ICIC Express Letters
Part B: Applications
Volume **7**, Number **8**, August **2016**

 ISSN 2185-2766
pp. **1719–1725**

AUTOMATIC RESPONSE ANALYZER IN CLASSROOM USING IMAGE PROCESSING AND CARDS

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Received February 2016; accepted May 2016

Abstract. *To accelerate communication between a teacher and many students in classroom, we have proposed the system that can count students' raising the color cards processing images input with a web camera. Moreover, to improve recognition accuracy of the system, we have proposed the improved image processing system using the new color cards and two web cameras. We have used the system with three kinds of color cards in the classroom; therefore, three kinds of answers can be chosen using the system. We have tried to construct the system with four or five kinds of color cards, but the recognition accuracy was not enough. In this paper, we propose the new system with new five kinds of color cards. Moreover, we propose the new system with three web cameras. We verified card recognition accuracy by experiment in the classroom.*
Keywords: Response analyzer, Color cards, Web cameras, Image processing

1. **Introduction.** A teacher usually lectures many students in a classroom. To accelerate communication between a teacher and many students in a classroom, the conventional automatic response analyzers using the electronic wired or wireless terminals have been developed as the commercial products [1-4]. However, they are not popular, because they request large initial cost, labored preparation and maintenance. Special compact terminals used in [1,2] must be managed carefully not to be lost or stolen. In case of commercial product [3], as all students must use cell phones or smartphones, we must prepare the lacking cell phones or the smartphones. Students' PC terminals used in [4] are not compact, and require IT classroom with PC terminals. Furthermore, the conventional automatic response analyzers may result in sparse communication between a teacher and students, because the conventional system does not require face-to-face communications. A manual method [5] was proposed that teachers count manually the color cards which students raised up, but it is time consuming to count the raising color cards. Based on the method [5], we have proposed the system [6-9] that can count automatically the students' raising color cards by processing the images input with the web camera. We show the concept of the system in Figure 1. At first, using simple three kinds of color cards [5], we proposed the previous system [6] that can recognize quantitatively students' understanding counting students' raising cards by processing image input by a web camera. To improve recognition accuracy of the system [6], we have proposed the previous improved image processing system [7-9] using the new color cards and two web cameras. The recognition accuracy of the previous system [6] was not sufficient because of two problems. First problem is to identify color cards correctly. Second problem is to capture color cards scattered widely in classroom. To solve these two problems, we propose the improved previous system [7] using new color cards with square frames, color calibration technology and two web cameras. We verified the recognition rate better than previous system [6] by

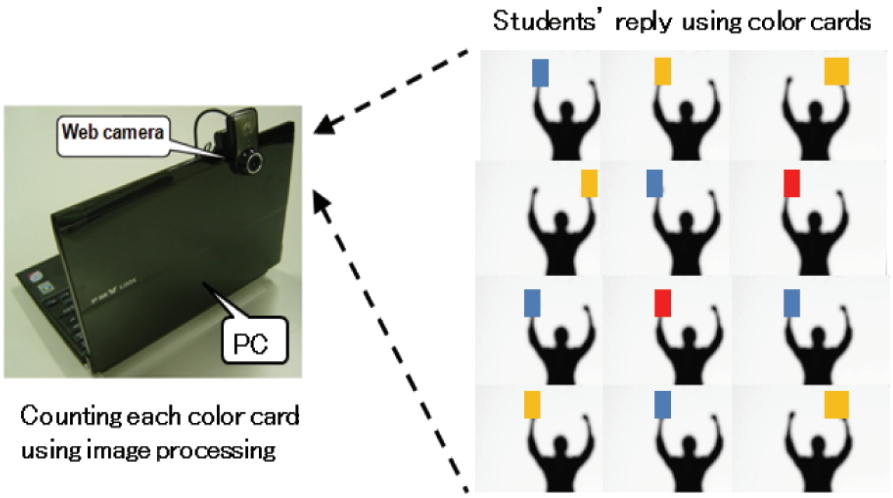

FIGURE 1. The concept of the system

experiment. We propose the more improved system [8], and report feasibility experimental results in classroom up to 100 students. To achieve higher card recognition accuracy, we have improved the image binarization process using local threshold, and the discrimination method using maximum likelihood procedure. We have also developed the tripod with two web cameras, to capture a classroom broadly. We have applied the system to lectures in classrooms, and we have verified an effect accelerating communication between a teacher and many students. In these systems [6-8], three color cards are used, and only three answers can be chosen. Therefore, we propose the two systems with more choices than three [9]. In the first system, four or five color cards would be used for four or five answer selection. In the second system, an asymmetry color pattern in a card would be used, and the rotating angle of a card would be used as an indicator of the answer. We used rectangular triangle color pattern in a card as the asymmetry color pattern in a card. We also report card recognition experimental results in the classroom.

In this paper, the previous system [9] and its problem are described in Section 2, and the improved system is proposed with experimental verification in Section 3, and we conclude in Section 4.

2. **The Previous System and Its Problem.** The process of the system consists of image acquisition and image processing. We show the image input device [8,9] in Figure 2. We have mounted two web cameras on the tripod, developing the connecting clasp. Since the two web cameras on the tripod are adjacent and high, there is no un-captured area in front of area between two web cameras, and rear students' cards can be captured by the web cameras. We show A5-size cards [9] in Figure 3. The color cards are made of two irreflexive papers that are fluorescent colored paper and black paper.

We have used the system with three kinds of color cards in the classroom; therefore, three kinds of answers can be chosen using the system. In the conversation, 'Yes' or 'No' questions are asked most frequently. 'A', 'B' or 'C' questions are secondary frequent pattern of questions. However, if the number of answer alternatives is two or three in the examination question, the correct answer may be selected with high probability of 50% or 33% by chance, without understanding questions and answers.

We have tried to construct the system [9] with four or five kinds of color cards, but the recognition accuracy for card standing on the desks in the classroom was not enough, as shown in Table 1. We show the specification of the classroom used for the experiment in Table 2. We experimented the system using the representative large classroom with 240

FIGURE 2. The image input device using two cameras

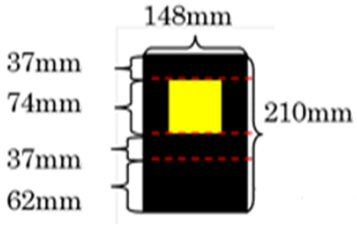

FIGURE 3. The color card's layout

TABLE 1. The color hue constraints and their recognition results for cards on the desks

Color name	Hue constraint (0∼359)	Putting out ceiling lights at front row	Putting out ceiling lights at front row and second row
Yellow Orange[1]	20∼60	100%	99%
Green[2]	100∼180	59%	47%
Blue[1]	190∼230	100%	89%
Peony[1]	310∼344	100%	72%
Red[3]	346∼18	100%	99%

[1]Illumi-colors #80 (fluorescent colored papers), Ehime Shiko Co. Ltd., Japan
[2](No fluorescent colored papers), Daio Paper Corporation, Japan
[3] Illumi IJ #80 (fluorescent colored papers), Ehime Shiko Co. Ltd., Japan

TABLE 2. The classroom specification

Width (m)	Depth (m)	Number of desks in width direction	Number of desks in depth direction	Number of seats in a desk
14.5	20.7	5	16	3

seats shown in Table 2, because almost classrooms are smaller than the classroom. If we succeeded in the experiment, we will be able to use the system in many classrooms.

3. **The Improved System.** We have improved the system, solving the previous system's problems. We selected new five kinds of color cards as shown in Figure 4, by adding new kinds of color cards with higher saturation and higher brightness. The recognition accuracy for card standing on the desks was higher, as shown in Table 3 and Figure 5.

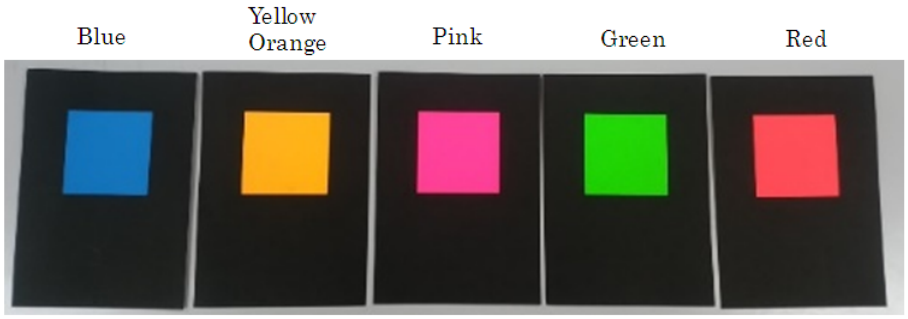

FIGURE 4. The color cards

TABLE 3. The color hue constraints and their recognition results for cards on the desks

Color name	Hue constraint (0∼359)	Putting out ceiling lights at front row	Putting out ceiling lights at front row and second row
Yellow Orange[1]	20∼60	100%	100%
Green[4]	80∼180	100%	100%
Blue[1]	190∼230	100%	88%
Pink[4]	310∼350	100%	99%
Red[4]	352∼18	100%	100%

[4](Fluorescent colored papers), Sasagawa Co. Ltd., Japan

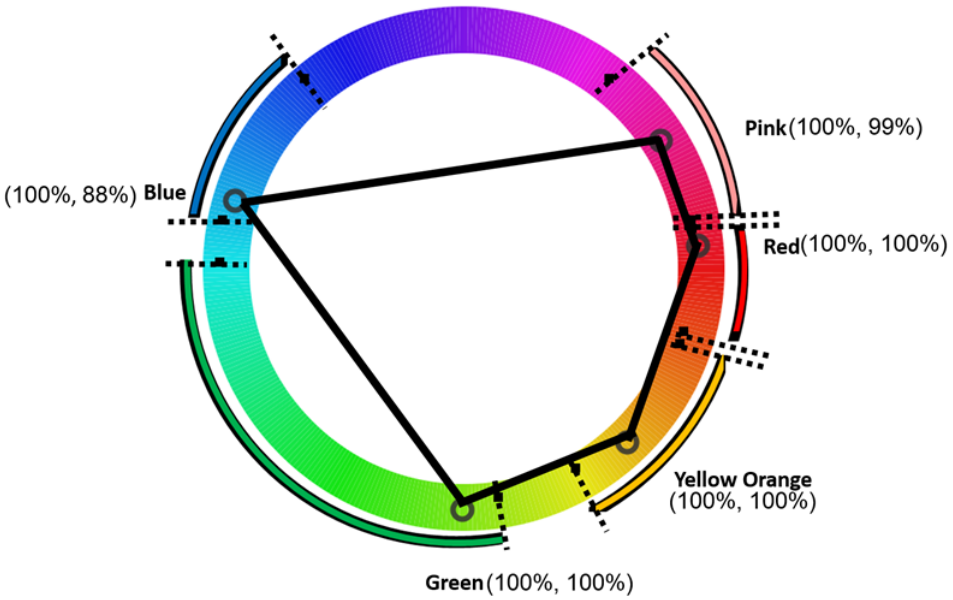

FIGURE 5. The five colors and the color cards recognition rate

We used the system in the classroom that counts students' raised up cards. The ceiling lights are put out at front row and second row. The recognition rate is shown in Table 4. The recognition rate in back area of classroom is low. We show an experimental result image in the classroom in Figure 6. Each card image in back area of classroom is very small.

To improve the recognition accuracy, we developed the image input device using three cameras as shown in Figure 7 adding third camera. We show the classroom three areas

TABLE 4. Colors cards recognition results using two web cameras

Color name	All area of the classroom	Front area of the classroom	Back area of the classroom
Yellow Orange[1]	83.8%	93.5%	67.4%
Green[4]	82.1%	100.0%	65.0%
Blue[1]	83.2%	85.5%	81.8%
Pink[4]	79.6%	94.3%	52.6%
Red[4]	74.5%	83.6%	57.8%
Total	80.7%	89.3%	67.6%

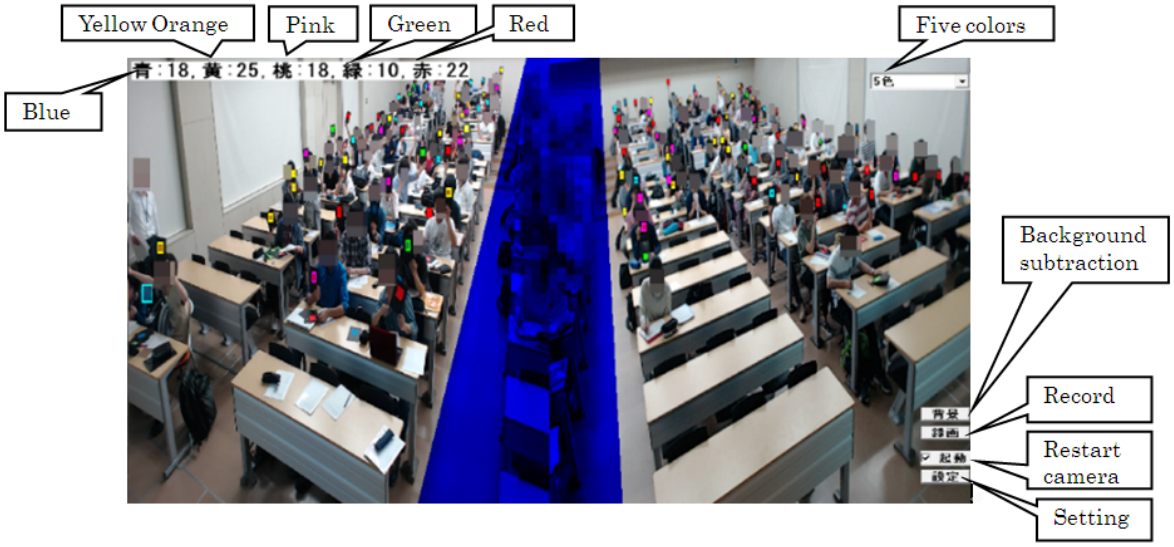

FIGURE 6. An experimental result image in the classroom

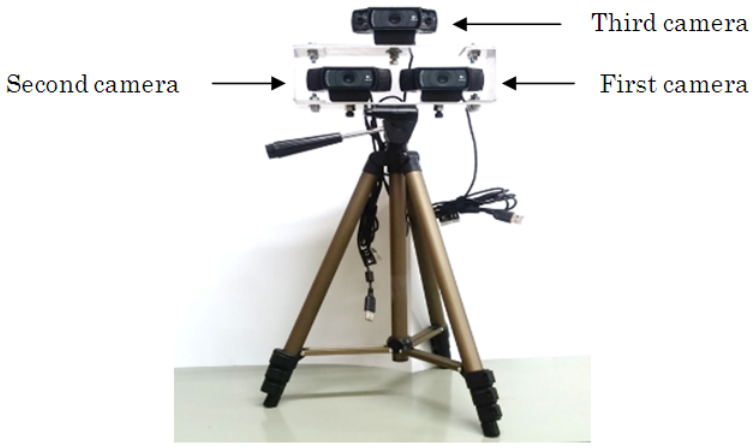

FIGURE 7. The image input device using three cameras

recognized by three cameras in Figure 8. First camera captures left side in front area of the classroom. Second camera captures right side in front area of the classroom. The setting parameters of first camera and second camera are the same as the setting parameters of the image input device using two cameras shown in Figure 2. Third camera captures back area of classroom as the image with higher-definition compared with the images captured by former image input device using two cameras.

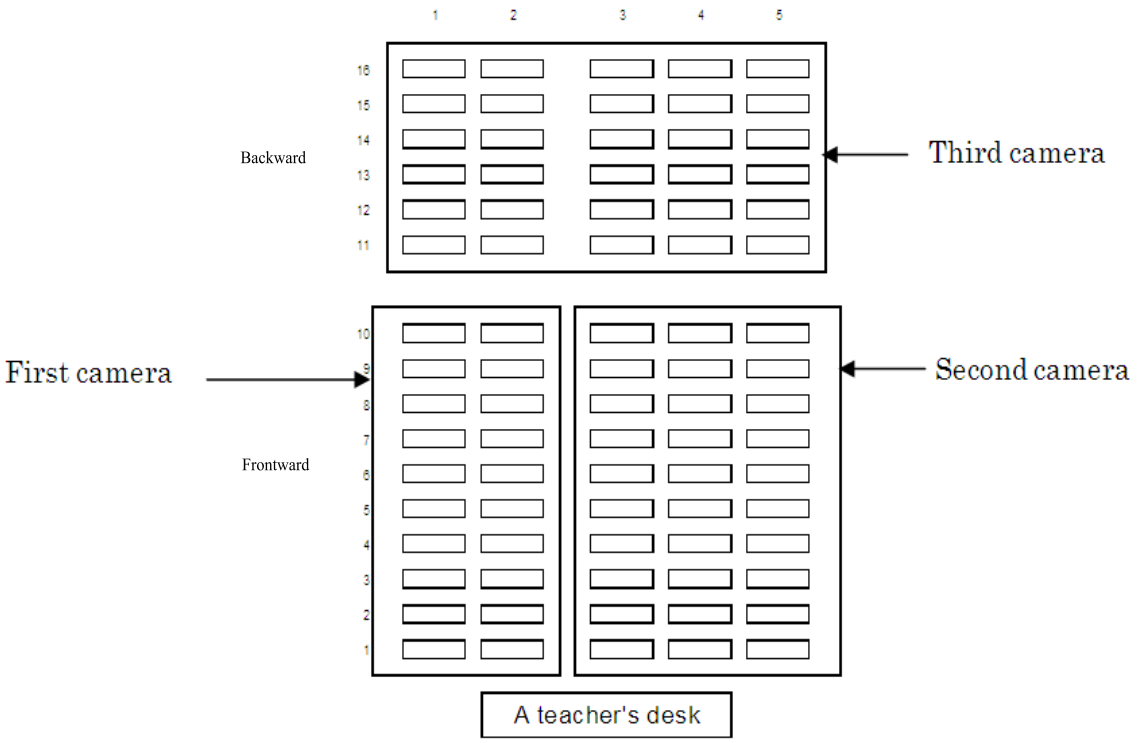

FIGURE 8. The classroom three areas recognized by three cameras

FIGURE 9. An experimental result of the image captured by third camera

The image shown in Figure 9 that was captured by third camera is higher-definition compared with the image in Figure 6 that was captured by former image input device using two cameras. An experimental result of the image captured by third camera is shown in Figure 9. The area with white frame in Figure 9 is the recognized area by third camera in Figure 8. Many cards became to be recognized in the area compared with the image in Figure 6.

TABLE 5. Colors cards recognition results using three web cameras

Color name	All area of the classroom	Front area of the classroom	Back area of the classroom
Yellow Orange[1]	96.2%	93.5%	100.0%
Green[4]	100.0%	100.0%	100.0%
Blue[1]	90.1%	85.5%	96.4%
Pink[4]	96.3%	94.3%	100.0%
Red[4]	85.8%	83.6%	88.9%
Total	92.2%	89.3%	96.2%

Colors cards recognition results using three web cameras are shown in Table 5. The recognition accuracy is 96.2% in back area of the classroom that has been improved from 67.6% in Table 4. The recognition accuracy is 92.2% in all area of the classroom that has been improved from 80.7% in Table 4.

We successfully selected new five kinds of color cards as shown in Table 3. We used the system in the classroom that counts students' raised up cards. The recognition rate is 80.7%, as shown in Table 4. We improved the recognition rate to 92.2% as shown in Table 5, by adding third camera that captures back area of classroom as high-definition image.

4. **Conclusions.** We have improved the response analyzer in classroom using the new color cards, the new image input device, and the new image processing. We have proposed the system with five choices, and we have proposed the system with three cameras. We have reported card recognition experimental results in the representative large classroom. However, there are a variety of environments of classrooms, for example lighting, and the shapes of rooms. Therefore, the verifications of the system in a variety of classrooms are future works.

Acknowledgment. This work was supported by JSPS KAKENHI Grant Number 15K01 041.

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