Ericsson (Sony, 2010). It features a highly sensitive and transparent capacitive layer above the surface of the phone screen. This capacitive layer is activated whenever the phone puts up a user interface that only needs movement from left to right or top to bottom, or even to select an option and as the finger navigates above the screen, a touchless coordinate processor software running in the background of the phone tracks the human finger continuously and sends the tracking results to the operating system of the phone. The innovative part of this design is that it not only eliminates the need of human body contact with the control or input interfaces but it also allows three dimensional finger gestures (e.g. how hard or soft the user presses a button down) to be received by the target device or application without the user actually touching the button (Nelson et al., 2018). Further information on touchless technology can be found in Athira (2020).

The developed system can be deployed in other services like automated teller machine (ATM), medical devices with touchscreens, gaming devices with touchscreens, entrance push buttons/keypads etc. that will help in curbing the spread of virus during the recent COVID-19 pandemic.

2. METHODOLOGY

The methodology adapted in this work is presented in this section. Figures 1 and 2 depict the design module and the schematic-circuit of the touchless phone module developed based on the idea that a microcontroller can be designed to act whenever the invisible infrared light coming from an infrared LED is obstructed from reaching an infrared receiver. This is possible because infrared light like any other form of light can be polarized i.e. made to be so thin, such that a human finger can successfully block this light from reaching its destination/receiver. If many of these infrared transmitter/receiver pairs are arranged to form a matrix, so that two infrared lights traveling perpendicular to each other will always intersect at a point, and then the phone is programmed with C programming language to place a button under the point where the two lines of light intersect, so that once a finger is pointed at the button, the finger will block the two lights. A dedicated high speed touchless input processor will detect these simultaneous blockages and send the exact coordinates of the intersecting lights to the main Graphical Liquid Crystal Display (GLCD) for further processing provided the finger drops close enough to the screen. Using a microcontroller running an embedded C program, a graphical LCD screen, infrared LEDs, infrared sensors and a GSM modem, the entire design was developed successfully.

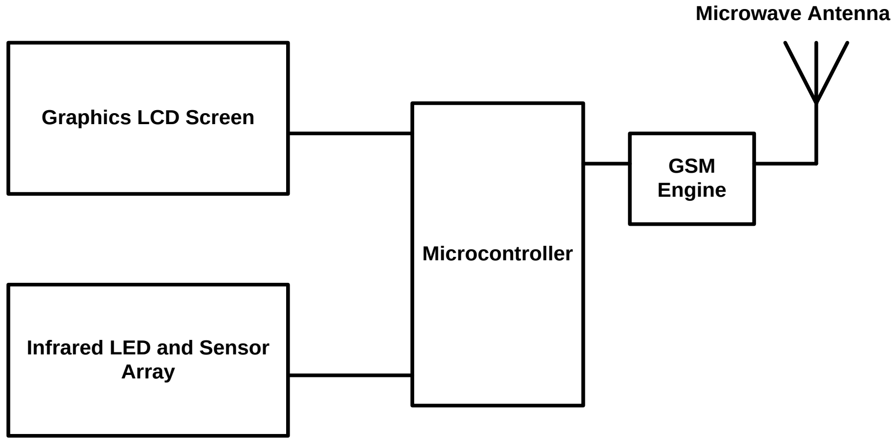

Figure 1: Block diagram of the touchless phone

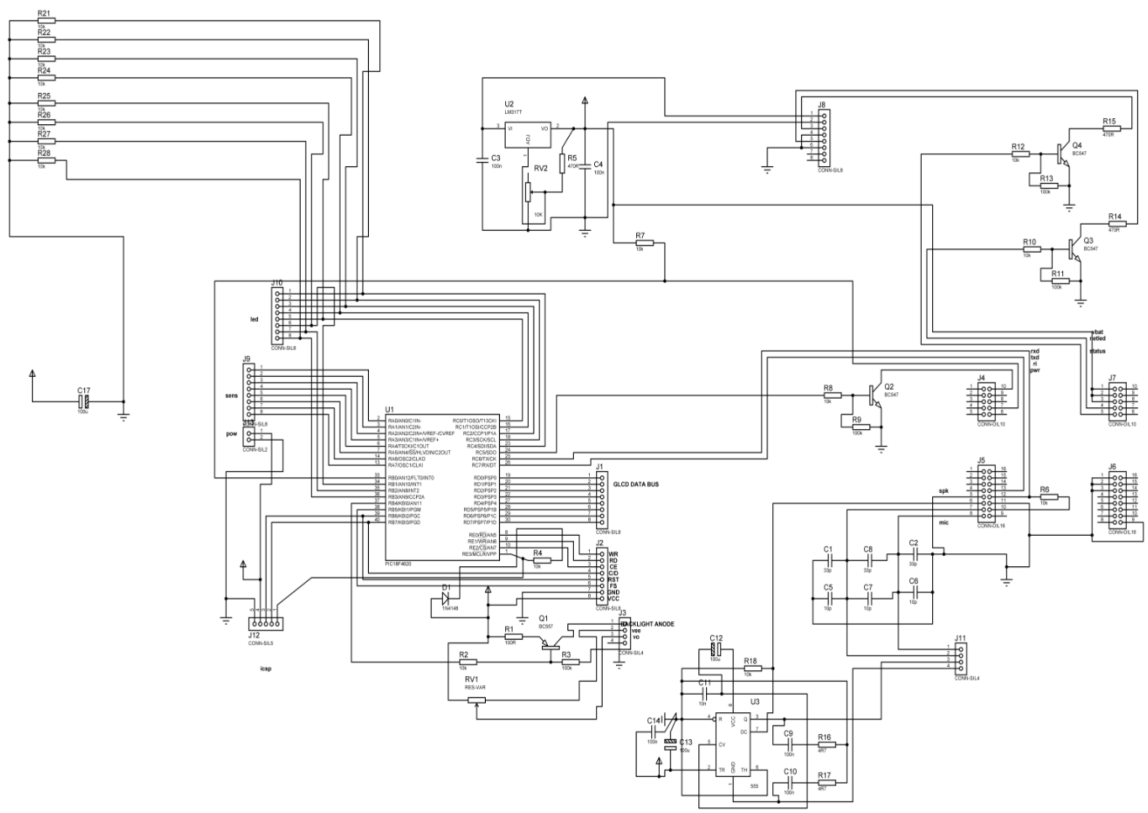

Figure 2: A schematic-circuit representation of the touchless phone

Principle of Operation

The principle of operation is depicted by the flowchart in Figure 3. The first thing the software does is to initialize and configure the microcontroller by setting which ports and pins to use for the different functions, then it establishes proper communication protocols with the GSM engine to enable reliable communication, e.g. the GSM engine and the microcontroller must agree on the data format for their data exchange as well as the speed of data transfer also known as baud rate. This system is designed to use a baud rate of 9600bps and this low rate was chosen to reduce error rates and make the system more reliable, since the focus is on accuracy of data rather than speed. The software must also configure the GLCD, to tell the computer chips on the GLCD the data format, the character size, the read and write pins and the parallel data I/O port to be used in exchanging 8 bit data. Next, the software puts up the already designed user interface on the screen; this drawing is just a bunch of neatly aligned buttons and text boxes as with the calls' user interface. Once the buttons are drawn on the screen, the user can then know what to press.

The next step for the software is to call the algorithm that is in-charge of using the hardware sensors to scan the user interface at a very high speed, speed is important here so that the system won't miss any finger input but at the same time the software must be robust enough to ignore unintended touches and keep accuracy as high as possible. Once a finger is detected above the screen, another algorithm capable of processing 2 dimensional signal is invoked, to be able to get the x and y coordinates of the finger in space and in real time, this is one of the most challenging aspect of the work but not as challenging as the next part. This 2D signal processing algorithm is also capable of processing 3D signals with some modifications, to allow gaming applications sense pressure the player is applying to the button in midair, this is impossible with all currently existing touchless input technologies. In the previous stage, the goal was to recognize where the user's finger is in space which could be anywhere on earth, but here the goal for the microcontroller is to recognize exactly which button on the LCD screen the user's finger is above. In order to do this the microcontroller must have an artificial sense of its own location in space in 2D coordinates, and surprisingly it has to be able to do this without using any form of GPS technology (using GPS means that whenever satellite network is bad you can't operate your phone). So an innovative idea was developed to make this impossible feat possible. The solution was to create a dynamic 2D array of coordinates stored in the flash memory of the microcontroller chip, so that whenever it detects the coordinates of a finger in space, it can use its reference coordinates of buttons to quickly search and sort through the 2D array to find the button coordinates that will match that of the finger in space. This is similar to how Google maps work.

Once the finger and button is matched, the button event algorithm takes over from here and processes the function allocated to that button, for example if it is to place a call, then the microcontroller will take the numbers input from the text box, format it and then send it to the GSM network for further processing and then wait for response to know if the call was successful or rejected or whatever the result. Then if for example the call was successfully connected, the microcontroller chip must quickly route the speaker and microphone through the GSM engine so that proper communication can take place.

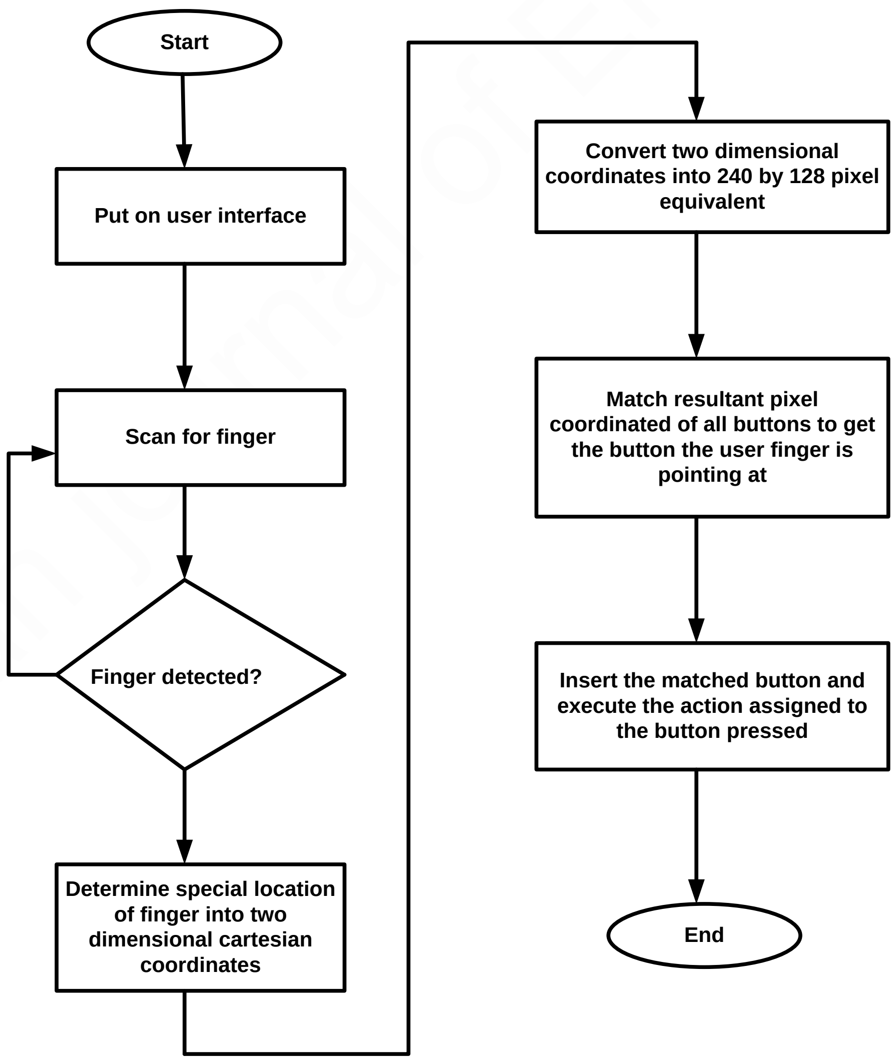

Figure 3: Touchless Phone Design Flowchart

3. RESULTS

The results follow directly from the implementation of the design in relation to the following stages: the Printed Circuit Board (PCB) stage, circuit mounting, the building of the touchless sensor and casing. After designing the circuit model of Figure 1 and 2 on PCB layout of the Proteus software, the resultant circuit layout was then printed using a laser printer, so that the ink will be very dark to make the exposing process more efficient and effective. Once the circuit pattern has been transferred onto the board, the board is placed in a solution of sodium metasilicate powder and water, this helps to expose the unwanted copper layers that will eventually be removed by the ferric chloride solution. After the unwanted copper layers have been exposed successfully, the board was then placed in a dilute solution of ferric chloride and water. To speed up the chemical reaction, the solution was constantly heated and disturbed with an eventual outcome shown in Figures 4 and 5.

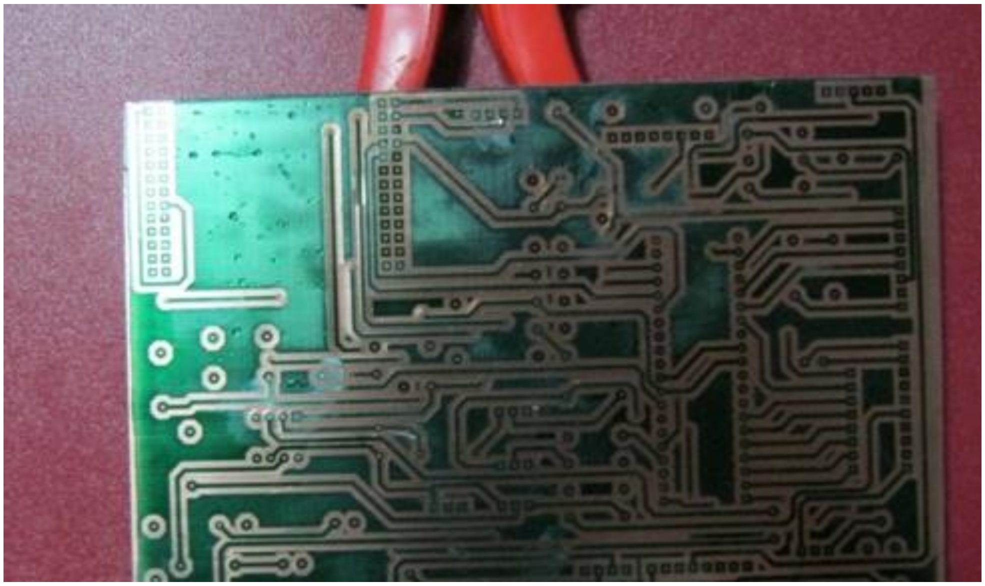

Figure 4: The final result of the pattern before soldering the components

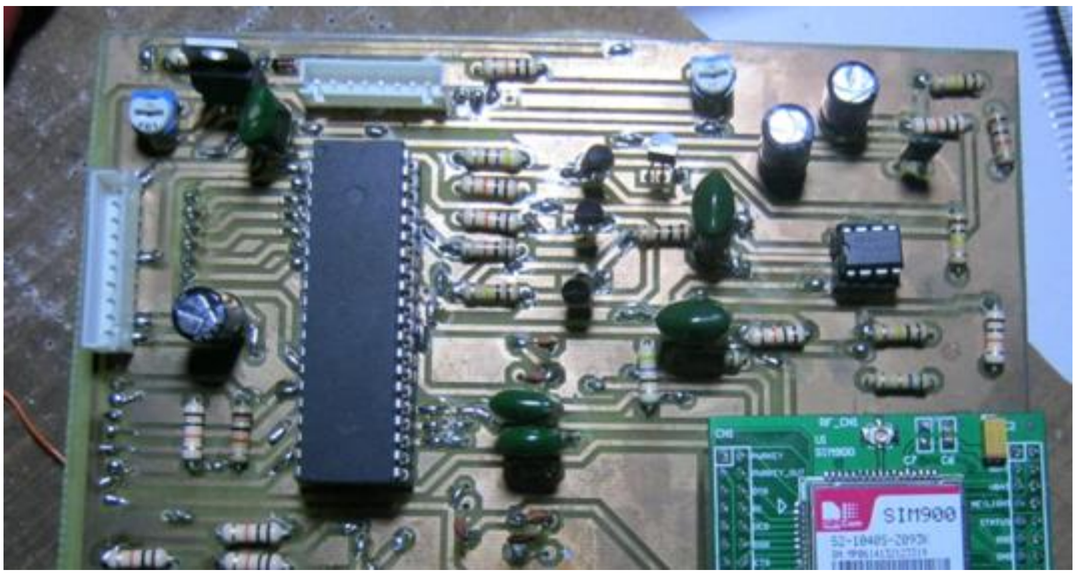

Figure 5: After the components have been fixed and soldered

Figure 6 shows the implementation of the touchless sensor. The touchless sensor case was built with the aid of glue, 3.5mm bolts and nuts, plastic sheets, flexible wires and drilling machine. The plastic sheet was first cut to a length that will fit to hold the touchless sensor circuit around the LCD screen, then the holes for the bolts and nuts were drilled using drilling machine. Next the flexible wires were stripped and then their copper ends were taken through suitable holes on top of the casing.

Figure 6: Building the touchless sensor

The LCD screen was then mounted on the cover surrounded by the touchless sensors as shown in Figure 7.

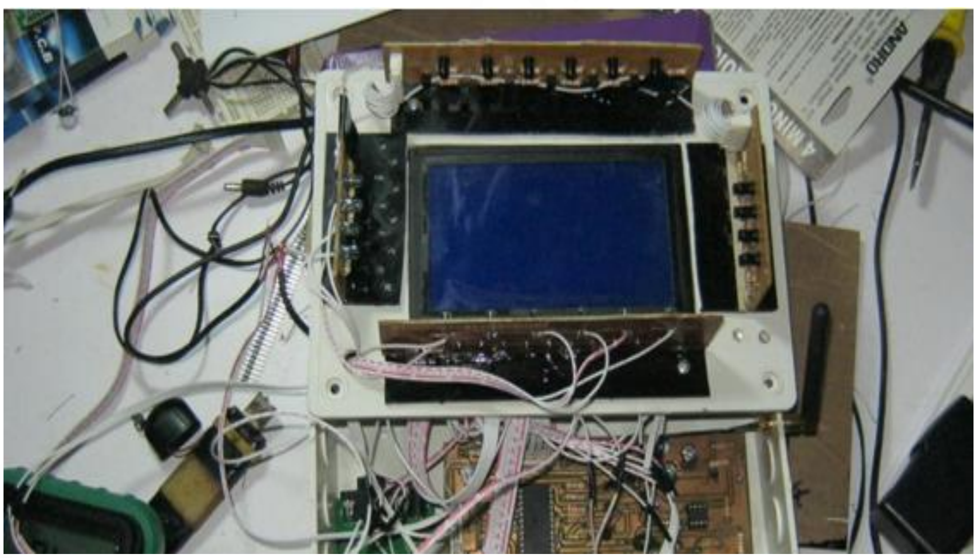

Figure 7: Mounting the LCD screen on within the touchless sensor arrays

The eventual touchless screen phone module is shown in Figures 8 and 9. While Figure 8 depicts the final setup in its prototyped casing, Figure 9 displays the final result which enables anybody to make, receive calls and send text messages without touching the screen of the phone. Just by pointing to buttons with finger positions as far as 2cm above the screen surface.

Figure 8: Mounting the circuit to the casing

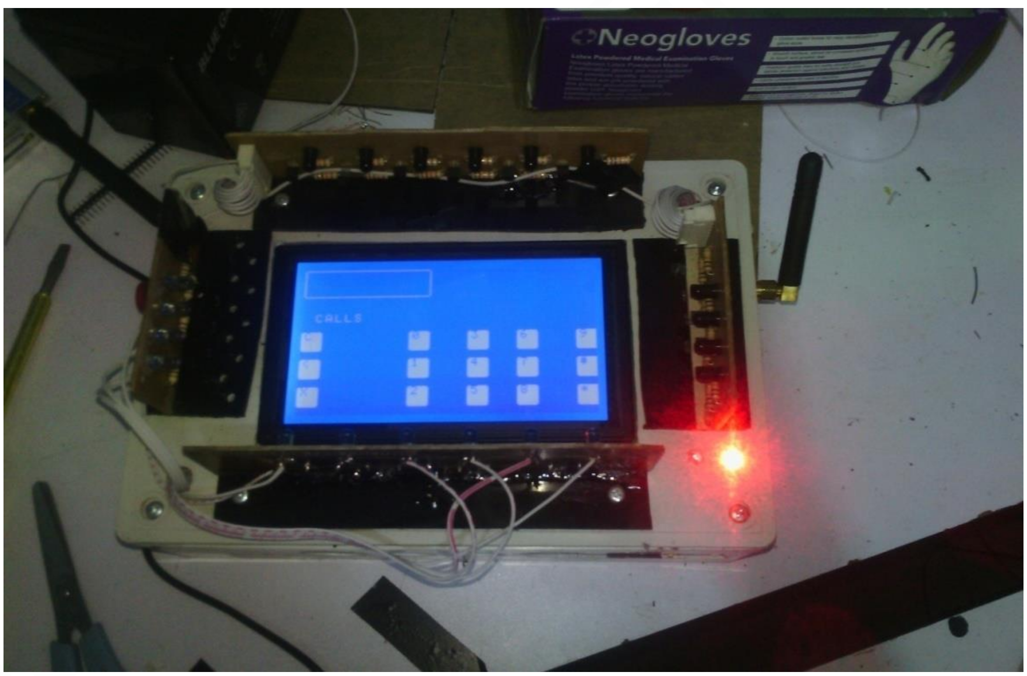

Figure 9: The finished work

4. CONCLUSION

This work has demonstrated the possibility of designing a touchless phone by using infrared optics and embedded system. The developed prototype worked satisfactorily and is therefore recommended for adoption in the consumer electronic industry taking into consideration the growing need for contactless services in relation to human to device interactions.

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The author declares that there are no conflicts of interests.

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Data and materials availability:
All data associated with this study are present in the paper.

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