Indian Currency Denomination Recognition for Visually Impaired

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ABSTRACT
There is a population of over 37 million people in the world that is visually impaired (VI). With the continuous advancement in technology, it's now possible to build viable technological solutions to help such disadvantaged people in their day to day life. In this paper we propose a solution that shall help visually impaired people identify Indian Currency notes which shall then simplify monetary transactions for them. The method proposed includes image processing techniques which have been elaborated in this paper.

General Terms
Image Processing, Computer Vision, and Solution to visually impair.

Keywords
Currency denomination; image processing; recognition.

1. INTRODUCTION
In the recent times technological advancements have led to components getting smaller and smaller that has allowed us to formulate portable solutions to a number of problems. In India, the population of visually impaired people is approximately 3.5 million. These people suffer daily trying to go about their lives and adapt to a world created for and by the sighted people .We have become so accustomed to the use of our eye-sight that we hardly stop to think about the different areas of life where it serves an extremely important function. Monetary transaction in daily life is one such area. To the unimpaired people it seems almost unimaginable to be able to perform such a transaction without the use of eyes. We in this paper have proposed a solution to the problems faced by visually impaired people during monetary transactions. A visually impaired person faces numerous difficulties in his daily life. Having no reliable method to measure the amount of money, they can be easily taken advantage of by others. In India, currency notes have some distinct tactile features to aid the visually impaired in identifying the Indian currencies. Whenever a VI person receives an Indian currency he/she has to use these feature for identifying a currency, however repeated use of a currency renders these markings useless. This is a huge disadvantage to them. Consequently a solution using image processing may be used to solve this problem. The idea here is to give the benefit of visual feedback to the visually impaired and perform the processing artificially of recognizing a currency which our brain can do naturally in case of unimpaired people.

People have tried different solutions using image processing, some which use Smartphone [1] for this purpose; however none of the solutions are convenient and easy to use in our day to day life. Use of a Smartphone would require much effort and practice by a visually impaired (VI) person to perform operations such as capturing the image of currency. For instance, to use a Smartphone application, the VI user shall have to first navigate to the application, this itself is a time consuming task since the user shall have to check each application using the talkback feature and then finally land on the required application, such a task is, to say the least, impractical in a real life situation. Our aim here is to create a solution that is free of such limitations.

Our proposal is to create a wearable device with a camera at a convenient position that can capture the image of a currency. The device would be connected to an image processing unit either wirelessly or otherwise and the image processing unit would then process the complete image and give out the result. The device mentioned would also have an audio feedback mechanism that can relay the result to the VI user. The device would be created in such a way that the user can wear it on his head like a pair of glasses or a headband with the camera at eye level. This will make the denomination recognition a hands-free process with the user only handling the currency.

There are numerous challenges that shall present themselves, some of them being

I. Efficiency- The solution is meant to be deployed in real life situations in which it would be impractical to have large amounts of lag between the user input and the output delivery. Therefore efficiency is important

II. Accuracy- Since we are developing the solution keeping in mind the needs of the visually impaired, near perfect accuracy is needed for this innovation to be a success. The accuracy depends on the image processing part of the implementation.

In this paper we have detailed the image processing part that has been completed on a windows operating system using C++ language and OpenCV library files. The images which have been taken as input have been captured using a Smartphone device camera. The camera while capturing the images has been kept at eye level near the face so as to simulate the device that has been proposed as part of our solution.

In India, currency notes of Rs 5, 10, 20, 50, 100, 500 and 1000 are in circulation. The image processing algorithm has been developed keeping all these types of currencies in mind. There are several unique identifiers in Indian currency notes that can be used to our advantage in our solution [2].

2. IMAGE PROCESSING
2.1 Methods Used
Currency Denomination recognition can be done using a variety of techniques and methods. These may include using color features [3], scanned images, pattern matching, neural networks [4], histogram analysis [5], LBP (Local Binary Pattern) [6], etc. The following are the image processing methods that have been used in our currency denomination

recognition. The use of these methods in our implementation shall be examined later in this paper.

I. Edge Filter

For the edge filter, we have used Sobel filter in our process. Sobel filter was decided upon after completing the complete process and comparing the results between using Sobel filter and Laplacian filter (See Section III- Results).

II. Gaussian Blur

III. Template Matching

IV. Grabcut Algorithm [7]

2.2 Procedure Followed

To facilitate the currency denomination recognition process, we have designed a process such that the amount of data to be processed is reduced in each step. The first step is to detect a currency in which we process the complete image that has been captured; in each subsequent step the amount of data to be processed keeps reducing as we keep segmenting the image until we get the region of interest (ROI). Given below is the description of each step of the process (Also see Figure 1. for the operational flow of the process).

2.2.1 Step One: Resize image and Noise removal

The image taken from android device were of 3264 X 1836 resolutions; to reduce the processor load, the image was resized to a resolution of 512 X 288. After resizing the next step would be to begin noise removal [8], so that later operations give result to minimum errors. Therefore noise from the image is removed using Gaussian Blur.

2.2.2 Step Two - Currency Detection

The input image is taken here and passed through an Edge Filter. For our purpose we have used the Sobel Edge filter. This will highlight any kind of edges present and shows them against a black background. The next step in currency detection is finding a marker that should be present if a currency note is contained in the image. For Indian currency, all currencies have the portrait of Mahatma Gandhi on the right side of the currency. Here an already stored Sobel filter applied Mahatma Gandhi image is used and that pattern is searched in the image. This is done using Template Matching. The Sobel filter here improves this process since with the edges being highlighted only the outline of the template is searched. This reduces the chances of error while matching. In our case if the template is not found we return the output that the image does not contain any currency note. Thus no further processing is required. If however the template is found, we proceed further. (See Figure-1, the green rectangle denotes the position of the template in the input image)

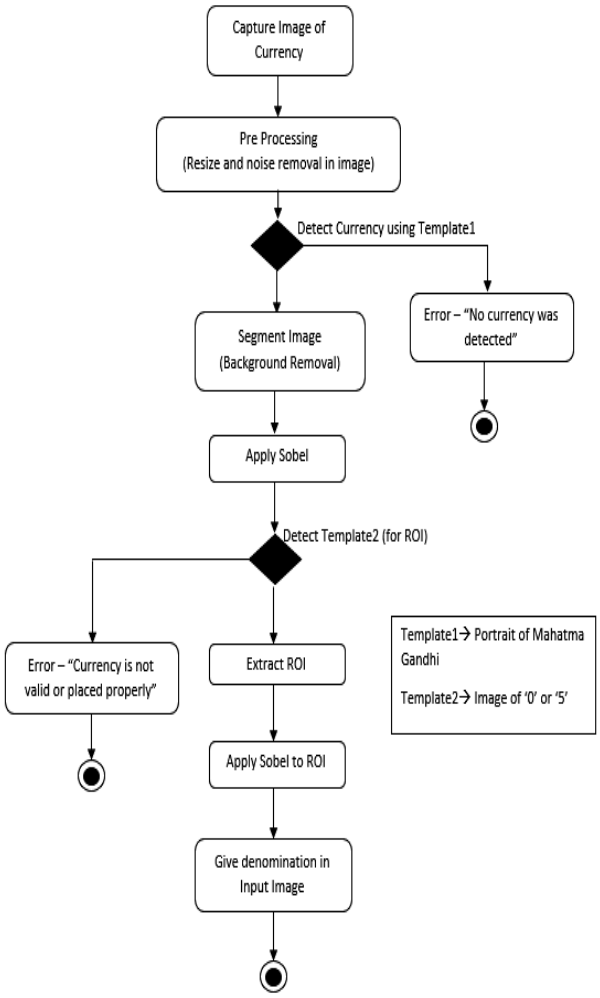

Fig.1: Flowchart for Currency Denomination

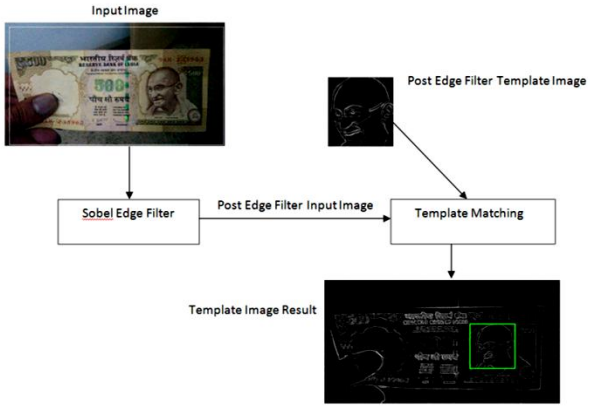

Fig.2: Note Detection

2.2.3 Step Three - Background Removal

After having detected the presence of a currency note, the next step is to remove part of the image which is not the currency i.e. the background in the image [9]. This is done so that only the relevant visual information about the currency is kept. We use the Grabcut algorithm to do this. (See Figure-2)

2.2.4 Step Four - ROI Extraction

After the currency part of the image has been segmented, we need to focus on the region of interest (ROI). In this case ROI is the center part of the currency which contains the currency value in numeric form. Extracting the ROI is a common process that is widely used in many such implementations [10]. Here using Sobel filter and Template Matching like before, the figure "0" or "5" is searched in the image, since all currencies have them in their numeric denomination. For this purpose sobel filter applied template images of "0" and "5" were stored and used. After obtaining their position, the ROI can found by extending the area around the "0" or "5". The Rs 1000 currency has largest area for the ROI when comparing all the currencies; therefore the extension around the "0" or "5" found, is done with enough margin so that value of the note in numerals of a Rs 1000 currency is contained in the ROI. The logic is that since Rs 1000 takes the largest area, margin used for this will be enough to enclose value in numerals for other value currencies which clearly take less area than the Rs 1000 currency. (See Figure-3)

Fig 3: Background Removal

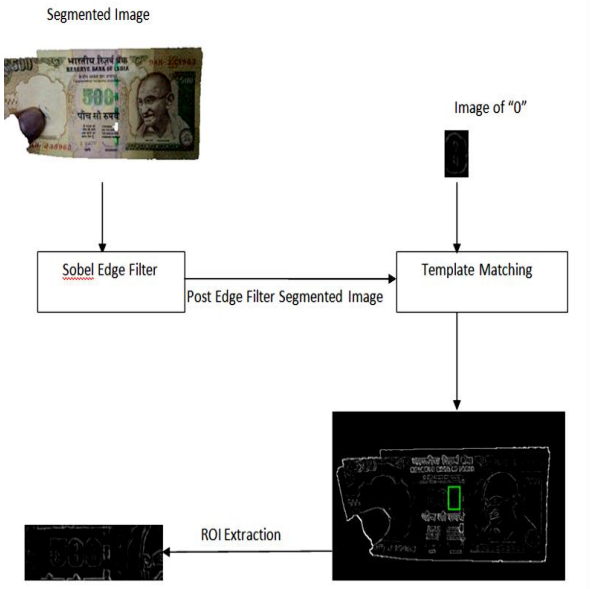

Fig.4: ROI Extraction

2.2.5 Step Five - Currency Denomination Matching

After the ROI has been extracted, that image can be used to do one final template matching with the already stored post-Sobel filter images of different currency denominations. A positive match shall then give us the value of the currency. (See Figure-4)

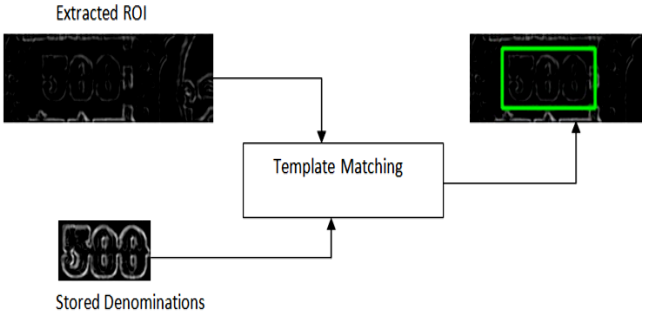

Fig.5: Currency Denomination Recognition

3. EXPERIMENTAL RESULT

Having completed the implementation, we tested the accuracy of our proposed method by taking real world test images captured via an android camera phone. We took various sample images of each denomination i.e. 10, 20, 50, 100, 500, and 1000 and tabulated our process's response time for each test case. The results (Figure 6) showed us that our process was accurate on 75% of the test cases and the average time for the complete process was of 1.5 – 2 seconds. Some of the sample images and the corresponding output are shown in Figure 6.

Fig.6: Working of the system

3.1 Sobel vs Laplacian Filter

In our work, there is a continuous use of an Edge filter and we had a choice of two edge filters- Sobel and Laplacian- which could be easily implemented. We applied both these filters individually wherever an edge filter was needed and then compared their accuracy. The accuracy of Sobel and Laplacian was compared by taking 4 sample images of each denomination. The resulting evidence (Figure 7) showed that Sobel filter is displaying more accuracy than Laplacian Filter.

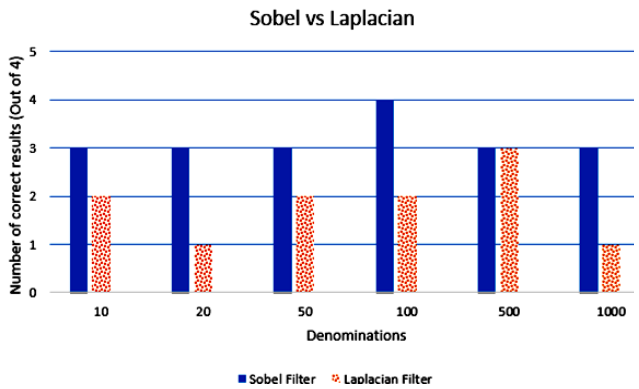

Fig.7: Comparison of Sobel and Laplacian Filter

4. CONCLUSION

The solution we have proposed will be easy to use and the image processing methods used are simple to implement. The proposed technique works for any denomination of Indian currency. All the steps listed in the image processing section when implemented can effectively recognize currency denomination for an Indian currency note. This process when integrated with a wearable device shall create a unique solution to problems faced by the visually impaired people in India.

5. FUTURE WORK

Further work needs to be done to make the process described in this paper of practical use. For the proposed idea of creating a wearable device which helps the visually impaired people recognize currency notes to be completed, the next phase of this project must commence. The next phase involves designing the wearable device and integrating it with the already completed process. The wearable device must have a portable camera, connectivity to the image processing unit for integration with the completed work and an audio feedback mechanism all of which can be done using existing technology. Along with the creation of the device, continuous enhancement and improvement of completed process must take place. Potential areas of improvement are increased accuracy by using techniques such as motion blur removal and increased efficiency by improving the algorithms used.

Another functionality that can be added to our solution is of detecting counterfeit currency using image processing methods. This is another area that we intend to work on and integrate it with our solution. There are several existing methods that implement counterfeit currency detection using image processing. Indian currency notes have a lot of identifiers which verify the authenticity of the currency; these will be used to successfully complete the counterfeit detection functionality. In addition to these features, there are several properties, such as color components [11], of an image that can be used to check for counterfeit currencies. The whole aim here is to bridge the gap that is present between visually impaired people and sighted people when it comes to monetary transactions.

6. REFERENCES

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