ICIC Express Letters
Part B: Applications
Volume **9**, Number **5**, May **2018**

ICIC International ©2018 ISSN 2185-2766
pp. 389–397

IDENTIFYING STUDENTS AND ACCURACY IMPROVEMENT ON AUTOMATIC RESPONSE ANALYZER

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Received October 2017; accepted January 2018

Abstract. *In order to grasp the degree of comprehension of lecture contents, teachers are asked to ask questions by raising hands. However, few students raise their hands positively. As another method, attempts have been made to use a terminal capable of operating with an electrical network and a button. However, this requires an investment to network the entire classroom. In order to solve the conventional problems, the authors propose a two-way class system in which color cards are distributed to students. This system is an inexpensive and simple system. In the previous study, we proposed a scheme using five color cards and three web cameras. In this research, we performed color analysis to make the discrimination of 5 color cards highly accurate. Furthermore, we tried to realize the function to identify the student by the listed color card, and realized the recognition system with three web cameras.*
Keywords: Response analyzer, Color cards, Web cameras, Image processing

1. **Introduction.** In the large classroom, one teacher needs to progress the lesson systematically for many students. In addition, it is necessary to grasp the degree of comprehension of the lesson for all students. For example, the most common way to grasp the status of many students is to ask questions or comments by raising hands. However, there are few students who raise hands and actively speak in the large classrooms. There is a need for a way to grasp the state of each student.

The dedicated miniature terminals [1-3], the dedicated digital pens [4], the student's mobile phones [5], the student PC terminals [6,7] are used as IT terminals for students' answers to questions of teachers. Although dedicated miniature terminals and dedicated digital pens have the advantage of not restricting the work space of students, management costs arise due to the risk of loss. For students' mobile phones, it is necessary for the students to pay communication packet cost. In a system using a PC terminal for students, it is necessary to make an investment to convert the whole classroom into IT. Also, there was an attempt that grasps the status of many students by using qCards: a sheet of paper that contains a printed code, similar to a QR code, encoding their student IDs in the past [8]. However, qCards are big. So it is inconvenient to carry and we cannot do it easily.

Therefore, we developed a simple system consisting of a PC and two web cameras [9,10]. It is based on the method [11] of distributing multiple colored cards to students and letting the teacher question the color card corresponding to the answer. The PC automatically compiles the card corresponding to the answer that the student cited. Figure 1 shows the configuration of the system.

Content of image processing is divided into five stages. First stage is that we change the input image into the grayscale image. Second stage is that we change it into the binarized image. Third stage is that we extract the area of the color portion from the binarized

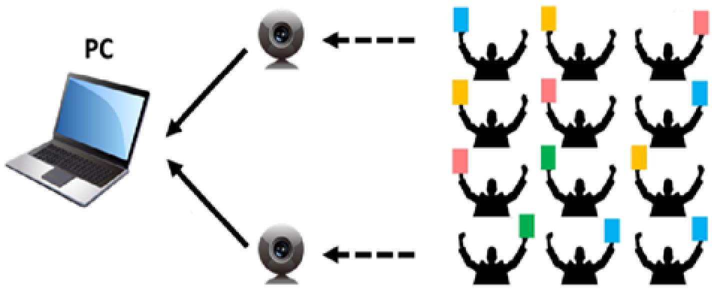


FIGURE 1. The concept of the system

image. Fourth stage is that we perform rectangle determination from the extracted area. Final stage is that we perform color determination after the rectangle determination.

According to this system, compared to the conventional system, there is an advantage that the introduction cost is low, the maintenance is easy, and the usage method is simple. Also, from answering by raising hands, those who answered with cards have the advantage of increasing the range of responses depending on the type of color.

Therefore, using the interactive lesson system of this system, students themselves should actively tackle lessons. By doing this, it is possible to communicate between teachers and students, and bidirectional lessons will be realized.

The previous system and its problem are described in Section 2, the improved system in Section 3, consideration in Section 4, and we conclude in Section 5.

2. **The Previous System and Its Problem.** The process of the system consists of image acquisition and image processing. We have mounted two web cameras on the tripod, and developed 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. And ask students to rise color cards against questions from teachers. We show A5-size cards in Figure 2. The color cards are made of two irreflexive papers that are fluorescent colored paper and black paper.

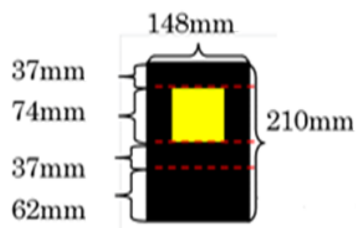


FIGURE 2. The color card's layout

2.1. **Recognition experiment of 5 color card.** In the previous study [9,10], cards were classified into five colors (Yellow Orange, Green, Blue, Peach, Red) from four colors (Yellow Orange, Green, Blue, Peach) as a result of the recognition test of the red card conducted in our classroom (width: 14.7 m, depth: 20.7 m). In addition, recognition experiments using five color cards in actual classes were carried out in two cases which consist of a case using two web cameras and other case using three web cameras. Regarding the lighting conditions, it was carried out under the condition that the lighting on the side of the teaching pendant and the front side was turned off (dark lighting condition). The light on the teaching side was turned off (bright lighting condition). In Figure 3, five hue ranges are drawn on the hue circle and Table 1 shows the recognition rate of each card.

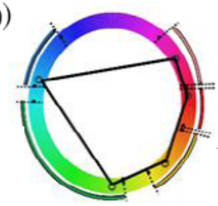


Figure 3. The hue range in the previous study

Table 1. The card recognition rate in the previous study

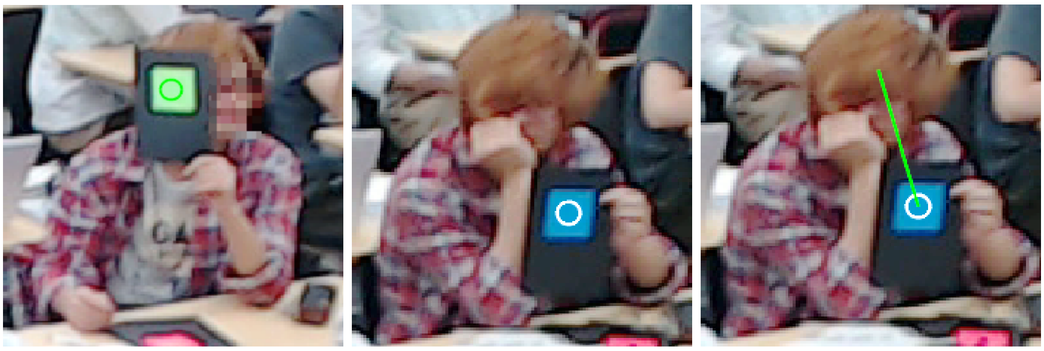
Color name	Two cameras (dark lighting condition)	Two cameras (bright lighting condition)	Three cameras (dark lighting condition)	Three cameras (bright lighting condition)
Yellow Orange	83.8%	95.2%	96.2%	98.8%
Green	82.1%	100.0%	100.0%	100.0%
Blue	83.2%	98.8%	90.1%	98.8%
Pink	79.6%	97.4%	96.3%	100.0%
Red	74.5%	50.0%	96.3%	50.0%
Total	81.3%	96.8%	93.4%	98.1%

From the results in Table 1, the card recognition rate was higher when three web cameras were used. However, the hue range in the color judgment part of the card recognition was determined by the experience of the system user. Also, it was not a system that could use three web cameras at the same time. However, two and one were connected to different PCs, respectively, and the system was operated with a total of three web cameras. From the above, the first problem is that the hue range of card recognition is not shown quantitatively. The second problem is that we cannot use three web cameras simultaneously on this system.

2.2. **Proposal of student's specific algorithm.** In the previous study [12], we used this system and proposed a specific algorithm for students to learn the tendency of individual students' answers. We tried to identify individual students by saving the data in csv file for each card. The contents to be saved are the color information and position data of the cards mentioned by individual students, the date and time. The position data is the center coordinate of the color part of the card. Through the use of these data, we validated the specific algorithms of three student individuals.

At first, a reference image was prepared, and we compare the distance between the center coordinates of the card in the reference image and the center coordinates of the card in the input image. The most least distance is recognized as the same students. Figure 4(a) shows the reference image, Figure 4(b) shows the input image, and Figure 4(c) shows the comparison result of the reference cards image and the input cards image. However, this method recognized the cards listed by students of some front rows as cards listed by students in the back row. Also, because there are students who do not list cards, there are students who sometimes do not mention cards, so there was a problem that one student would result in multiple cards.

Secondly, the recognition of the students in the front row and the back row was identified by comparing the maximum length of the diagonal of the card. However, this method has a problem that the maximum length of the diagonal changes greatly depending on the angle at which the card is raised.



(a) Reference card image (b) Input card image (c) Comparison result

FIGURE 4. Recognizing that the shortest card in two images is the same

Thirdly, we extract areas in the range where students can point cards in reference images and identify students by comparing with input images. However, in some cases, students may raise the card beyond the area in the input image, which is not effective.

From the above, the third problem is to make a prospect of a student specific algorithm.

3. The Improved System.

3.1. Hue extraction of color cards in color discrimination. In order to solve the first problem of the 5 color card recognition experiment, the hue value of the card on the image was extracted. We used the "color threshold of image processing and computer vision" application of MATLAB in the programming development environment. This application can acquire the upper limit value and lower limit value of hue, saturation, and lightness from the selected range on the image. Table 2 shows the hue range of each card extracted from the recognition results of three web cameras in the previous research (5 color card recognition experiment [9,10]) and the hue range of color determination. Also, there were no unrecognized cards on the green card.

From the results in Table 2, the hue range extracted from recognized color cards is similar to the range of the previous study [9,10]. However, the unrecognized yellow orange hue range expanded significantly. We thought that this result is caused by the classroom lighting. In particular, we thought that the cards raised by the students are influenced by the classroom lighting and appear white. Figures 5(a) and 5(b) show yellow orange cards which appear to be white due to illumination of the classroom.

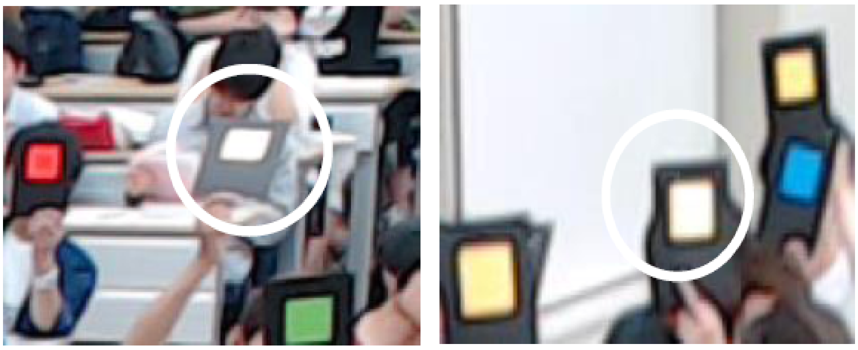
Data on yellow orange cards affected by lighting in Figure 5 shall be eliminated. Also, we merge the hue ranges of recognized cards and unrecognized cards. This makes it possible to clarify the hue range of each card. Table 3 shows hue ranges of recognition and unrecognized of each card.

From the results in Table 3, the hue range of the cards recognized as yellow orange, blue, peach encompassed the hue range of unrecognized cards. However, it is different

TABLE 2. Hue range of each extracted card

Hue: 0 ∼ 359

Card name	Recognized	Unrecognized	Threshold for color judgment
Illumina color #80 yellow orange	14 ∼ 60	0 ∼ 150	20 ∼ 60
Sasagawa green	98 ∼ 154	–	80 ∼ 180
Illumina color #80 blue	185 ∼ 218	193 ∼ 216	190 ∼ 230
Sasagawa peach	327 ∼ 353	339 ∼ 353	310 ∼ 350
Sasagawa red	346 ∼ 21	331 ∼ 19	352 ∼ 18



(a) Example 1 (b) Example 2

Figure 5. Yellow orange cards that look white with classroom lighting

Table 3. Hue range of each card extracted and unrecognized

Hue: 0 ∼ 359

Card name	Hue range of color card	Threshold
Illumina color #80 yellow orange	14 ∼ 60	20 ∼ 60
Sasagawa green	98 ∼ 154	80 ∼ 180
Illumina color #80 blue	185 ∼ 218	190 ∼ 230
Sasagawa peach	327 ∼ 353	310 ∼ 350
Sasagawa red	331 ∼ 21	352 ∼ 18

Table 4. Student ID response rate

	Correspondence rate	Number of sheets
Correspondence	66.7%	36/54
Miscorrespondence	33.3%	18/54

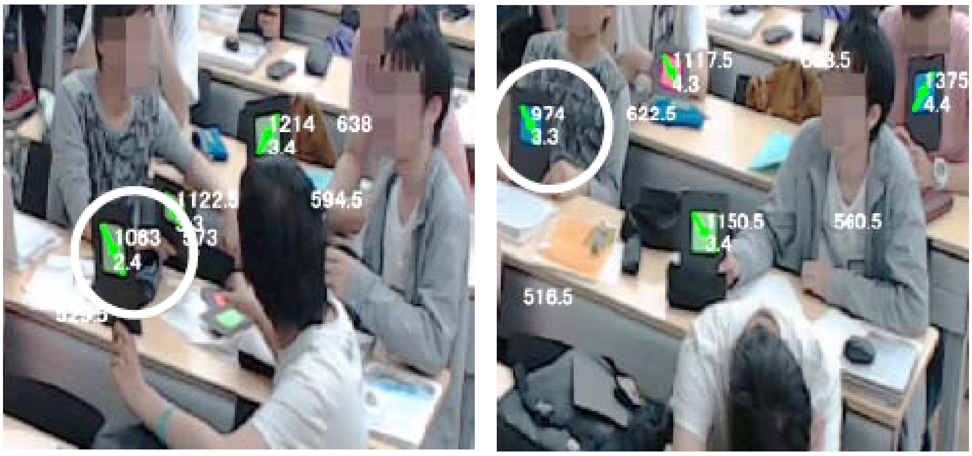
Table 5. Cause of miscorrespondence of rows/columns in miscorresponding ID

Miscorrespondence \ Cause	Card location	Compact cards
Either row or column	44.4% (8/18)	33.3% (6/18)
Both row and column	22.2% (4/18)	–
Total	66.7% (12/18)	33.3% (6/18)

from the hue range applied in this system. Therefore, it became clear that extraction of the hue range alone does not lead to a factor that determines the hue range to be applied to the present system.

3.2. **Identifying students.** In order to solve the third problem of the student specific algorithm, we prepared reference images and input images at the beginning. Next, we recognized students who are closer in distance between two points as the same student. First point is the center coordinates of the cards in the image. Also, second point is the center coordinates in the stored image. We clarify the reason why the students in the front row and the back row become misunderstanding. Also, IDs for each seat are pre-allocated to students who raised cards so that the results can be shown quantitatively. Table 4 shows the student's ID correspondence result at the shortest distance of the card between the two images. From Table 4, we visually check the cause of false correspondence. Table 5 shows the cause. Also, we divide it into two cases, the first case that one of rows and columns was miscorresponding, and the second case that both rows and columns were miscorresponding.

From Table 5, the cause of the misleading ID was caused by a position such as that students in the front row got high cards and the distance to the back row student's card got closer. Figure 6(a) and Figure 6(b) show the state of the student whose ID was misunderstood depending on the position of the card. In addition, Figure 7 shows the cards which are the cause of miscorrespondence of rows and columns among the misleading correspondence IDs are dense.



(a) Image for reference (b) Input image

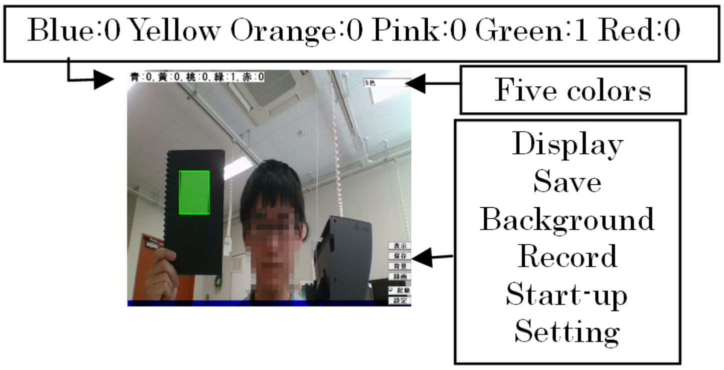
FIGURE 6. A student whose ID was misunderstood depending on the position of the card

FIGURE 7. The state that the cards are dense

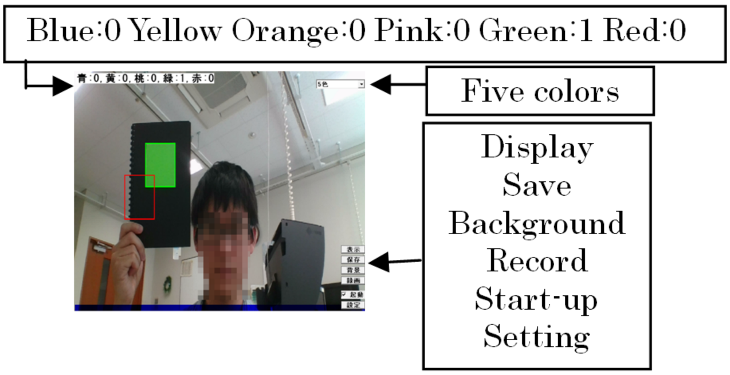
From these results, the problem caused by the position of the student's card is caused by the fact that the position of the student's card is not fixed. And it is necessary to have the students raised at the same positions as much as possible. Therefore, we thought that it is possible to solve by saving the position where the card is mentioned, visualizing the saved position on the screen, and having it raised at that position. Figure 8(a) shows an image for saving the card raising position and an image visualized on the card stored in Figure 8(b).

From Table 6, the correspondence rate increased significantly. Also, the cause of the misleading ID was caused by a position as before.

3.3. **Connecting three web cameras.** In order to solve the second problem of three web cameras, we split the window displayed by two and one. Figure 9 shows an image



(a) Image to be saved



(b) Visualized image

FIGURE 8. Save and display the position of the card.

TABLE 6. Student ID response rate

	Correspondence rate	Number of sheets
Correspondence	89.3%	50/56
Miscorrespondence	10.7%	6/56

FIGURE 9. The image input device using three cameras

using three web cameras. Figure 10 shows the classroom layout. Two units capture the front of the classroom, and one unit shows a range to capture the back of the classroom. In addition, Figure 11 shows the recognition screen when using three web cameras.

4. **Consideration.** In the extraction of color information, we could expand the recognized yellow orange hue range and clarify the hue range of each card. However, the hue

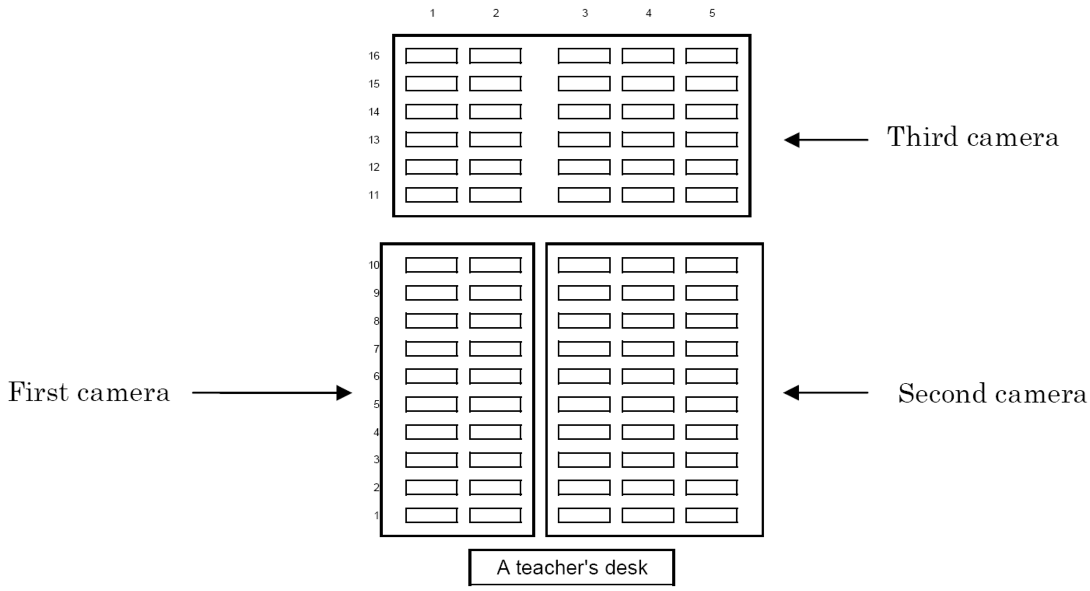


FIGURE 10. The classroom three areas recognized by three cameras

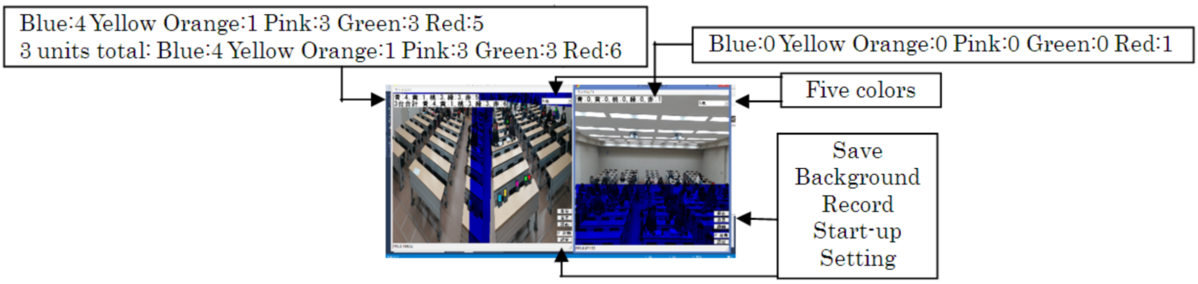
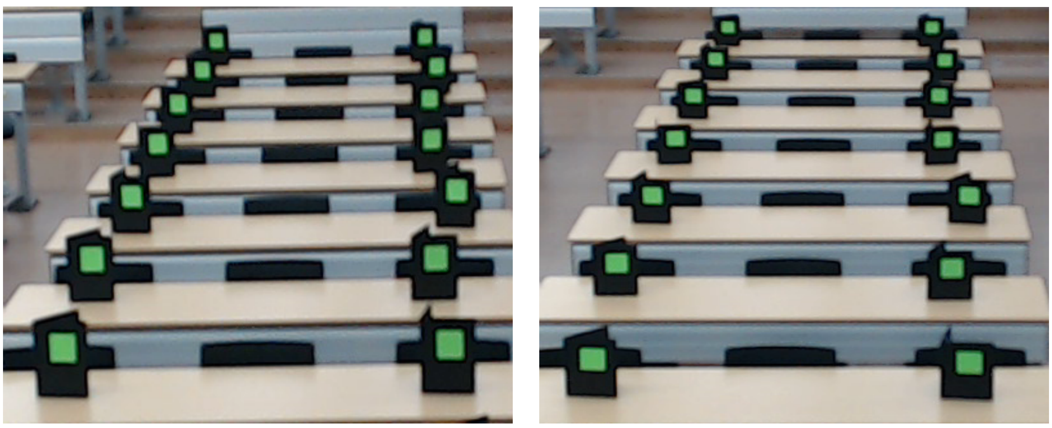


FIGURE 11. An experimental result image in the classroom



(a) The current capturing position (b) A position 2 meters from the floor

FIGURE 12. Dense degree of card depending on capturing position

range of this system could not be determined from the hue range of the extracted card. As a countermeasure in the future, it is thought that it is necessary to extract the closest hue from not only the lower limit value and the upper limit value of color but also from the distribution diagram of color information. Also, we could increase the correspondence rate greatly. The problem that arises due to the dense cards is thought to be solved by photographing the back of the classroom with the third web camera. Moreover, we think that it can be solved by increasing the place to capture. Figure 12(a) shows an image from the current capturing position (1 meters 35 centimeters from the floor). Figure 12(b) shows an image captured from a position 2 meters from the floor.

5. **Conclusion.** In this research, we improved this system to be able to connect three web cameras. As a result, unrecognized cards behind the classroom are reduced, and smoother lesson management can be expected. In student identification, about 90% corresponded as the ID coincidence rate, and clarified the cause of false correspondence. In the future, we plan to identify student's answers with images of classrooms photographed with three web cameras, and increase the number of samples, study and analyze.

Acknowledgment. This work was supported by JSPS KAKENHI Grant Number 15K0 1041.

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