Study on Evaluation of Constructed Block Model based on Deep Learning for ConPlay System

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Abstract

Programming education is a required subject in elementary school from 2020 in Japan, and the teachers in elementary school must teach logical thinking in programming education. This study developed the "ConPlay" that allowed for improving and training programming thinking using constructing playing of blocks. In the "ConPlay", a pupil thinks of a construction plan according to the rules of our system, a struct of blocks. Then, our system evaluates the structured blocks and processes and provides a score to a student. Finally, the student reviews the score result, thinks about why it was this score, and works on the task again. This study focuses on block recognition using image processing.

Keywords: Deep Learning, Conplay System, Computational Thinking

Introduction

The difference from previous reports is that it requires no prior knowledge and can be used in independently by elementary school students. In conventional research, subjects receive instructions from the researcher or teacher regarding what to do in each step of the process, and then act on the instructions. Therebefore, the subjects are left to think passively.

On the other hand, in this research, three cases are set, but without clear instructions, subjects must think independently in order to accomplish the tasks. Subjects will be more likely to improve their logical thinking skills through independent thinking.

In this study, we develop programming teaching materials that utilize blocks and focus on the process of assembling them. This teaching material is evaluated by capturing the assembly scene with a camera. We aim to

develop teaching materials that enable the improvement of spontaneous thinking ability by providing feedback afterwards.

So far, the relationship between logical thinking ability and programming thinking ability (Takahashi et al. 2019) and the use of blocks to improve programming thinking ability have been investigated, such as (Inatomi et al.2021), which shows that it can be done. Based on those evidence, we clarified that blocks can be used to improve children's logical thinking ability. In this research, we have created a system for improving logical thinking skills based on the following conditions (Ooi et al. 2022).

1. Construct the same shape (40points)
2. Construct adjacent colors so that they do not overlap (40points)
3. Construct with fewer colors (20points)

The color and shape of the blocks assembled by the subject are identified using the machine learning model YOLO v4 (Alexey et al.) according to the three cases described above and substituted into the formula for calculating the data conditions. As Figure 1 shows the total score is then obtained and provide to the user, reflecting the correct way of assembly where mistake was made.

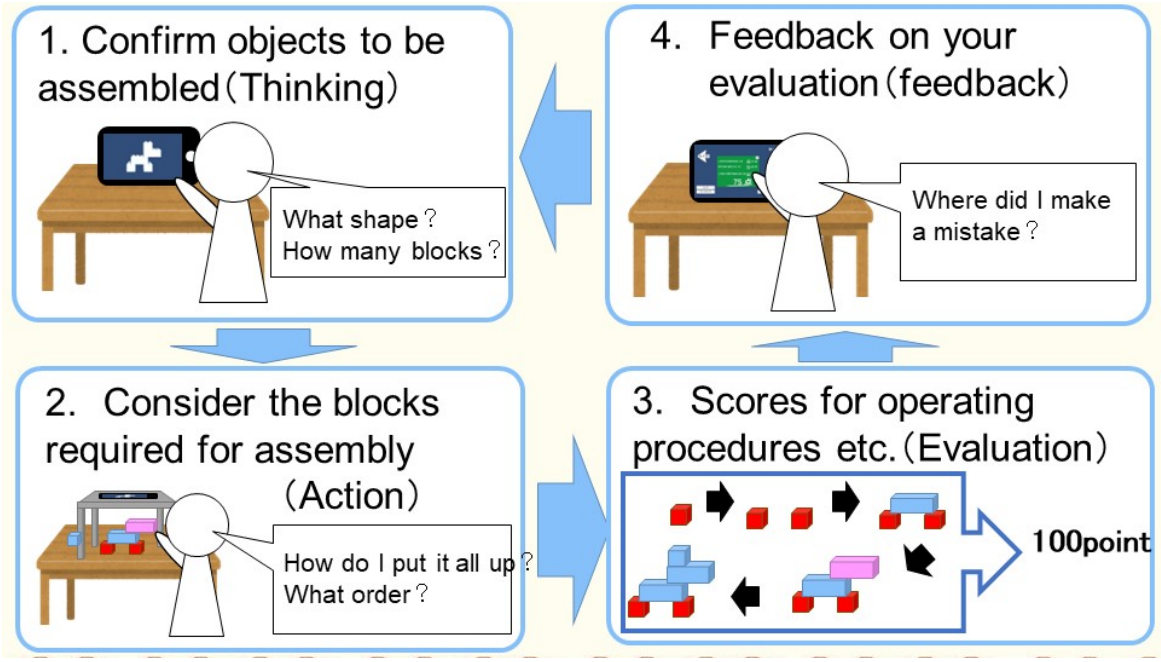

Figure 1 The process flow of our proposed method.

Methods

As the step of this system, first, the user image acquired in real-time is processed for noise cancellation. To accurately recognize the blocks placed by the user at each step, the background differencing method was used to identify and extract where they were placed. In addition, shadow processing was added to account for changes in the external environment and other factors.

Next, the clean data was subjected to recognition using the pre-created machine learning model Yolo v4 as shown in Figure 2 and 3. The type and color of the blocks detected by the model were used to fit into the three conditions described above.

In case 1, the shape of the blocks assembled by the user is compared to the pre-registered correct image using the Phash method, and the Hamming distance is used to calculate the similarity between the images.

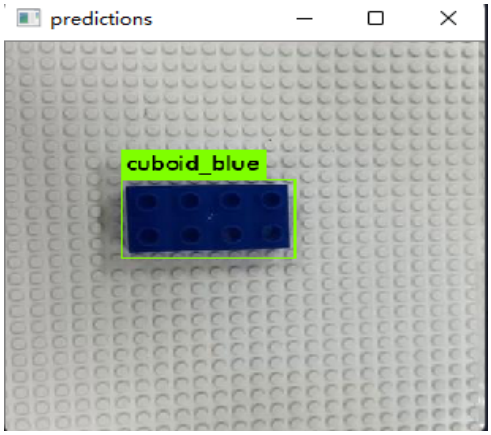

Figure 2 result of identification

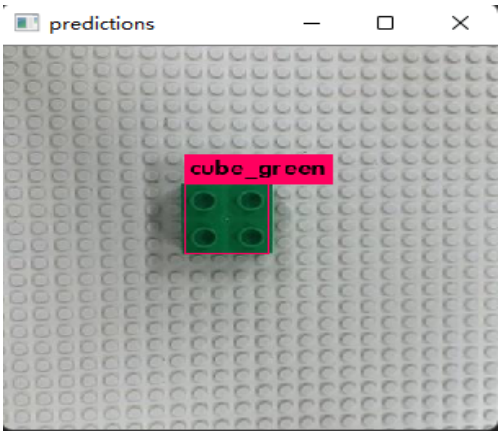

Figure 3 result of identification

In case 2, the color data of the blocks placed in each step is used to determine whether the colors of adjacent blocks overlap. However, the system is set up so that no points are deducted even if colors overlap in the cases shown in the Figure 4.

In case 3, the colors of the blocks assembled by user are counted and scored based on the minimum number of colors that each object can be assembled.

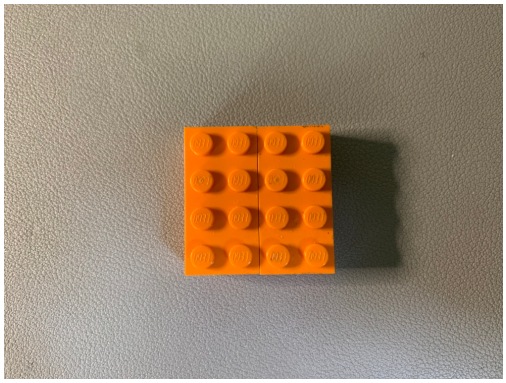

Figure 4 Parallel arrange

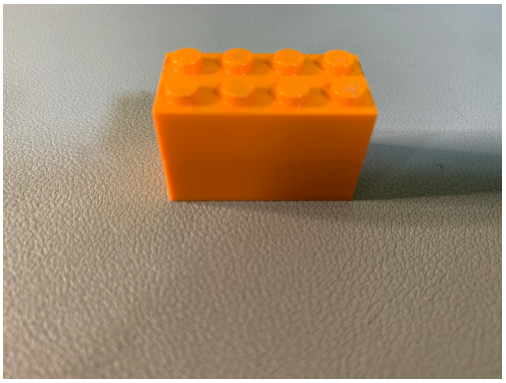

Figure 5 Vertical columns

Result

As a result, we prepared a total of 2 types of blocks, 4 colors, and 8000 pictures of data to be trained on the Yolo v4 model. We stopped at 6000 convolution operations, because the convolution operations are flattening out after 5000 operations. The resultant color and type of each block had a recognition rate of over 85 percent.

As for future plans, we are planning to conduct a small-scale experiment at an elementary school in Nara, Japan. during this summer vacation. For this purpose, we need an ethical review for in-person experiments, so we have submitted those documents to the university committee and await the results. In addition, we would like to create a web application for this system for user experience and other considerations. At the current stage, web cameras are connected to PC for image data acquisition, but web app would allow a single smart phone to complete the process.

References

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