The Grading Multiple Choice Tests System via Mobile Phone using Image Processing Technique

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Abstract—Grading devices are expensive causing budget waste, in addition some are difficult to use. Therefore, an objective test grading system via Android mobile phone was developed to save cost and time in grading. The system uses image processing technique developed by Java. A camera on a mobile phone was used to capture the edge of answers and an equation of geometric simulation of digital camera sensor was applied to identify answers selected from calculation of pixel intensity in real time. The objective test grading system via Android mobile phone can work effectively and accurately more than 95%.

Keywords—Grading multiple choice tests, Image processing, Edge Detection

1 Introduction

Nowadays, smartphone technology plays an important role in daily life. There are plenty applications available to serve users' needs. Technology has become an essential part in people's daily life and studies on technology has been key to educational driving. Grading is one of the systems that applies technology. Grading devices are expensive which cause budget waste. It also takes more time when using the device at the same time. Therefore, an objective test grading system via Android mobile phone using image processing technology was developed to save cost and time in grading.

Image processing theory was applied to objective test grading in several means including an automatic marking system for multiple choice test on network [1], an image-processing oriented multiple-choice checking system [2] and a flexible and cost-effective multiple-choice exam system [3]. The systems use a scanner to receive images into a computer. Then, image files are processed. Multiple-choice exam program with parallel processing [4] is a system development that enables a grading device to work faster. Additionally, an investigation of the color and density of different multiple-choice answer sheet input factors [5] using image processing techniques is a system development that makes grading faster. In order to develop objective test grading system, the researcher developed an objective test grading system via Android mobile phone to make grading faster, more convenient and to save cost and time in grading.

2 Related Research

2.1 Color Retention in Matrix

It is a part of image processing preparation. A colour pixel positioned in this digital image is a pixel, referring to brightness level of the digital image in a two - dimensional M x N matrix as shown in Fig 1.
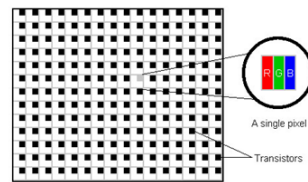

Fig. 1. Thai license plate

2.2 Grayscale

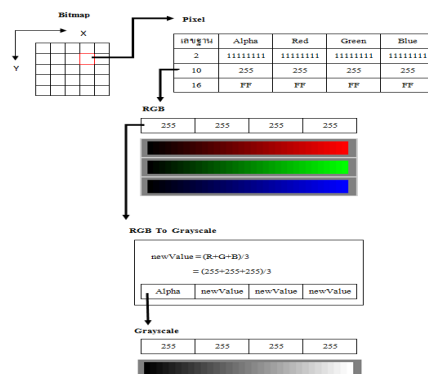Adjusting grayscale before processing an image makes image processing easier. Grayscale adjustment is shown in Fig 2.

Fig. 2. Grayscale adjustment

2.3 Edge Detection

Edge detection identifies edges of an object in the image which is outstanding and important to knowing that object captured by a computer. Edge detection identifies outstanding features of the object. Outstanding feature that people could see is a ridge or an edge of the object. When the light reflects on the object, this part is brighter than other areas. In general, good features of edge are thin (an edge of the image should have only one width), consistent (edges within the same image should be consistent) and a position of a pixel should be accurate. The edge of the accurate image is within an area

where intensity of the pixel is higher. The edges are represented through different numbers. The thick edges of the image (2 points of width) and inconsistent edges of the image are shown in Fig 3.

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0 0 0 1 1 0 0 0 0        0 0 0 1 0 0 0 0 0
0 0 0 1 1 0 0 0 0        0 0 0 1 0 0 0 0 0
0 0 0 1 1 0 0 0 0        0 0 0 0 0 0 0 0 0
0 0 0 1 1 0 0 0 0        0 0 0 1 0 0 0 0 0
0 0 0 1 1 0 0 0 0        0 0 0 0 0 0 0 0 0
0 0 0 1 1 0 0 0 0        0 0 0 1 0 0 0 0 0
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(a) The thick edges (2 points of width)   (b) Inconsistent edges

Fig. 3. Features of edges of the image

2.4 Image Processing Algorithm

Logical reasons and mathematics are applied to choose the next methods or procedures. The final method is to subdivide and sort operational procedures in image processing in order to increase effectiveness, rapidness and accurate results. Mathematical principles used in processing are shown in Fig 4, 5, 6. Symbols representing a distance between P and Q is PQ.
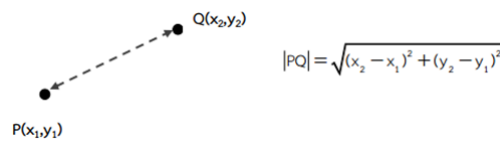
$$|PQ| = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$$

$Q(x_2, y_2)$

$P(x_1, y_1)$

Fig. 4. Identify a distance between 2 points

$Q(x_2, y_2)$

$R(\dfrac{x_1 + x_2}{2}, \dfrac{y_1 + y_2}{2})$

$P(x_1, y_1)$
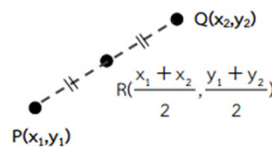
Fig. 5. Identify a center between 2 points

m $Q(x_2, y_2)$

n

$R(\dfrac{mx_1 + nx_2}{m + n}, \dfrac{my_1 + ny_2}{m + n})$

$P(x_1, y_1)$

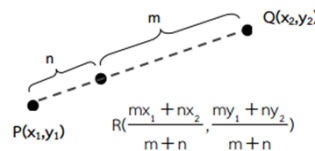**Fig. 6.** Identify a break point of a distance m:n

In addition, perspective transformation is applied. Since images of answer sheets are normally bending, perspective transformation is applied to capture the position desired. A sample is shown in Fig 7.
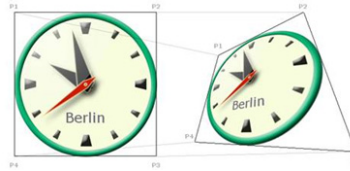
Fig. 7. A sample of perspective transformation

3 System Design

A user uses the system via Android mobile phone, using a camera on the phone to capture an image for processing. The system consists of 2 main parts including an interface and processing. The interface is divided into 4 parts including keeping answer key, checking answers, value clearing and existing the program as shown in Fig 8.
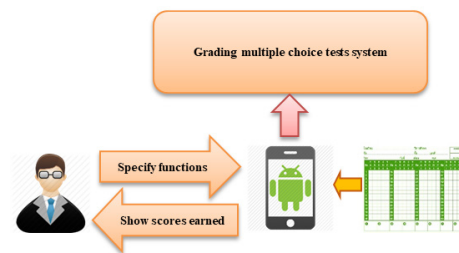

Fig. 8. Overall system

3.1 Image Processing Design

The system processes the image received according to image processing, consisting of 4 main steps including importing input, processing preparation, image processing and result displaying as shown in Fig 9. The program components are shown in Fig 10.
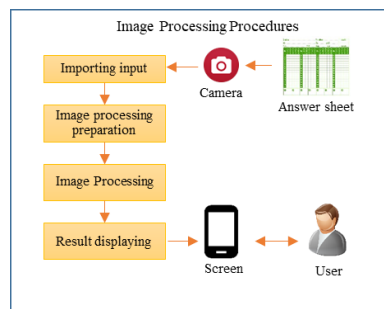

Fig. 9. Image processing design

Fig. 10. Program components

Input is imported via a camera on the phone and transformed into a digital image. The image is stored as digital data and transferred into reading process of digital image pixel.

Processing preparation begins with identifying 4 corners of the answer sheet by capturing the top left coordinate. A 30*30-pixel green square in the application is placed on it as shown in Figure 11. It moves from the top left corner of the green square to the top right corner and to the bottom right corner and the bottom left corner as shown in Figure 12.
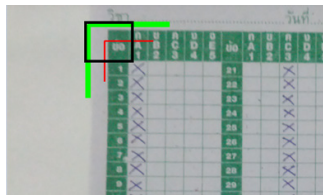

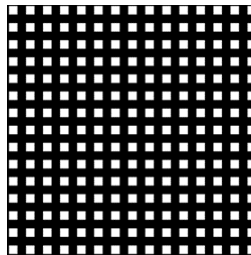**Fig. 11.**Identify the top left corner

Fig. 12. Pixels in processing

After that, the top left coordinates of every pixel of Fig 12. are identified. The system will examine whether each coordinate is the top left position by checking pixels around it, consisting of a set of pixels along the line S[0] S[1] S[2] S[3] and S[4] as shown in Fig 13. The top left coordinate (X1,Y1) needed can be identified by using mathematical principle used to calculate (X1,Y1). That is, percentage difference shown in equation

(1) which A and B represent the sum of intensity of pixel of the two linear lines compared is used.

$$\% \text{ difference of AB} = \left(\frac{\text{Max}(A,B) - \text{Min}(A,B)}{\text{Max}(A,B)} \right) * 100 \tag{1}$$

To identify (X1,Y1), 4 sets of the two linear lines are compared to identify the intensity. The percentage difference should be in the range according to the test as follows.

Percentage difference of (S[0],S[1]) ≤ 5
Percentage difference of (S[0]+S[1], S[2]) ≤ 10
Percentage difference of (S[3],S[4]) ≤ 10
Percentage difference of (S[0]+S[1]+S[2],S[3]+S[4]) ≥ 20
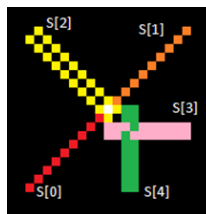

Fig. 13. Identify the top left coordinate

Image processing is algorithm developed for objective test grading after the 4 coordinates are identified including the top left position, the top right position, the bottom left position and the bottom right position. Image processing applies image processing perspective transformation principle. It systematically begins with perspective transformation technique and scanned answer sheet image without bending. Then proportions of image sizes and of image sizes from a phone camera are identified in order to compare with reference image to find the position to be examined. After that, the points of intersection of each choices are picked up from a 2 linear equation in order to identify crossing mark point. The first linear line is a horizontal line separated into the top and the bottom parts that crosses the (Xi,Yi) and (Xr,Yr). The second linear line is a vertical line halving the choice being considered that crosses the (Xu,Yu) and (Xd,Yd). As a result, the point of intersection is at the (Xx,Yy) as shown in Fig 14. Finally, the point of intersection is framed for grading as shown in Fig 15.
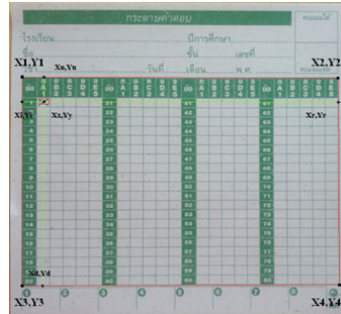
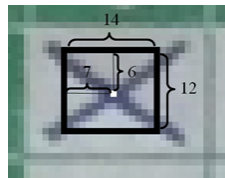**Fig. 14.** Positions on answer sheet in processing

Fig. 15. Framing the point of intersection for grading

The choice values to be considered are kept and the coordinates of cross marks are identified as shown in Figure 16.
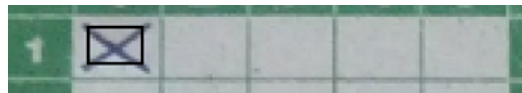

Fig. 16. Procedures of keeping the choice values in an answer sheet.

Fig 15 shows procedures of keeping the choice values in an answer sheet. The choice values are framed and calculated according to the following procedures.

The calculation formula for keeping the CV (Choice Value) in an answer sheet in equation (2) is:

$$CV = \left(\frac{MAX_{AVG} - MIN_{AVG}}{MIN_{AVG}} \right) * 100 \tag{2}$$

MAXAVG is an average of pixel intensity which is higher than an average of overall pixel intensity within the square. MINAVG is an average of pixel intensity which is lower than an average of overall pixel intensity within the square compared with CV of each choice. The answer is the choice with the highest CV, when examining other items that have no cross marks or that have more than 1 cross mark which will score 0.

Score result is displayed on a mobile phone screen.

4 Experimental Results

The accuracy tests for the objective test grading system via Android mobile phone were carried out via 2 means.

4.1 Examining for no cross marks.

Fig. 17. Examine for cross marks.

4.2 Examining for a single-cross mark in one item.

Fig. 18. Examine for a single-cross mark in one item.

4.3 Summary of Results

Table 1.

Items examined	800 items Correct items	Percentage of accuracy
No cross marks	790	98.75
Single-cross mark in one item	760	95.0
Mean	1550/1600	96.875

Of 1600 items, the system yielded 1550 correct items on 1550 items or 96.875 percent. According to the result, examining answer sheets without any cross marks yielded more accurate results than examining answer sheets with more than one cross mark in one item.

5 Conclusion

The Grading multiple choice tests system via Android mobile phone was developed for actual use in objective test grading, using image processing developed from library of Java. Of 1600 items, the system yielded 1550 correct items or 96.875 percent.

The Grading multiple choice tests system via Android mobile phone is effective and accurate. It is convenient for users, saves time in grading and saves cost of objective test grading devices. However, the developed algorithm can be used with one answer sheet format only.

6 References

[1] Eason, G., Noble, B., and Sneddon, I. N. (1955). On certain integrals of Lipschitz-Hankel type involving products of Bessel functions. Phil. Trans. R. Soc. Lond. A, 247(935), 529-551. https://doi.org/10.1098/rsta.1955.0005

[2] Boonsook, W.(2006). Automatic Marking System for Multiple Choice Test on Network. Ubon Ratchathani University, 2006

[3] Chinnasarn, K., and Rangsanseri, Y(1998). Image-Processing Oriented Multiple Choice Checking System. The 36th Kasetsart University Annual Conference 3-5 Feb. 1998, Page 218.

[4] Laopracha,N., Chamchong, R., and Pattanapong, C.(2013). Flexible and Cost-Effective Multiple Choice Exam System. KKU Engineering Journal. 40, Vol. 2. 2013, Page 221-227.

[5] Ketcham, M., Ganokratanaa, T.,and Srinhichaarnun, S. (2014, May). The intruder detection system for rapid transit using CCTV surveillance based on histogram shapes. In Computer Science and Software Engineering (JCSSE), 2014 11th International Joint Conference on (pp. 1-6). IEEE.

[6] Thitapa, P.,and Mahasak, K. (2012, December). A lane detection for the driving system based on the histogram shapes. In International Conference on Systems and Electronic Engineering (ICSEE'2012) (pp. 43-47).

[7] Ketcham, M., Yimyam, W.,and Chumuang, N. (2016). Segmentation of Overlapping Isan Dhamma Character on Palm Leaf Manuscript's with Neural Network. In Recent Advances in Information and Communication Technology 2016 (pp. 55-65). Springer, Cham.

[8] Yimyam, W.,and Ketcham, M. (2017, March). The automated parking fee calculation using license plate recognition system. In Digital Arts, Media and Technology (ICDAMT), International Conference on (pp. 325-329). IEEE.

[9] Phatchuay, S., and Yimyam, W. (2016, November). The System Vehicle of Application Detector for Categorize Type. In Signal-Image Technology & Internet-Based Systems (SITIS), 2016 12th International Conference on (pp. 683-687). IEEE.

[10] Yimyam, W., and Ketcham, M. (2016, August). The Electroencephalography Signals Using Artificial Neural Network for Monitoring Fatigue System. In Pacific Rim International Conference on Artificial Intelligence (pp. 160-169). Springer, Cham.

[11] Pinthong, T., and Ketcham, M. (2017, March). Screening of Rice Berry Rice specification with Image Processing methods. In Digital Arts, Media and Technology (ICDAMT), International Conference on (pp. 126-131). IEEE.

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