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A Japanese Block-structured Programming Language Environment for Beginner Programmers Using a Drone

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Abstract

This paper describes the construction and evaluation of a programming environment for beginner programmers using drones to help them acquire computational thinking. In Japan, the Ministry of Education, Culture, Sports, Science and Technology made programming education mandatory in elementary schools in 2020, junior high schools in 2021, and high schools in 2022. The aim of programming education is that students learn computational thinking. For beginner programmers to learn computational thinking, it is important to provide an environment in which they can learn to program and visually check their results. The present study thus constructs and evaluates a Japanese programming environment for beginner programmers using a drone to acquire computational thinking. We held a hands-on drone operation event using a smartphone and conducted a questionnaire survey of the programming environment at a school festival. The results of the survey showed that even though most of the participants were novice programmers with no experience in programming or operating drones, the participants were willing to use an environment that allows them to learn to program with a drone. The results also suggested that beginner students are interested in using a drone-based programming environment to acquire programming skills. A programming environment for beginner programmers using drones is thus effective.

Keywords: Toy drones, block-structured programming language, Japanese programming environment

1 Introduction

In Japan, the Ministry of Education, Culture, Sports, Science and Technology (MEXT) mandated programming education in elementary schools in 2020, junior high schools in 2021, and high schools in 2022. The aim of programming education is that students learn computational thinking, which MEXT defines as the ability to think logically about what combinations of actions are required, how to combine symbols corresponding to different actions, and how to improve the combination of symbols to realize a series of activities one intends or approximate the outcomes to one's intention [2]. In addition, MEXT states

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that while it is conceivable that children will naturally learn programming languages and acquire programming skills, this is not the goal in itself. In other words, the purpose of programming education is for students to acquire not programming skills but computational (logical) thinking skills.

For beginner programmers to learn computational thinking, it is important to provide an environment in which they can learn to program and visually check their results. The present study thus constructs and evaluates a programming environment for beginner programmers using a drone as a means for them to acquire computational thinking.

2 The Tello

2.1 The Tello Drone

This paper adopts the Tello drone (Figure 1). The Tello drone is manufactured by Shenzhen Ryze Technology and features flight control technology from DJI [6] and an Intel processor. The official specifications of the Tello drone are given in Table 1.


Figure 1: Tello [5]

2.2 Reasons for Adoption

The Tello drone is adopted for three reasons.

1. The use of the Tello drone is not restricted by aviation laws.
2. Users can control the Tello drone through programming.
3. The sale price of the Tello drone is lower than that of other programable drones.

First, the Tello drone is a toy drone that weighs only 80 g and can be used without registration. The Civil Aeronautics Law was amended on June 20, 2022, making the registering of drones weighing 100 g or more mandatory. The process of obtaining a registration code, which includes payment and application processes, is time-consuming and requires effort. The use of a toy drone dispenses with this process and the drone can thus be easily adopted by schools.

Second, most toy drones are not programmable, whereas the Tello drone can be programmatically controlled like most general drones.

Third, the Tello drone is an affordable drone, priced at 12,980 yen, whereas other toy drones that can be programmed and controlled cost around 30,000 yen. In addition, the Tello drone has many features that distinguish it from other models, such as its camera and its ability to fly in formation with other Tello drones. The low cost is even more advantageous when multiple units are required, such as in schools.

2.3 Control Method

Programs connect to the Tello drone via Wi-Fi and communicate via the User Datagram Protocol (UDP) to control the Tello drone (Figure 2). UDP [10] is a standard protocol of the Internet and provides a procedure for application programs to send messages to other programs with a minimum protocol mechanism. This mechanism emphasizes communication speed by sending data without checking whether a connection is established.

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Table 1: Tello Specifications [5]

Drone	
Weight	About 80 g（Including propeller and battery）
Size	98 × 92.5 × 41 mm
Propeller	3inch
Built-in apparatuses	A distance meter, A barometer, LED, Vision system (DJI's flight control technology), 2.4GHz 802.11n Wi-Fi, 720p Live view
A port	A micro USB charging port
Flight performance	
Maximum flight distance	100 m
Maximum speed	8 m/s
Maximum flight time	13 minutes
Maximum flight altitude	30 m
Battery	
Removable battery	1.1AH/3.8V
Camera	
Photograph	5MP（2592x1936）
FOV (Field of View)	82.6°
Video	HD720p30
Format	JPG (Photograph) MP4 (Video)
EIS (Electric Image Stabilization)	Support

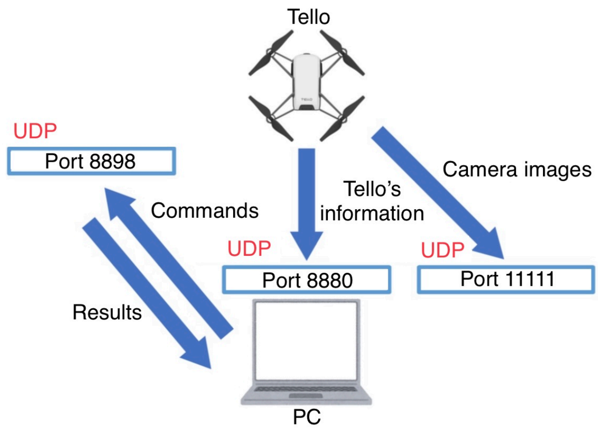

Figure 2: Overall view of control method

The Tello drone adopts peer-to-peer communication with direct end-to-end connection for communicating between a device and the Tello drone.

Programs send commands from a personal computer (PC) or other device to the pre-defined port number 8898 of the Tello drone after connection. The available commands include takeoff, movement, landing, turning, shooting, and shooting streamon commands [11]. The Tello drone operates by receiving a series of these commands that starts with the takeoff command and ends with the landing command.

A server with specific port numbers is set up to enable a PC or other device to receive the Tello information and camera images. Figure 2 shows that the Tello drone continuously sends information about itself to port number 8880 of a PC or other device through the UDP and provides camera images to port 11111 of the PC or other device after receiving the streamon command.

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3 Building the Programming Environment

3.1 Programming Environment

The gap between the Japanese and English languages is greater than the gaps between other languages. This gap is a fundamental problem for Japanese people dealing with the English language. Therefore, programming environments designed in the Japanese language are advisable for Japanese beginner programmers. In addition, a block-structured programming language is a better environment for beginners [8]. This paper thus implements a Japanese block-structured programming language environment for Japanese beginner programmers.

Computational thinking is defined by MEXT as the ability to think logically about what combinations of actions are required, how to combine symbols corresponding to different actions, and how to improve the combination of symbols to realize a series of activities one intends or approximate the outcomes to one's intention.

The environment proposed in this paper provides blocks that indicate symbols, which are easily understood by beginner programmers. The blocks thus cultivate computational thinking efficiently.

The proposed environment is developed using Unity [9] and C#. Unity is a development platform provided by Unity Technologies and supports a wide range of platforms including Windows, Linux, and macOS, smartphone operating systems such as iOS and Android, and home game consoles such as PS4 and PS5, Nintendo Switch, and Xbox One.

Some beginner programmers may have insufficient experience using a PC. The proposed environment thus implements Unity and supports both smartphones and PCs such that it is more accessible to beginner programmers.

3.2 Description of the Environment

Figure 3 is the screenshot of the proposed environment. The environment is roughly divided into three parts, namely the black bar at the top, the bar containing blocks at the bottom left, and the white canvas at the bottom right.

The general workflow in the environment is as follows.

1. Users select a block that they want to use as a command for Tello from the bar at the bottom left.

2. Users add the selected block to the white canvas at the bottom right.

3. By repeating the above steps, users place a block of a series of actions that they want the Tello drone to perform on the canvas.

4. Users turn on the Tello drone.

5. Users open the Wi-Fi screen on their PC or smartphone and access the Wi-Fi emitted by the Tello drone.

6. Users press the run button on the black bar at the top.

7. The Tello drone moves according to the sequence of commands on the canvas.

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Figure 3: The screen of the application

Any series of blocks on the canvas must start with the takeoff block and end with the landing block. Users send the corresponding commands to the Tello drone when clicking the run button.

The bar at the bottom left calls up the blocks shown in Figures 4, 5, 6, and 7. In the selection of a block, the block appears highlighted when selected and it is then placed on the canvas by the user. The block is closed by clicking or tapping on the light background. A block placed on the canvas is deleted by the user clicking or tapping on the block.

Figure 5 shows the selection of the landing block, Figure 6 shows the seven blocks that appear for forward, backward, left, right, up, down, and stop commands in the navigation selection, and Figure 7 shows that two camera blocks that appear for taking a photograph and starting the recording of a video in the camera selection.

After placing the blocks of the sequence of actions that the Tello drone needs to perform on the canvas, users turn on the Tello drone and connect a PC or smartphone to the Wi-Fi emitted by the Tello drone. Having successfully connected to the Tello's Wi-Fi, users press the run button on the black bar at the top of the environment.

Figure 8 illustrates the sample program presented in Figure 9. The Tello drone performs a series of actions, moving right, forward, left and back, to return to its original position. Figure 9 shows the series of blocks for programming the above movement.

The programming of the Tello drone in the proposed environment allows beginner programmers to learn to program while visually confirming the results of what they have programmed. The environment thus enables the programmers to practice computational thinking efficiently.

4 Assessment of the Programming Environment

We held a hands-on drone operation event using a smartphone and conducted a questionnaire survey at a school festival. The questionnaire asked the following questions.

1. Do you have programming experience?
2. Have you ever operated a drone?
3. Rate your satisfaction in operating the drone with a smartphone.
4. Would you like to use a drone programming learning environment on a smartphone?

One-hundred and thirty attendees of the event completed the survey. The survey did not restrict the participant age. There was no significant difference in responses between age groups.

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Figure 4: The takeoff panel

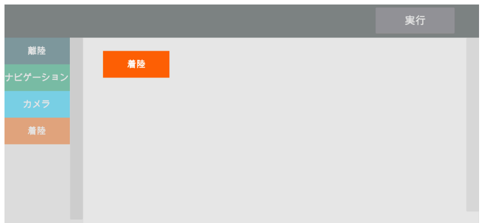

Figure 5: The landing panel

Figure 6: The navigation panel

Figure 7: The camera panel

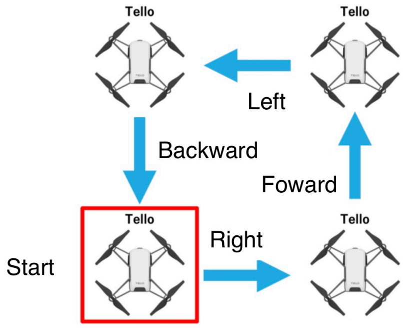

Figure 8: An image of the Issue

Figure 9: The application screen of the issue

Figure 10 shows that the majority of respondents were inexperienced in programming; i.e., 80% of respondents (104 respondents) had no experience and 20% (26 respondents) had experience.

Figure 11 shows that 11% of respondents (14 respondents) had experience in controlling drones and 89% (116 respondents) had no experience. These results are thus similar to those for programming experience, in that most respondents had no experience controlling drones.

Figure 12 shows that 77% of respondents (100 respondents) were very satisfied in operating the drone with a smartphone, 20% (26 respondents) were satisfied, 3% (four respondents) were neutral, 0% (no respondents) were dissatisfied, and 0% (no respondents) were very dissatisfied. The participants thus expressed a level of satisfaction in using a smartphone to operate the drone, even though most respondents were inexperienced in operating drones.

Figure 13 shows that 61% (79 respondents) of respondents agreed that they would like to use a drone programming learning environment on a smartphone, 1% (two respondents)

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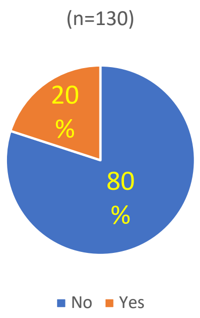

Figure 10: Do you have programming experience?

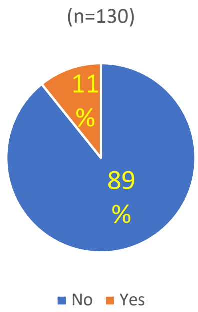

Figure 11: Have you ever operated a drone?

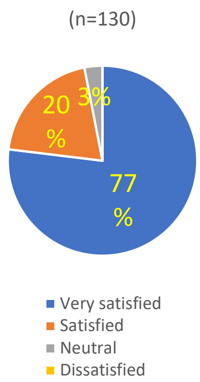

Figure 12: Rate your satisfaction in operating the drone with a smartphone.

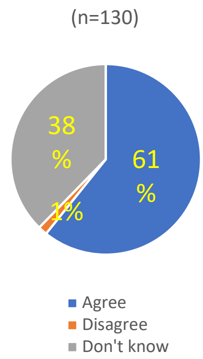

Figure 13: Would you like to use a drone programming learning environment on a smartphone?

disagreed, and 38% (49 respondents) did not know. Most respondents thus expressed an interest in using a drone programming learning environment.

The above results indicate that even though most of the participants were novice programmers with no experience in programming or flying drones, the participants would be willing to use an environment that allows them to learn programming with a drone. In addition, the participants expressed their satisfaction in using a smartphone to control a drone. The survey results thus indicate that many beginner students would be interested in using a drone-based programming environment to acquire programming skills.

5 Summary

This paper described the construction and evaluation of a programming environment for beginner programmers using drones to help them acquire computational thinking. The study adopted a Tello drone to carry out the actions in the programs created in the environment because the use of this drone is not restricted by aviation laws and the drone is programable despite its low price.

The environment is a Japanese block-structured programming language environment. The gap between the Japanese and English languages is large compared with gaps between other languages, which is a fundamental problem for Japanese people dealing with the English language. In addition, a block-structured programming language is a better option for beginners. The environment thus helps Japanese people to learn to program. In addition, the environment is developed using Unity and C# and can thus be used on a wide range of platforms.

We held a hands-on drone operation event using a smartphone and conducted a questionnaire survey at a school festival. The results of the questionnaire survey showed that even though most of the participants were novice programmers with no experience of programming or flying drones, they would be willing to use an environment that allows them to learn to program with a drone. In addition, the results revealed that beginner students are interested in using a drone-based programming environment to acquire programming skills.

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Future tasks are to add more functions to the environment and investigate the usefulness of the environment in terms of learning effectiveness.

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