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Setting the template for Naira denominations detection

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Abstract

The ubiquitous method of counting money by hand is definitely not acceptable when large amount money is to be dealt with, from time and accuracy stand points, which have led to the use of Automated Money Counter to determine the number of fed notes without distinguishing their denominations. Although numerous algorithms and devices have been developed to detect denominations for several currencies but, based on all accessible literatures, this paper seems to be the first attempt to automatically detect Nigeria currency denominations as it provides an algorithm that detects both paper-based and polymer-based Nigeria currencies. Thus, this paper set the pace for future research studies in the area of automatic Nigerian Naira denominations recognition systems. The algorithm used is achievable with relatively cheap hardware requirements, yet with substantial overall accuracy of 98.75% for non-mutilated notes but it is yet to be tested with defaced and mutilated notes. The algorithm developed can be deployed to function as mixed-denominations money counter or as denomination detector.

Keywords: Nigeria currency; naira denomination; naira detector; money recognition; image extraction

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1. Background

As the world is getting increasingly automated, faster and more efficient means are developed on daily basis. Likewise, the act of manually counting money are being reduced in money intensive industries, especially banks, as automated money counters have taken over the space, which have been developed to a high accuracy. Despite the accuracy of the money counters, they do not distinguish between currency denominations hence for mixed denominations, money have to be manually sorted, no matter how bulky it may be; grouped into categories based on denominations before they are fed into the machine; after which calculation has to be done for each denomination categories. Obviously, productive time is wasted during sorting, and may even be subjected to human error when large amount of mixed currency notes are to be processed. Thus, the search for a faster means for detecting the denominations is necessary.

The Nigerian currency notes (Naira) is of two forms, which are the paper-based and the polymer-based, although the coins still exist in the country but they are hardly found in circulation. The polymer based ones are the lower valued notes which are: five Naira(N5), ten Naira(N10), twenty Naira (N20), and fifty Naira(N50) notes; whereas the higher valued notes are paper based which are: hundred Naira (N100), two hundred Naira (N200), five hundred Naira (500), and one thousand Naira (N1000) notes. Thus, a total number of eight notes are currently in use in Nigeria and this study attempt to recognise all of them. In the country, all the currencies in circulation can be grouped as new, neat, dirty, defaced and mutilated notes; the first three, referred to as non-mutilated notes, were the basis for which the algorithm in this paper was developed.

Image recognition have been employed for money recognition by several researchers using different approaches, for some years now, but the only one found in Nigeria (based on all accessible literatures) was that of Almu and Muhammad (2017). They used image recognition to ascertain the authenticity of Naira notes, by comparing some extracted features of the fed Nigeria currency over the internet with the ones stored on a remote server, which they were able to accomplish with somewhat low accuracy of 70.40%. Their process was time consuming as each note must be uploaded for extraction and verification process which needs internet presence and may take a while, especially when the internet signal drops. Since their research was geared toward authenticity, this present study can be said to be the first one to determine the denomination of Nigerian currency notes (both the polymer and paper based). Though, the author plan to embark on another research which will, in real time, ascertain the authenticity of the currency with a high degree of accuracy, but this present study does not consider authenticity of the notes.

Researchers have used different methods to recognize different currencies. For example, Shettigar and Singal (2017), Sarfraz (2015), and Althafiri et al. (2012) employed some neural network configurations for currency recognition, whereas Bhawani et al. (2012) used local binary pattern for extracting textures for accessing the authenticity of Indian currency. In 2016, Eshita and Bhavika recognized fake Indian currency by extracting some notable features from a region of interest in the fed notes, which are then compared with some sets of features stored in a local database; this paper followed this approach with some modifications. In this algorithm, surface features are extracted from frames captured by a camera or scanner, and then compared with some locally accessible surface data based on a set of matching criteria.

2. Proposed Algorithm

The program works by collecting frames from a low resolution camera, and if the resolution of the fed frame is large, the algorithm resizes the image such that the longer part of the frame is of size 300 pixels, while preserving the aspect ratio of the frame. Low resolution frames are used so as to reduce the overall processing time of each of the frames. Another advantage is that, using low resolution images makes the program more versatile and can be deployed using, virtually, any type of camera device there by reducing the hardware requirement of the program. The whole process is as depicted in figure 1. A graphical user interface named “NairaDetector” was also developed with MATLAB® software to ease visualization of the process.

2.1. Pre-processing

The captured frame is subjected to some pre-processing steps which are majorly, conversion to grayscale and filtering. The image is converted into its grayscale form to ensure that the program is able to utilize the several available image analysis method, most of which are optimized for grayscale and binary images. Conversion to grayscale, also allows the algorithm to deal with some camera defects which may interfere with the colour of the image if colour-based processing is to be done. In order to reduce the image impulse noise which may be perceived as a result of disturbance in the image signal, the image histogram is first adjusted so as to increase its contrast by mapping the intensity data of the grayscaled version to fill-up the whole intensity range, after which a two-directional 3-by-3 neighbourhood sampling median filtered is employed. The choice of median filter is due to the fact that the aim here is only to reduce noise while preserving the edge details.

To get the frame ready for segmentation, the filtered grayscaled image is converted into binary image by subjecting it to a threshold level, which is computed on-the-fly using Otsu's method, with addition of a bias parameter which is determined by experimentation. The output of the binary conversion process is composed of 0's and 1's, where all the pixels with a luminance value greater than the computed threshold have been replaced by 1’s whereas lower luminance values are replaced by 0's. In other words, the image is converted into a black and white image without any intermediate colour. Canning algorithm is used to locate the edge of the currency, which entails searching for local maxima of the binary image using threshold values which are computed on-the-go. The size of the Gaussian filter is determined by setting the appropriate standard deviation, and then dilated using a specified number of neighbours in both vertical and horizontal dimensions after which the dilation process is speeded-up using the binary image packing. Holes within the edges are flooded with 1's, while some unwanted structures that are not part of the area of interest are detected and deleted by sampling the unsparsed-real-logical image for specified neighbourhood connectivity. The output is immediately followed by binary erosion with a specified structuring element. The area of interest (the actual currency note) is retrieved and the image cropped for feature extraction and detection.

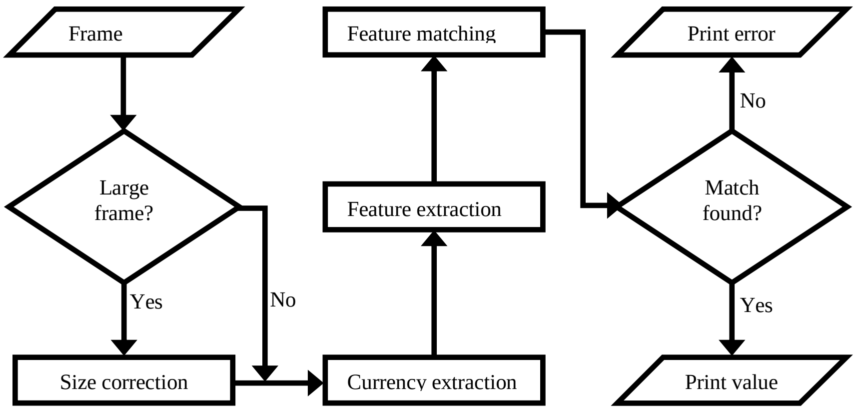

Figure 1. detection flow-chart

2.2. Feature extraction and detection

Several features are extracted from the image by searching for blobs in the cropped image using the Speeded-Up-Robust-Features (SURF) algorithm, and then compared with saved features of each currency notes. Since currency notes have some things in common (such as the flag, coat of arm and signatures), and the same currency notes have some features which are different from each other (which include date and number), hence, some criteria is set for the matching process which is majorly based on the number of successfully matched features. If the frame is successfully matched to one of the Nigerian currency notes, the value is displayed (but may be modified to perform other actions for specific purposes), and in a case whereby the features in the frame fed does not match any of the ones in the database, the program reports that no valid currency is found.

3. Results and Discussion

The program was used to detect all the 8 denominations, each with 20 representatives each (10 front views and 10 back views) but, for space economy, only the detection of the front views of four denominations are shown in figure 2 and figure 3, the two denominations in figure 2 are N20 and N50 which are representatives of polymer-based notes whereas the two denominations in figure 3 are N500 and N1000 denominations which are representatives of the paper-based notes. As obvious in figure 1, the typical polymer-based currencies tend to squeeze which may pose some problems during the recognition stage as folding usually result to loss of exposure some features in the note. In other to overcome such challenges, the required number of features needed for recognition was reasonably reduced such that only sufficient number of features for accurate detection is used. An overall success rate of 98.75% was recorded for the non-mutilated notes, though mutilated and defaced notes were not supplied for detection.

The algorithm is able to detect the actual currency note despite the change in background; this is due the removal of the background during the pre-processing stage as only the note is cropped before feature extraction. It must be stated that in cases where the background will be stable during application, the stage of removing the background can be skipped which may increase the overall speed of the program. The algorithm is also not affected by orientation and squeezing of the currency, which also makes it versatile during

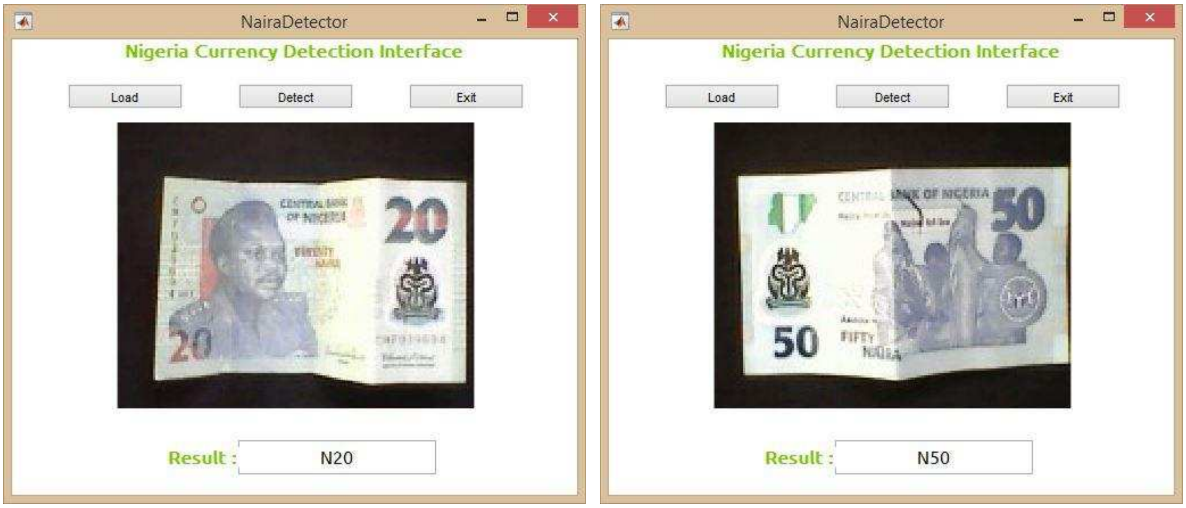

Figure 2. N20 note detection; (b) N50 note detection

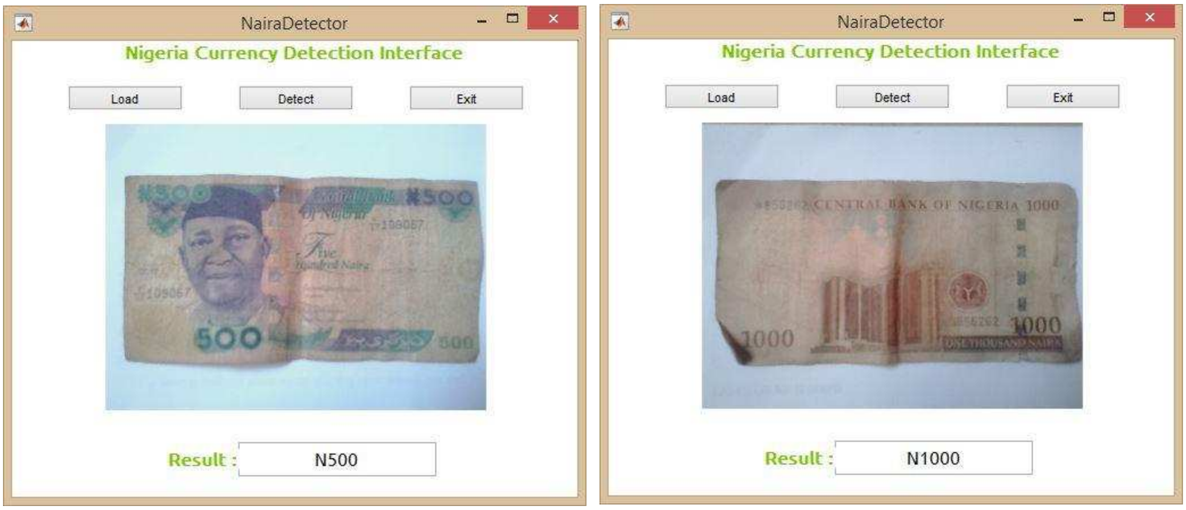

Figure 3. (a) N500 note detection; (b) N1000 note detection

application as the user does not have to bother, too much, about its orientation and straightening of the currency which may prove tedious, especially for the polymer-based notes. The colour change, which may be as a result of handling, does not also disturb the process as the detection was based on the shapes of extracted features.

4. Conclusion

Although, many researchers have worked on denominations detection for several currencies, but no algorithm was found, in literatures, for Nigerian currency. Thus, this paper applied several principles of image recognition to come up with an algorithm that automatically detect Nigerian Naira and its denominations, it must be noted that the algorithm does not attempt to ascertain the authenticity of the money which may be an area for further research studies. The proposed algorithm has been found to behave satisfactorily, with a high level of accuracy (98.75%) for neat paper and polymer notes, though it is yet to be fed with defaced and mutilated notes which are commonly found in market places. This program can be deployed on devices with inexpensive hardware, to function as automatic multidenominational money counter or as denomination detector for visually impaired.

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