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DEVELOPMENT OF E-ABACUS

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ABSTRACT

Nowadays, most people prefer to use calculator as it is the easiest machine to perform their calculation. However, using calculator would not illustrate how the calculation was performed. On the other hand, abacus illustrates the steps to perform mathematic operations, although it takes time to learn. To decrease the time spending in learning the abacus, electronic abacus or E-abacus is introduced. The main objective of this project is to make E-abacus easy to learn and use. The idea of the proposed device is to combine the traditional abacus with the calculator. E-abacus can perform two tasks; displaying number according to the beads and four basic mathematical operations which are addition, subtraction, multiplication and division. The hardware used in development of E-abacus are Japanese abacus (Soroban), Arduino Mega microcontroller, and Infra-red (IR) sensor. Open Source Arduino software (IDE) is used to program the microprocessor using C language. From observations, E-abacus evidently can operate successfully to perform mathematical operations.

Keywords: abacus, arduino, mathematical operations.

INTRODUCTION

Abacus is a calculating instrument that uses beads that slide along a series of wires or rods set in a frame to represent the decimal places. Probably of Babylonian origin, it is the ancestor of the nowadays modern digital calculator. Start from bargains in the Middle Ages throughout Europe and the Arabic world, it was gradually replaced by arithmetic based on Hindu-Arabic numerals. It is used in Europe past the 18th century and is still used in the Middle East, China and Japan (Merriam-Webster.com). The abacus is known as the first external aid to compute mathematic or calculation device. It is interesting that one of the first uses of beads comes under mathematics. Abacus was first used 2400 BC by the Babylonians. In the first century in China and India, the abacus with beads was recorded as been used. It is estimated that abacus had been in Rome or in Greece at around 300 BC (Artbeads.com, 1999). However, in the modern world, calculator was invented and mathematical operations can be solved easily using a calculator. That is the reason people no longer use abacus. After certain period of time, the use of abacus started to vanish due to the people especially bargains are more interested using calculator that is faster and requires less thinking as compared to abacus.

As a drawback, calculator would not illustrate the steps of getting to the answer. Abacus in the other hand, give illustration to the user on how the calculation is performed. In addition, abacus can increase the level of arithmetic thinking among children. A research made by Nelvin R. Nool, validate that abacus improve student's performance in addition of integer (Nool, 2012). In Malaysia, Ministry of Education practice the abacus learning in the syllabus for mathematic subject under program of Abacus and Arithmetic Mental in primary school (Kementerian Pelajaran Malaysia, 2012). However, abacus is a time-consuming device to learn. Thus, teachers need to have the knowledge about the abacus operations before they can teach the students. The implementation of Abacus and Arithmetic Mental is not a program that can be implemented immediately and need some time to be successful (Kementerian Pelajaran Malaysia, 2010). In order to avoid time wasted on learning the abacus, the E-abacus is proposed as a learning tool in order to support this program. It displays the value of the beads and also the answer of mathematical operations. E-abacus is expected to solve the problem for student to learn the basic operations of mathematic especially for student in primary school.

ELECTRONIC ABACUS

Initial idea in developing the E-abacus prototype is to combine the modern and traditional calculating device, which are calculator and abacus respectively. Calculator has buttons that represents numbers and mathematical operations symbol. Yet, unlike abacus, calculator gives direct answer when user performs the mathematical operations. For young children that still in the stage of learning basic mathematic, calculator is not helping them to understand on how the mathematical operation works. On the other hand, abacus requires student to perform the mathematical operation step by step to obtain the answer thus can lead them to understand the mathematical operations and also able to increase arithmetic thinking. Traditional abacus is used beads to represent numbers, which cause a problem for new user to understand the operation of abacus. Therefore, in order to overcome this problem, E-abacus is developed with the same concept of calculator interface, except the buttons for

calculator were replaced with the beads of traditional abacus.

There are two important tasks of E-Abacus which are to display the number according to the beads movement and to perform the mathematical operations; addition, subtraction, multiplication, and division.

Several projects which are quite similar to the E-Abacus are evaluated in aspect of their advantages and disadvantages as shown as in Table-1.

Table-1. Related work of E-Abacus.

No.	Title	Advantages	Disadvantages
1	Electronic Printer Abacus by David Shaw, 2008	Using traditional abacus	Does not have display, - Not suitable for learning purposes
2	Electronic abacus by KLNKLEIN Product Development Inc., 1994	Attractive tool Suitable for young children	- The beads are replaced by buttons and consists of a few rows only
3	Accessible Software for the Electronic Abacus by A.R Barker, 2005	Software-based abacus	The interface is not interactive
4	Interactive Abacus Learning Application for Beginners by Suzana Baharudin, 2010	Interactive software-based abacus	Not hardware-based
5	Indian Abacus Digital by Basheer Ahamed and Naina Mohamed, 2013	Combination of hardware and software of abacus.	Using sliding switch, does not use a real or original abacus

E-abacus operation

Figure-1 shows the flowchart of the E-Abacus operations. User can simply move the beads based on selected value before select the required mathematical operation. Once the operation button was pressed, E-abacus display will show the value of movement according to the beads position. Then, user needs to move the beads for the second value and press the operation button once again for E-abacus display the second value and the answer of the mathematical operation.

Hardware design of E-abacus

The Japanese abacus (Soroban) is used as an interface in this project. Soroban has specific colour to optimise the sensitivity of the sensor. Beads of the Soroban are painted white and other parts of the Soroban are painted black. The positions of the sensors were critical in this project. In electronic abacus, the sensor is set to be active low. It only detects the beads when the beads are counted. The position of the sensors must be parallel to the place where the beads stop while the beads are counted up. Figure-2 shows the side view of the beads and IR sensors positions. In this project, two microcontrollers were used. The function of the first microcontroller is to process data from IR sensors and operation buttons and then the result will be sent to the second microcontroller. The second microcontroller then will display the result through 16x2 Liquid Crystal Display (LCD).

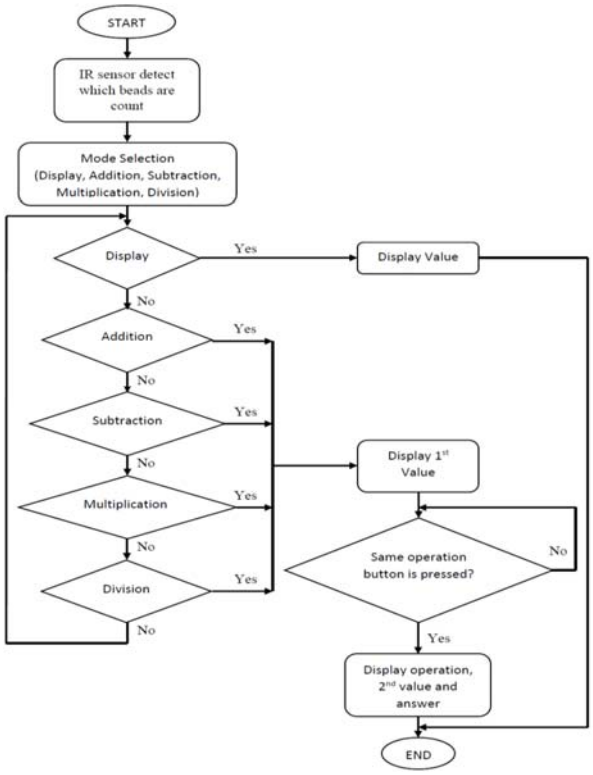

Figure-1. Flowchart of E-Abacus.

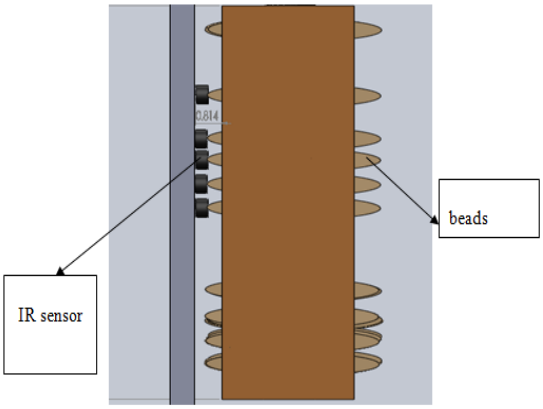

Figure-2. The side view of beads and IR sensor.

Source code development

The source code was built using Arduino IDE software. The open-source Arduino environment enables the source code to be uploaded into the microcontroller. The software runs on Windows, Mac OS X, and Linux. The environment is written in Java and is based on processing and other open source software (Arduino.cc, 2014). The source code is built in two files as there are two microcontroller used in this project. The first file of the source code is to collect and process data from the sensor and operation buttons. The source code is then uploaded to first microcontroller that is connected to second microcontroller via serial communication. Another file of source code is built up to print out the data received from first microcontroller.

Simulation design

In this project, ISIS Proteus software is used to simulate the circuit design. Arduino Mega acts as microcontroller, which control most of abacus operation. The inputs for E-Abacus are the IR sensors. The program is activated with active low; when sensor receives low value (approximately 0), the push button will be 'ON'. While when the IR sensor does not receive any signal, it will be counted as high.

Two microprocessors are used due to the amount of input and output (I/O) required in this project. IR sensor needs 65 of I/O pins representing each beads five switches as operation selectors that require five I/O pins and LCD 16X2 needs seven I/O pins to operate. The totals of I/O pins used were 76 pins. However, Arduino Mega 2560 only has 70 I/O pins.

Serial communication is applied to allow these two microcontrollers to communicate. The first microcontroller will collect data from the sensor and operation button. Then, data will be sent to the second microcontroller to display the data at the LCD. Figure-3 shows the simulation circuit of E-Abacus.

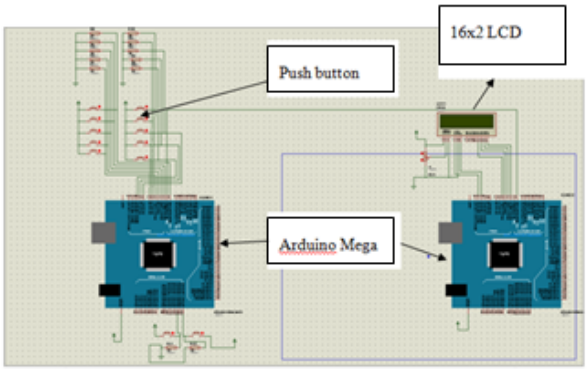

Figure-3. Simulation circuit of E-Abacus.

E-Abacus prototype

The IR sensors position is the critical part on this project. The position of the IR sensors must be placed in synchronize with the position of the abacus' beads. Donut board is used as the base to place the IR sensors. The donut board has holes that are not electrically connected to each other, making it suitable to be used as the base for IR sensor. Figure 4 shows the arrangement of IR sensors at the Donut board.

The traditional abacus is attached to the system developed (E-Abacus) to give user the real experience of using the abacus. The traditional abacus which attached to the E-Abacus can also be removed after the user understands and proficient enough in using abacus. Figure-5 shows all the parts of the E-Abacus which are the traditional abacus (Soroban), LCD, IR sensor set, electronic circuit and microcontroller, fitted to the chassis or project box. The chassis is made from transparent acrylic.

Figure-4. Arrangement of IR sensor at the Donut board.

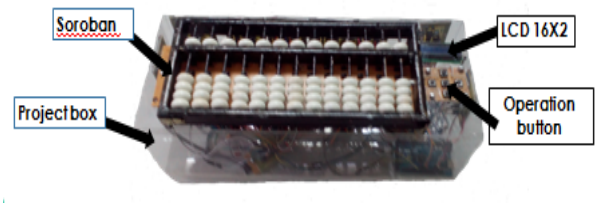

Figure-5. Parts of E-Abacus are fitted to the project box.

RESULT

Two main tasks of e-abacus are to display the value according to the beads moves as well as the

mathematical operations: addition, subtraction, multiplication and division. Figure 6 and Figure 7 shows how the E-Abacus perform multiplication task (32x3). Figure-6 shows the E-Abacus display the first value (32) inserted by user.

Figure-6. E-Abacus display the first value (32).

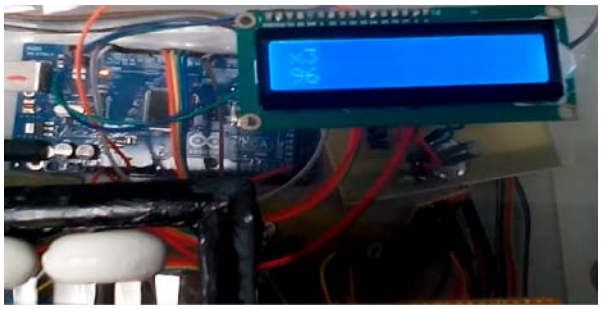

Figure-7. E-Abacus display second value (3) and answer (96).

Once the electronic abacus displays the first value, user is able to insert the second value by controlling the beads movement. Same operation button is pressed and E-Abacus displays the operation selected, second value of the beads (3) and the answer (96). The procedures are similar for addition, subtraction, and division operation. For display operation, E-Abacus will directly display the beads value after the display operation button is pressed.

CONCLUSIONS

This project had successfully designed an E-abacus prototype that can implement simple mathematical operations. The mathematic operations that can be performed using this device are addition, subtraction, multiplication and division. Thus, it will give real experience and help users to understand mental arithmetic concepts. IR sensor that was used is essential to ensures that the electronic abacus will not disturbed by any mechanical movement. From the observation, it showed that this electronic abacus has succeeded in achieving all the specific objectives. Interest in abacus will increase and the usage will be preserve since abacus is a special ancient device that will be lost if it was forgotten.

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