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PEKEMON: A Mobile Application for Detecting Fake Money

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ABSTRACT

Banko Sentral ng Pilipinas (BSP) released and redesigned/new Philippine peso bills last December 2010 in accordance to stop the proliferation of counterfeit money, but circulation of fake money continues. The project developed a mobile application that will help detect fake new Philippine bills by using an algorithm in a mobile application. The researchers devised a tool in detecting fake money by distinguishing between genuine and counterfeit Philippine peso bills using built-in phone camera. The method used in detecting fake money was image segmentation using Sobel Edge Detection Algorithm. It converted the image to grayscale and detected two kinds of edges in an image: Vertical Direction Edges and Horizontal Direction Edges. After the image was converted, it counts the number of white pixels which had been the basis to determine if it is fake or not. The mobile application is available for android operating system only. The programming language that the researchers used is Java. The application resulted to 50% - 70% accuracy in detecting fake bills because it uses a phone camera for detection instead of Ultra Violet Light. It is recommended that the design be enhanced by adding more functionality such as sending a message to the office of Banko Sentral ng Pilipinas (BSP) if the money is detected as fake.

Keywords – Technology, image segmentation, mobile application, sobel edge detection algorithm, Philippines

INTRODUCTION

Fake money is circulating in the Philippines such as Cebu City, Taguig City, Pasay City, and Manila. While there are some fake money dealers who got arrested, still, there are people who got fooled by these dealers even if there are many machines available to detect fake bill, such as Counterfeit Money Detector, Currency Validator, and Counterfeit Detector Pen with Reusable UV Led Light (philstar.com, February 2014, inquirer.net, April 2014 & gmanetwork.com, March 2013).

To stop the proliferation of counterfeit money, Banko Sentral ng Pilipinas (BSP) released and redesigned/new Philippine Peso Bills last December 2010. The regular practice of central bank in changing the designs of their money is intended to protect the currency against counterfeiters by making it difficult and costly for them to produce exact copies. The new designed money has unique features but still fake money dealers are smart to think of ways to fake even the newly designed money.

With the possible proliferation of counterfeit money in the country, it is best to be familiar with the security features of genuine bank notes and detect the fake ones. It is for this reason that, the authors developed a mobile application that may use as a counterfeit money detector. The application used photos taken by the cellphone camera and apply the Sobel Edge Detection Algorithm for determining counterfeit money using image segmentation. If Counterfeit Money Detector is installed to mobile phones, a large proportion of the population that relies only on cash transactions will get an accessible and handy detector on their phones that will allow them to check the bill.

FRAMEWORK

Ways of Detecting Fake Money

There are 2 ways of detecting fake money: [1] manually, and [2] by ultraviolet light.

Manual

Figure 1. Security Features

According to Malic and Malabrigo (2010), there are Security features which can be easily recognized by the public without the use of special instruments. These are the "look," "feel," and "tilt" elements in the notes, as enumerated: (1) Embossed prints: The embossed or raised print nature of the ink deposition combined with the quality of cotton-based paper gives the traditional banknote a unique tactile effect that makes it the first and the most important line of defense against counterfeiting. This can be felt over the words "REPUBLIKA NG PILIPINAS," denominational value in text, signatures, and value panels particularly, the one located at the lower right corner of the bill can be observed; (2) Asymmetric Serial Number: Alphanumeric characters at the lower left and upper right corners of the note bearing one or two prefix letters and six to seven digits, with font increasing in size and thickness; (3) Security Fibers: Visible red and blue fibers embedded on the paper and randomly scattered on the face and back of the note; (4) Watermark: Shadow image of the portrait with the highlighted denomination value that is particularly seen against the light from either side of the blank space on the note; (5) See-Through Mark: The pre-Hispanic script (Baybayin) at the lower right corner of the face of the note slightly above the value panel. This is seen in complete form only when the note is viewed against the light. This script means "PILIPINO"; (6) Concealed Value: The denominational value superimposed at the smaller version portrait at the upper left portion of the note. This becomes clearly visible when the note is rotated 45 degrees and slightly titled; (7) Security Thread (Embedded or Windowed): Embedded thread that runs vertically across the width of 20-and 50-peso notes when viewed against light. Also, the stitch-like metallic thread on the 100, 200, 500 and 1000-peso notes which changes color from red to green and bears the clear text of "BSP" and the denominational value on the obverse and "BSP" on the reverse, both in repeated series; (8) Optically Variable Device (OVD) Patch: Found only in 500 and 1000-peso notes, this patch is a reflective foil, bearing the image of the Blue-napped parrot for 500-peso, while clam with South Sea pearl for 1000-peso, changes color from red to green when the note is rotated 90 degrees; and (9) Optically Variable Ink (OVI): Found only in the 1000-peso note; this embossed denominational value at the lower right corner of the face of the note changes color from green to blue when viewed at different angles.

Figure 2.4.2

Home/Menu Screen

Ultraviolet

Security features recognizable by professional cash handlers/bank tellers with the use of magnifying lens or ultraviolet light. Examples are fluorescent features and micro printing.

In relation to the ultraviolet light, Bolo, (2008) stated that the UV light technology was chosen over other technologies because it is the most commonly used bill authenticity detector. Also, studies show that the ultraviolet light can scan fluorescent fibers of the bill, enabling the user to verify the authenticity of the bill accurately.

This was also supported in the study of Sanjana, Diwakar and Sharma (2012) showed that embedding fluorescent fiber into the paper, or printing ultra-violet ink onto the paper, creates a form of optical verification easily used at counters, checkouts, etc. By exposing the note to ultra-violet light, the ink or fiber fluoresce, revealing a colored pattern not visible under natural light.

Edge Detection

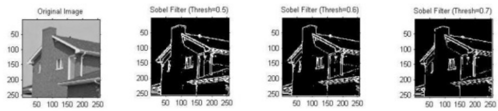

Figure 2. Edge Detection
(Source: Maini & Aggarwal, 2009)

Edge detection refers to the process of identifying and locating sharp discontinuities in an image. The discontinuities are abrupt changes in pixel intensity which characterize boundaries of objects in a scene. There are an extremely large number of edge detection operators available, each designed to be sensitive to certain types of edges. The geometry of the operator determines a characteristic direction in which it is most sensitive to edges. Operators can be optimized to look for horizontal, vertical, or diagonal edges. Edge detection is difficult in noisy images, since both the noise and the edges contain high frequency content (Maini & Aggarwal, 2009).

In addition, Kumar and Saxena (2013) introduced that edge detection is a well-developed field on its own with image processing. Edge detection is basically image segmentation technique, divides spatial domain, on which the image is defined, into meaningful parts or regions. Edges characterize boundaries and are therefore a problem of fundamental importance in image processing. Edges typically occur on the boundary between two different regions in an image. Sobel operator is a discrete differentiation operator used to compute an approximation of the gradient of image intensity function for edge detection. At each pixel of an image, Sobel operator gives either the corresponding gradient vector or normal to the vector. It convolves the input image with kernel and computes the gradient magnitude and direction.

Edge detection is one of the most frequently used techniques in digital image processing. The boundaries of object surfaces in a scene often lead to oriented localized changes in intensity of an image, called edges. This observation combined with a commonly held belief that edge detection is the first step in image segmentation, has fueled a long search for a good edge detection algorithm to use in image processing. Edge detection techniques transform images to edge images benefiting from the changes of grey tones in the images. The Sobel Detection: The Sobel operator performs a 2-D spatial gradient measurement on an image and so emphasizes regions of high spatial frequency that correspond to edges. Typically it is used to find the approximate absolute gradient magnitude at each point in an input grayscale image. In theory at least, the operator consists of a pair of 3x3 convolution kernels (Senthilkumaran & Rajesh, 2009).

Chaudhary and Gulati (2013), says that edge detection in images significantly reduces the amount of data and filters out useless information, while preserving the important structural properties in an image. The Sobel edge detection method is introduced by Sobel in 1970. The Sobel method of edge detection for image segmentation finds edges using the Sobel approximation to the derivative. It precedes the edges at those points where the gradient is highest. The Sobel technique performs a 2-D spatial gradient quantity on an image and so highlights regions of high spatial frequency that correspond to edges. In general it is used to find the estimated absolute gradient magnitude at each point in an input grayscale image.

Based on the study of Gupta and Mazumdar (2013) of International Journal of Computer Science and Management Research (IJCSMR), compared to other edge operator, Sobel has two main advantages: because of the introduction of the average factor, it has some smoothing effect to the random noise of the image. Also, because it is the differential of two rows or two columns, the elements of the edge on both sides has been enhanced, so that the edge seems thick and bright.

Meanwhile, Vincent and Folorunso (2009) said that the Sobel edge detector uses a pair of 3 x 3 convolution masks, one estimating gradient in the x-direction and the other estimating gradient in y–direction. The Sobel detector is incredibly sensitive to noise in pictures, it effectively highlight them as edges. Hence, Sobel operator is recommended in massive data communication found in data transfer.

Another source, Juneja and Sandhu (2009), showed the method of locating an edge as a characteristic of the "gradient filter" family of edge detection filters and includes the Sobel method. The Sobel method finds edges using the Sobel approximation to the derivative. It returns edges at those points where the gradient of the image is maximum. Sobel operator provides both differencing and smoothing, it detects part of the edges in the image.

Image Segmentation

Based on the study of Kumar and Pandey (2013), digital image processing image segmentation is an essential step for image analysis. The image segmentation separates an image into its components parts and its objects. Segmentation algorithms for image are generally based on the discontinuity and similarity image intensity values. Discontinuity which is based on the abrupt changes in intensity and similarity is based on the partitioning of images into the regions. Edge detection is a part of the image segmentation. The effectiveness of many images processing depends upon the perfection of detecting meaningful edges. It is one of the techniques for detecting intensity discontinuity in digital images. The process of classifying and placing sharp discontinuities in an image is called edge detection. These discontinuities are immediate changes into pixel concentration which distinguish boundaries of objects."

The first step in an image analysis is to segment the image. Segmentation subdivides an image into its constituent parts or objects. The level to which this subdivision is carried depends on the problem being viewed. Sometimes the need to segment the object from the background is to read the image correctly and identify the content of the image, for this reason there are two techniques of segmentation, discontinuity detection technique and similarity detection technique. In the first technique, one approach is to partition an image based on abrupt changes in gray-level image. The second technique is based on the threshold and region growing. (Al-Amri, Kalyankar & Khamitkar, 2010)

From the article of Kato and Pong (2006), image segmentation is an important early vision task where pixels with similar features are grouped into homogeneous regions. A broadly used class of models is the so-called cartoon model, which has been extensively studied from both probabilistic and variational viewpoints. The model assumes that the real world scene consists of a set of regions whose observed low-level features changes slowly, but across the boundary between them, these features change abruptly.

OBJECTIVE OF THE STUDY

The study aimed to: 1) develop a mobile application that will help detect fake new Philippine bills; 2) use Sobel Edge Detection Algorithm in image segmentation; 3) devise a tool in detecting fake money; and 4) distinguish between genuine and counterfeit Philippine bills using built-in phone camera.

METHODOLOGY

Mobile apps are designed with consideration for the demands and constraints of the devices and also to take advantage of any specialized capabilities they have. This program runs on a handheld device, has a "smart" operating system, supports standalone software and can connect to the internet via Wi-Fi or a wireless carrier network.

The method used in detecting fake money was image segmentation using Sobel Edge Detection Algorithm. It converted the image to grayscale and detected two kinds of edges in an image: Vertical direction edges and Horizontal direction edges. After the image was converted, it counts the number of white edges. This mobile application is available for android operating system only. The programming language that the researchers used is Java.

As the main objective of this paper is to detect counterfeit Philippine peso bills, the application was built in Eclipse where Sobel Edge Detection Algorithm will help detect the counterfeit money through image segmentation. Bank notes are available in values of 20, 50, 100, 200, 500, and 1000 and these notes have the same size. This role was played by the camera phone which captures the whole bill at once. With the aid of a high definition camera, the application will implement Sobel Edge Detection on the image, and count the white pixels. This application has the ability to distinguish if the peso bill was counterfeit or genuine. Though there are different smart machines that are available to detect counterfeit bills, this mobile application is more portable and accessible to use.

RESULTS AND DISCUSSION

PekeMon is a mobile application that will help determine if the bill is genuine or counterfeit. It will use the device's camera and memory to perform its actions by implementing the Sobel Edge Detection Algorithm on the image, and count the white pixels of the bill to determine whether it is genuine or counterfeit.

The users can detect fake money with the use of the camera of their mobile phones, android as their Operating System (Kitkat and Lollipop only), also through the use of Sobel Edge Detecting Algorithm in image segmentation. This mobile application has 50% to 70% accuracy in detecting fake bills. The definite use of Sobel Edge Detection Algorithm is by converting the captured image of the bill into a binary image consisting of black and white pixels showing that white pixels represent the edges of the image and the elements of the image. In this manner the converted image through the use of Sobel might be processed to count the number of white pixels of the image which will be the basis of determining if the bill is genuine or fake.

Based on the tests that we had conducted, we found out that each genuine bills has greater white pixels than the counterfeit one. Through the help of another application which we implemented the use of Sobel Edge Detection Algorithm, and count the white pixels. This process guided us in having the average white pixel count in each bill. After having samples and tests on each bill, we came up with the accuracy percentage of each bill. For the 20 and 50 peso bills, 70% to 90% accurate. While on the 100, 200, and 500 peso bills, 50% to 70% accurate. And lastly, 30% to 50% accurate for 1000 peso bill.

This application has limitations. Crumpled money is not advisable for detection of the app. One should not take pictures on dark areas, therefore, proper lighting is required. The device's camera must be 8 megapixels and above, and has auto-focus. Be sure to focus on the bill before capturing the image. Also, never use a blurred image in the detection process. The intended users of this application are those who have android operating system, Kitkat and Lollipop versions only.

CONCLUSION

This mobile application was created to provide big or small establishments an easy way to detect counterfeit money with the use of their android phones. This study differs from other counterfeit money detector app in which they used UV light for detection. Compared to our research, we used Sobel Edge Detection Algorithm in image segmentation to detect counterfeit money. Users simply have to capture an image of the money, and the application will automatically detect whether the money is counterfeit or genuine.

RECOMMENDATIONS

The study can be a reference for future researchers who are into developing mobile application projects using Eclipse as their IDE. Furthermore, it is recommended that the design be enhanced by adding more functionalities such as sending a message to the office of Banko Sentral ng Pilipinas (BSP) if the money detected is fake.

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Appendices

Figure 2.4.1
Application Drawer

Figure 2.4.2
Home/Menu Screen

Figure 2.4.3
Office Lens Camera

Figure 2.4.4
Image Segmentation