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Construction of Indian Currency Identifier for Visually Impaired

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***Abstract:** Visually impaired people often face difficulty to identify a nominal of money. Indian currency notes are available in different sizes and colours with tactile qualities that enable the visually impaired to identify different currency notes, but these tactile makers are worn out with usage. Various smartphone-based apps are available for note identification but using a smartphone by a visually impaired person gets difficult. So, it is necessary to design a device that supports visually impaired people in note identification. So, to overcome this problem we have designed an Indian currency identifier that will help visually impaired and blind people to identify Indian banknotes easily in less time using a colour sensor and sound module that will give output in audio form. The device makes use of a colour sensor and Arduino Uno to differentiate between currency denominations. The RGB output from the colour sensor is matched with the pre-stored RGB value. If RGB values fall inside any denomination pre-stored value the mp3 module is activated and the output voice is played from the store mp3 according to the result obtained from the Arduino Uno by mp3 module. A prototype was made to see the feasibility which has a Sensitivity of 85.71% and a Specificity of 66.66% to identify Indian currency notes. The cost of the construction of this device would be around 700-800 1NR.*

***Keyword**: Blind people, Colour sensor, Currency identification, Indian currency recognition, Visually impaired.*

I. INTRODUCTION

Recent estimates show that there are 285 million people who are either blind or visually impaired in the world [1] out of which 8 million blind people and 54 million visually impaired are in India [2]. Blind people often face difficulty to identify bank notes. It is extremely difficult to do daily routine tasks independently for the visually impaired and to identify Indian currency notes, particularly while accepting their money back when shopping for their daily needs is a challenging task. Indian currency notes are printed on different size and colours of paper with tactile qualities that enable visually impaired people to identify between different currencies notes but the problem with these tactile makers are that markers are worn out with usage. In 2016 Indian government announced the demonetization of all 500 INR and 1000 INR Mahatma Gandhi series banknotes and also announced new series of 500 INR and 2000 INR banknotes, which made it difficult to identify by blind or visually impaired people due to almost similar sizes. While old notes had a difference of 10mm, either in width or length in each denomination, for new notes this has been reduced to 4mm, making it difficult for persons with the visually impaired to identify. Various smartphone-based apps are also available to identify the different currency notes but using a smartphone by a visually impaired person is difficult as they require to click correct focused pictures of a currency note. Most of the devices are developed for the United States and Canada which identify their currency but none of these devices can identify Indian currency [3-6]. So, it is necessary to design a device that supports visually impaired people to identify the nominal of money. The study aims to construct an Indian currency note identifier for visually impaired people.

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II. LITERATURE SURVEY

iBill U.S Banknote Identifier has become a popular device for currency identification in the U.S, iBill has the advantage of being a small compact handheld device that gives output as a currency denomination by voice or patterns of vibrations. A visually impaired person inserts one end of the bill into the device, clicks the button on the device and the device gives an output of the currency denomination. The disadvantage of iBill is that it does not identify foreign or counterfeit banknotes or Indian currency. iBill is based on the contact image sensor, which is an expensive device but given free of cost for visually impaired people or blind by the US Government [3]. Tel-money Tel-money also uses similar technology (contact image sensor) as used in the iBill. Tel-Money gives voice output designed for people who have a visual impairment. It works for U.S. currency in denominations from 1 to 100 dollars. The user slides the currency into the money identifier and then presses a button, and the device reads the bill's denomination and announces the currency denomination [4]. The Canadian Bank Note Reader gives a voice output and reads all Canadian bank notes now in circulation and those expected to be in circulation in future [5]. Sri Lankan currency note identifier identify banknotes for visually impaired people, this system is based on colour sensors and photodiodes. According to the nearest neighbour method, the Euclidean distance (Kreyszig, 1973) between the sensed parameters of the note to be recognized and the centroids of each domain is calculated and compared. The note is then classified based on the value which falls near to domain.

The system had an overall accuracy of 87.27% [6]. Money Talker's Is based on the technique of the transmission/reflection property of light. Coloured lights pass through the note and as each note is a different colour, the amount of light that is passed through the note is different and dependent on the colour of the note. The note value is determined using the value which falls possibly near the classification algorithm for the data set. The Money Talker has proven to have high accuracy of 98% [7]. Malaysian Automated Bank Note Identification System recognise currency denomination for the visually impaired. Based on an RGB Colour Sensor module (CS), Sound module (SM) with an Arduino Microcontroller (AM). The AM initiates the RGB Colour Sensor to acquire RGB Value from a banknote and sends it to AM. The AM module computes the RGB based on the designed sorting algorithm to determine the colour of the banknote. Once the colour is identified the AM initiates the SM with the instruction set of appropriate audio sounds. The SM module will play the sound accordingly. The algorithm designed based on that sample size produces a system efficiency of 93.33% [8].

Table- I: Devices available worldwide for Currency identification for the visually impaired

No.	Devices available in worldwide		
	Device	***Read***	***Identification technique***
1	iBill Taking banknote [3]	US currency	CIS
2	Tel-money [4]	US currency	CIS
3	The Canadian bank note reader [5]	Canadian dollar	IR
4	Sri Lankan currency note recognizer [6]	Sri Lankan Rupee	CS
5	Money Talker's [7]	Australian dollar	T/R
6	Automated banknote identification system [8]	Malaysian currency	CS

CIS: Contact image sensor, IR; Infrared light sensor, CS: Colour sensor, T/R: Transmission/reflection properties of light

III. SYSTEM DESIGN

The device is largely depending on the different base colours of Indian currency notes. The main working of the device is based on the colour sensor. Here we used a colour sensor instead of using a contact image sensor as the main objective was to build a cheaper device. Colour has an array of the photodiode (a matrix of 8×8, so a total of 64 sensors). These photodiodes have three types of filters. 16 sensors have a RED filter so can detect only the component of red in the incident light. Same way, the other 16 have a GREEN filter and 16 have a BLUE filter.

As any visible colours are a combination of three primary colours but different intensities of each. So, these three types of filtered sensors help measure the weightage of each of the primary colours in incident light. The rest 16 sensors have a clear filter. The Colour sensor converts the intensity of incident radiation into frequency. The colour sensor is controlled by Arduino UNO. System design diagram is shown in Figure I. The Colour sensor is placed in a black box so the output is not interfered with by outside lighting conditions (Figure II). Currency note placed in the box every time gets a fixed testing position underneath the colour sensor so that they can match with the prestored value of the RGB pattern. An MP3 Player (DF Player Mini) was attached to Arduino Uno, which is a tiny and cheap MP3 module that is used for audio output. The MP3 player was used in combination with an Arduino and a speaker for audio. For the storage of output sound, we have used an SD card. Once, the reading has been performed they are compared with prestored value, so each currency has its own unique RGB value for each side of notes and if the reading value matched with the prestored value output is given by the device. Arduino Uno was programmed using Arduino IDE. The device is controlled by Arduino Uno which initiates the colour sensor, and give RGB value for different currency notes which are sent back to Arduino Uno, based on these values RGB algorithms were created for each currency note which was allowed to generate the reference data set were named as domains. Domains were created for each Indian currency note based on the RGB value so each Indian currency domain had its own unique RGB value which did not match with others. All programming of Arduino was done Using Arduino.

Table- II: Specification of the material

Materials	***Specification***	***Quantity***
Arduino	Arduino UNO	1
Colour Sensor	TCS3200	1
Battery	9-Volt	1
Jumper wires	-	-
Sound module	DFplayer mini mp3	1
Speaker	0.50w speaker	1
Resistors	1 k ohm	2
Breadboard	170 points mini breadboard	1

IV. SYSTEM WORKING

Arduino Uno initiates the colour sensor and a currency note is inserted. The outputs from the colour sensor are RGB values which are sent back to Arduino Uno and compared to the values that are stored in the memory as domains. If these values fall near the domains, the appropriate note value will be announced by the sound module. There are 4 possibilities that money can be placed inside the device and for each possibility, domains were created (Table III), so that the device can identify the correct nomination of Indian currency.

An analysis sample set consisted of 4 samples of each note category. The notes selected were in various conditions of newness. The dataset was created by inserting notes into the device, four times for each possible orientation. So that 4 samples for each side of the note, the mean value of RGP is taken and a dataset was created similarly for each side of the note.

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Table- III: Domain for 100 INR and 500 INR

	100 INR				500 INR		
Position	***RED***	***GREEN***	***BLUE***		***RED***	***GREEN***	***BLUE***
1ST Position	372<R>402	371<G>401	240<B>270		377<R>407	368<G>398	251<B>273
2ND Position	408<R>438	386<G>416	295<B>325		418<R>448	391<G>421	245<B>275
3RD Position	403<R>433	379<G>409	273<B>303		418<R>449	386<G>416	221<B>250
4TH Position	393<R>423	361<G>391	240<B>270		377<R>407	363<G>393	196<B>226

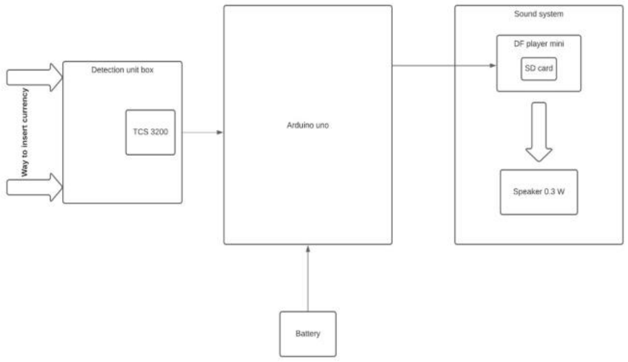

Fig. I: System design diagram of device

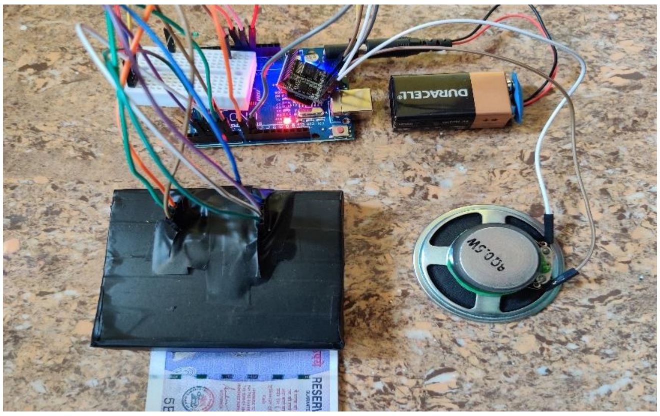

Fig. II: Mechanical structure of the device

100 Rs note value is determined only when the RGB value from the colour sensor falls in between above mention prestored values in Table III, similarly for other notes. The Colour sensor is placed in a black box so the output is not interfered with by outside lighting conditions. Currency note placed in a box every time gets a fixed testing position underneath the colour sensor so that it can match with prestored value of the RGB pattern.

V. RESULTS

The prototype device was tested against 5-5 samples of Indian currency note denominations (Table IV). During the test, the currency note was inserted randomly into the device without taking care of any side of the currency note. The prototype was made to see the feasibility, the device has a Sensitivity of 85.71% and a Specificity of 66.66% to identify Indian currency notes.

Device accuracy is a little lower compared to other devices, as we have used low-cost colour sensors to make the device cheaper. This work will be extended to all ranges of Indian currency notes available. The cost of the construction of this device would be around 700-800 INR. Device accuracy depends upon the physical condition of the currency notes. The RGB colour sensor is coded to identify Indian currency notes with the help of Arduino Uno which process the information obtained from the colour sensor, the mp3 module is activated and the output voice is played from the store mp3 according to the result obtained from the Arduino Uno by mp3 module.

Table- IV: Result of prototype device

Indian currency notes denominations	*Total notes inserted*	*Correctly identified*	*Incorrectly identified*
100 INR new note	5	5	0
200 INR	5	4	1
500 INR new note	5	4	1
100 INR old note	5	3	2
2000 INR	5	2	3
50 INR	5	4	1
10 INR	5	4	1
Fake notes	10	10	0

INR: The Indian rupee

VI. CONCLUSION

Here we have to deal with the common problem of visually impaired people identifying currency notes. A device which helps visually impaired people identify currency notes must be lightweight, portable and cheap. The device is constructed using a colour sensor which is cheaper than a contact image sensor as the device must be cheap.

The prototype was made to see the feasibility which has a Sensitivity of 85.71% and a Specificity of 66.66% to identify Indian currency notes. The cost of the construction of this device would be around 700-800 1NR. Indian currency identifier will help around 8 million blind people and 54 million visually impaired to identify bank series notes. Indian currency identifier has the advantage of being lightweight, portable and cheap. Another advantage of the Indian currency identifier if any change in the Indian currency denomination it can easily update for the new set of bank series notes. The accuracy of the device depends upon the physical condition of the notes. The device will be able to determine all new currency notes but not old currency notes would be a potential future investigation area.

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