Money Utilization through Digitalization in Remote Areas (MUDRA).

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***Abstract*—The project MUDRA basically aims at providing to the people, a different mode of digital transaction. Uniquely, this mode doesn't depend on the availabilty of internet connectivity unlike the prevalent existing digital transaction methods. Hence, it would enable one to have the the advantages of both : (a) the paper currency and (b) the digital wallet. The money transfer device (named MUDRA) does not require a third party server to exchange the information or the data. For the transaction to get completed, it simply requires the payer to swipe his/her device onto the device of the payee. Keeping in mind the prospect of *Digital India* as well as the current internet access scenario in remote areas, the project has immense potential to hit the grounds.**

I. Introduction

MUDRA is a device which uses the serial communication properties of an Arduino , in order to transmit and receive the data, which is basically, the net amount to be transferred.

A. The components

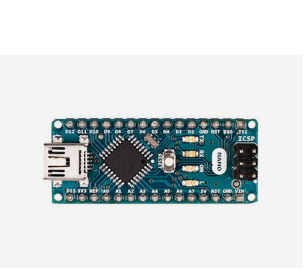
The major components which are used for making the device, are briefly discussed here :

1. Arduino : Arduino is a system that uses ATMega 328 as its microcontroller (a system that serves as the center of all systems and regulates all activities of the input/output system). Arduino consists of an Arduino Board as hardware part and an IDE (Integrated Development Environment) that used C-like as its software language. [1]

The Arduino Nano is a small, complete, and breadboard-friendly board based on the ATmega328 (Arduino Nano 3.x). It has more or less the same functionality of the Arduino Duemilanove, but in a different package. It lacks only a DC power jack, and works with a Mini-B USB cable instead of a standard one. [2] [3]

2. Keypad : Matrix keypads use a combination of four rows and four columns to provide button states to the host device, typically a microcontroller (in this case, Arduino). Underneath each key is a pushbutton, with one end connected to one row, and the other end connected to one column.

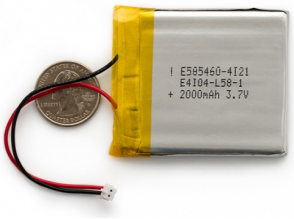
In order for the Arduino to determine which button is pressed, it first needs to pull each of the four columns (pins 1-4) either low or high one at a time, and then poll the states of the four rows (pins 5-8). Depending on the states of the columns, the Arduino can tell which button is pressed. [4]



(a) An Arduino Nano. [5]

(b) A Matrix Keypad. [6]

(c) A 16x2 LCD. [7]



(d) A Li-Po battery. [8]

Fig. 1: **Major components used in the making of device.**

3. LCD Display : LCD (Liquid Crystal Display) screen is an electronic display module and find a wide range of applications. A 16x2 LCD display is very basic module and is very commonly used in various devices and circuits. These modules are preferred over seven segments and other multi segment LEDs. The reasons being: LCDs are economical; easily programmable; have no limitation of displaying special and even custom characters (unlike in seven segments), animations and so on.

A 16x2 LCD means it can display 16 characters per line and there are 2 such lines. In this LCD each character is displayed in 5x7 pixel matrix. [9] [10]

4. Li-Po Polymer Rechargeable Battery : Lithium Polymer batteries, are a newer type of battery, now used in many consumer electronics devices. They have been gaining popularity in the radio control industry over the last few years, and are now the most popular choice for anyone looking for long run times and high power. [11]

For the project, two such batteries per device proved to be sufficient enough.

B. Motivation behind the Idea

The motivation behind our idea lies in achieving the following :

1. Financial Inclusion, which is the delivery of financial services at affordable costs to sections of disadvantaged and low-income segments of the society.

2. Digitalization of cash in remote areas : The solutions existing in the mobile network regions are not very user-friendly, especially for the users in rural areas.

3. Removing Network Requirement : We aim to remove the dependancy on any kind of network connectivity, be it internet or be it mobile, for enabling the digital transactions.

Moreover, the name MUDRA itself draws its motivation from the Hindi word *mudrā* (IAST)[1] , which means currency.

C. Target Audience

Though the project basically aims at providing a digital mode of transaction to the people from remote/rural areas, it is not only limited to them.

Initially, the system can be implemented on a small scale viz. a college campus or a township , and later on, if feasible, throughout the country.

D. Conversion of Digital Money into Cash

Since the project is currently at the prototype level, the currency conversion feature has not been implemented yet. But it can be implemented by either of the following two ways :

Method-1 : The users go to authorised kiosks set up across borders and transfer cash into their MUDRA wallets. This is very much similar to the mobile recharge process and hence is quite easy for the rural people to pick up on.

Method-2 : An alternate approach to the currency conversion feature can be to have tie-ups with the banks. This again, is a method which is not complex for the people from the remote areas to understand.

II. Implementation of MUDRA

A. Making of the device

To demonstrate the working of the device, two identical sets were made.

1. First of all, the code to be fed into the Arduino was drafted and stored in the device. The pseudo code for PAY MODE is shown in Fig. 2 :

```
Read key value
if pressed key is pay key
        ask to enter the amount
                read key values
                if key pressed is cancel
                        cancel transaction and return to initial mode
                if key pressed is some number
                        remember as input money
                if key pressed is clear
                        clear the input money and initialise money input
                if key pressed is 'ok'
                |       ask for passowrd
                |       get the password value from eprom
                |       if password do not match
                |               print incorrect password
                |               cancel transaction and return to initial mo
                |       if password matches
                |               wait to receive the 'ready' signal from
                                another machine through Rx pin
                |       if other machine sends 'ready'
                |               start sending the input amount signal
                                through Tx pin
                |               wait to recieve the 'confirmation'
```

(a) First half of the code.

```
                |               wait to recieve the 'confirmation'
                                signal from another machine through
                                Rx pin
                |               if confirmation received
                |                       deduct input amount from eprom
                |                       save the transaction to
                                        eprom's transaction space
                |                       print success message
                |                       return to initial mode
                |               if any key pressed
                |                       if key pressed is cancel
                |                                       cancel the transaction
                                                        and return to initial mode
                |       if any key pressed
                |               if key pressed is cancel
                |                       cancel the transaction and return to
                                        initial mode
                |
                end if

end if
```

(b) Second half of the code.

Fig. 2: **Pseudo code, when the user selects Pay Mode.**

2. Next, the LCD Display was connected to the Arduino board. Subsequently, the keypad was connected to the same.

3. All the components were soldered onto a PCB [2] and wires were connected according to the circuit design.

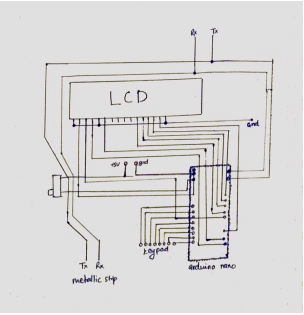


Fig. 3: **The circuit showing the connection of Arduino pins with the LCD.**

4. Finally, the case of the device was made by cutting a PCB into the required shape. Chart paper was used to cover the casing.

[1] International Alphabet of Sanskrit Transliteration

[2] Printed Circuit Board

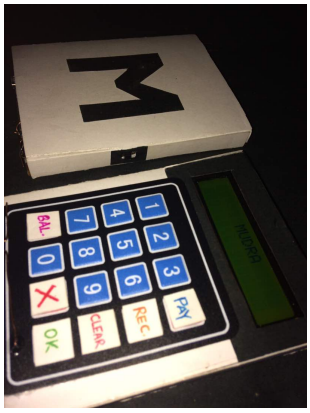


Fig. 4: **(a) The device on the top of the image shows the rear side. (b) The device at the bottom of the image displays the front side, with MUDRA being displayed on the screen.**

B. Working Principle of the Device

1) For storing the balance and transactions: In order to store the current balance available in the device and the details of last 5 transactions, we used the EPROM [3] of the Arduino.

An Arduino Nano has 1 kilobyte of EPROM, which is sufficient enough to store this amount of data.

2) For transferring the amount from one device to the other: TX and RX pins of the Arduino are used for tansmitting the data. One byte of data can be sent through the TX pin of arduino of one device and can be received through the RX pin of arduino of the other device. Since a 'char' data type consumes one byte, a maximum of 255 (the cross check number of characters in one byte) can be sent through the TX pin at one time. A sample conversion of 301 INR to string of characters and then back to the amount is shown below :

$$301 \rightarrow 100+100+101 \rightarrow [d, d, e] \rightarrow 100+100+101 \rightarrow 301$$

Hence, to send the amount through the TX pin, we had to break the amount into small numbers between 0 and 255. Next, we converted these small numbers into characters and stored them in an array as a string. On the receiver's end, the arduino receives the data byte-by-byte until the whole array is not received. The array of these characters is first converted into the small numbers, which are then added to obtain the net amount.

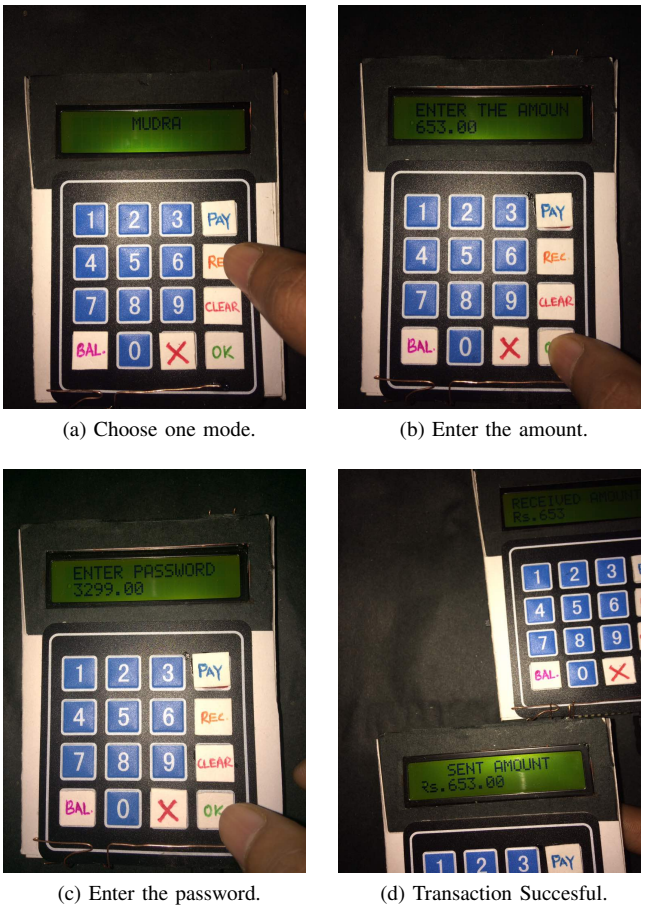
C. How to Use.

The transaction gets completed in four simple steps :

Step 1 : The user first needs to choose the operating mode - Pay/Receive, by pressing the **PAY/REC** button.

Step 2 : Next, the user has to enter the amount and press the **OK** button.

[3]Erasable Programmable Read-Only Memory



(a) Choose one mode. (b) Enter the amount.

(c) Enter the password. (d) Transaction Succesful.

Fig. 5: **Four simple steps showing the working of the device.**

Step 3 : In the third step, the user is required to authenticate himself/herself by entering the password.

Step 4 : Finally, the process gets completed on swiping one of the device's pins onto the metal pins of the other. Once the transaction is completed, a success message is displayed on both the devices.

• One can easily check the balance and the last 5 transactions by pressing the **BAL** button.

Fig. 6: **Devices displaying their current balance.**

III. Results and Discussions

TABLE I: Table showing the component wise cost.

Sr. No.	Name of the Component Used	Cost (for 1 device, in INR)
1	Arduino Nano	350
2	Li-Po batteries	345
3	LCD Display	150
4	Keyboard	80
5	Slide Switch	10
6	Connecting Copper Wires	15
7	Other expenses	50
	Total Cost	**1000**

The total cost of a single device is around **1000 INR**.

Since, two identical sets were made for demonstration, the total cost of the project stays around **2000 INR**.

The current cost per device is neither too high, nor too low. But, the cost can be largely reduced if the device is produced on a large scale.

IV. Conclusions

A. Advantages of this mode of transactions

Some of the advantages of using this device are :

1. Secure Transaction : Password based authentication is required. Hence, it is very safe to use.

2. Offline : No connectivity is required for the operation of the device.

3. Convenient : Operating the device is as easy as picking out money from the pocket and paying.

4. No fee for micro-payments : Some existing online wallets charge on transactions. Our device is hence, a one-time-investment kind of product.

5. Decreases theft tendency : The fact that the transfer of money to the person stealing the device is nearly impossible, makes our device less vulnerable to theft attacks.

6. Displaying the Current Balance and Transactions : The addition of this feature removes any kind of ambiguity in real life transactions. Also, this removes the necessity of keeping the track of one's daily expenditure, which is really difficult for the people belonging to the remote areas.

B. Future Implementations in the project

Some of the restrictions which currently exist in the device, can be removed. These are :

1. Restoring the lost device : A GPS based tracking system can be introduced in the device, in case the device is lost or stolen.

2. Replacing the damaged unit : If the device gets damaged, the data can be recovered from the device by storing it in a very rigid case (a black box kind of thing). Thus, rest of the damaged parts can be replaced easily, without any loss of money from either side.

3. Reduction in Cost : The cost per device can be greatly reduced if pins are made and used instead of using an Arduino.

4. Recognition : The device can get recognized as an official alternative mode of payment.

5. Increased Security : The password based authentication process can be replaced with biometric based one, without much increase in the cost.

Remarks : In this paper, the idea, implementation and future prospect of the project MUDRA was discussed. This device can be looked upon as an alternative mode of making payments, which encompasses the features of both : the currency notes as well as the digital money. The concept of the device lies in the fact that it does not depend on network connectivity, which is still a major hinderance in the aim of getting India, fully digitalized.

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