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Research article

Human motion tracking AI revealed that a hand-made swing in Nature led to the emergence of children's cooperative society.

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Abstract

In recent years, urbanization has led to a loss of outdoor natural play opportunities in children. Instead, the development of video games and the Internet has increased their opportunities to play indoor alone. For children, interactive play in the natural environment is recommended to learn social skills, including independence, active participation, collaboration, creativity, and persistence. When the citizen and university encouraged children to enjoy nature play for these goals, a hand-made swing consisted of a wooden seat, rope, pulleys and supporting trees, emerged. The swing extended the original function, in which a non-rider pulled the rope to lift the rider up and down. In order to evidence this voluntarily generated cooperative behavior by achieving objective identification, we attempted to develop an artificial intelligence based on video feature identification by using basic deep learning techniques. This validation example may provide a future proposal to support the development of children's social skills based on behavioral identification.

Keywords: children, play, cooperate, create, altruism, nature, artificial intelligence, deep learning, CNN

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1. Introduction

The human species has evolved by cooperating each other when faced with difficult challenges in the natural environment on Earth [1]. The independent and relentless exploration of natural diversity, the willingness to overcome challenges, and the lifelong social skills to collaborate with one another may have been nurtured in childhood in the outdoor nature with peers [2]. However, the modernization has led us to spend most of our time in man-made environments controlled by humans, which may have resulted in various psychological vulnerabilities [3], and the search for interventions to solve this problem may be an international challenge [4].

We have held several "playground" events in which local citizens, government, and universities have collaborated to cultivate children's independence, creativity, collaboration, and overcoming abilities in a public, urban park where they can easily engage in activities in a natural environment [5,6]. Citizens and students worked together to create a simple swing consisting of a rope, a wooden seat board, and supported by mature trees [7]. At first, the swing was played with the same pendulum motion as existing functions, but gradually, an extension of the original was created, in which the rider was lifted up and down by pulling the rope. Improvement progressed utilizing pulleys to make pulling the rope simpler. Although pulling up a single rider with a single rope-puller required a heavy load, several children working together got learned their ability to lift a child higher and more quickly.

[1]Open Access paper (available freely at www.isbsjapan.org)
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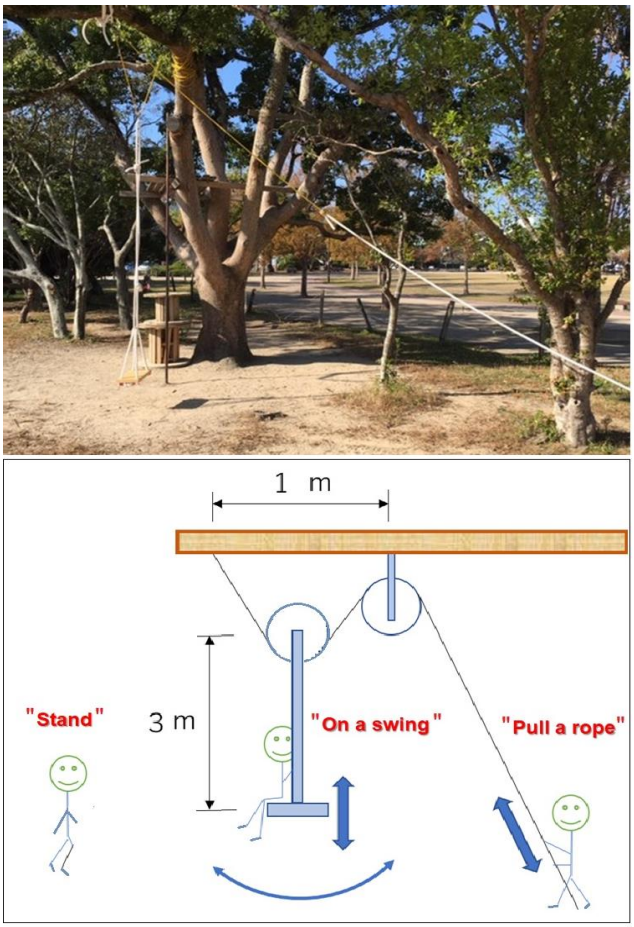

Figure 1. Three representative behavioral types observed around a hand-made swing.

The rope puller's behavior might be regarded as a kind of altruistic act, in which the puller's own labor voluntarily brought about the elevation of the rider, hypothetically, a kind of cooperative play achievement [8]. In this report, we set up this hand-made swing at a playground event, and by quantifying whether behavioral patterns such as riders and pullers might occur during a certain period of utilization, we evaluated this natural equipment about the reproducibility in the cooperative effect. The first step was to identify patterns of behavior by the researcher's visual exploration. Furthermore, to corroborate the objective evaluation, we generated a computational model that enables identification based on video images of behavior patterns labeled by the researcher through deep learning technique [9], and evaluated the percentage of correct responses to the researcher's label of test images, thereby verifying the existence of the identified behavior through a reproducible quantitative evaluation based on machine identification with their confusion matrix summary [10].

2. Method

2.1. Children in the playground events

The study protocol was approved by the Yamaguchi University General Human Research Review Committee. The study was conducted in compliance with the contents.

The playground events were held at a city park of Ube and Hagi, Yamaguchi prefecture in multiple seasons from 2018 to 2023 [11]. During the events, a hand-made swing consisted of rope, a wooden seat and pulleys emerged by the attenders' setting. Because there was no introduction for this play equipment, only those who were aware of it used it freely. Video images at 30 frames per second with a fixed-point camera (Everio R, JVC) supported by tripods were acquired for children's behavioral analysis.

2.2 Behavioral identification by human and machine

The video data were first observed by the researchers to discriminate multiple types of behaviors and quantified. For the purpose of estimating children's cooperation including reference types, three typical behaviors described in **Figure 1**, "Stand", "On a swing" and "Pull a rope" were focused on analysis by human and machine identification. These three representatives were designed each implication on "Stand" as "other behaviors", "On a swing" as "Requirements for definition of the following altruistic behavior", and "Pull a rope" as the principal target for the assumed "altruistic behavior". Quantitative analysis was performed on arbitrary one-hour continuous video data extracted randomly for both human and machine detection simultaneously.

The software for machine analyses was based on Windows 11, Python 3.9.18, CUDA (12.2), Pytorch (2.1.0) with hardware (CPU: Intel(R) Core(TM) i7-10700 CPU @ 2.90GHz, RAM: 16GB, GPU: NVIDIA GeForce GTX 1650 SUPER). DEEPSORT [12], which predicts forward/backward continuity using the coordinates and speed coefficient of YOLO detection [13], four objects with a box (bounding box: each two examples of three behavioral types shown in **Figure 2**), and automatically tracks IDs with errors visually

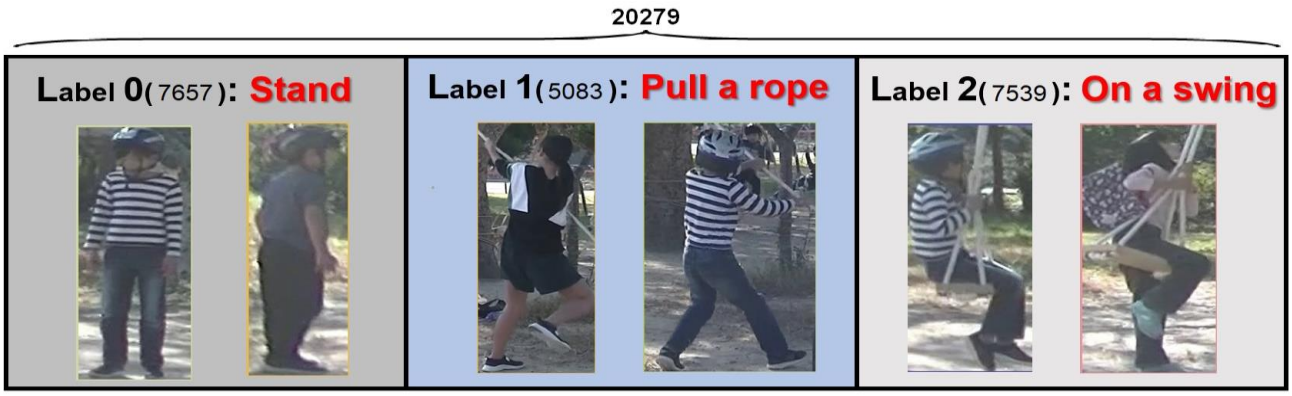

Figure 2. Children's bounding box examples extracted by DEEPSORT for CNN training or test.

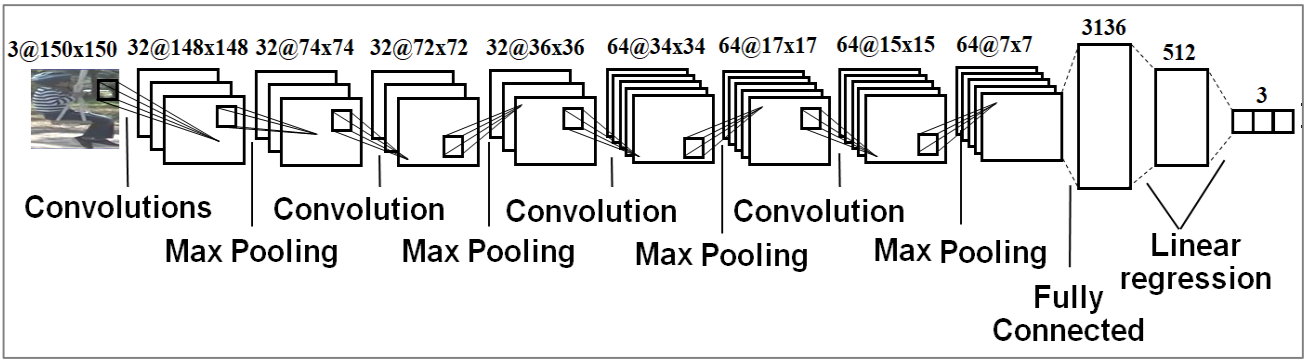

Figure 3. Architecture of the CNN for identification of children's typical behaviors

extracted and excluded by additionally customized applications. The machine learning process was conducted basic Convolutional Neural Network (CNN) algorithm (**Figure 3**) [14]. Each of the child bounding box images labeled behavioral types was resized 150 pixels square for normalization, and were prepared with augmentation (in rotation, parallel shift, brightness) [15]. Five sets of convolution and max pooling were repeated then were fully connected layers and linearization with network convolutional wights and hidden layer consideration [16]. Activation functions were used ReLU[17].

3. Result

3.1. Number of children exhibiting each behavioral type as quantified by human visual inspection

In the approximately one hour of video data randomly selected for this study analysis, the results regarding the number of children around the nature swings that utilized local natural materials are shown in **Table 1**. The numbers in parentheses indicate the ratios of children who expressed each behavior out of the total number of 25 children who would have shown some interest in the swing set. The number of children "On a swing" riders, who used the original function, was 11, while "Pull a rope," which was a special extension of this handmade swing, was slightly smaller at 9 riders, but the order was generally similar.

Table 1. Numbers of children per type of behavior emerged at the hand-made swing with the regional resources

Behavioral Types	Children Number
Children who had looked at a swing (**ALL**)	25 (1.0)
"Stand"	16 (0.64)
"Pull a rope"	9 (0.36)
"On a swing"	11 (0.44)

3.2. Development of machine artificial intelligence for identification of three types of behavior

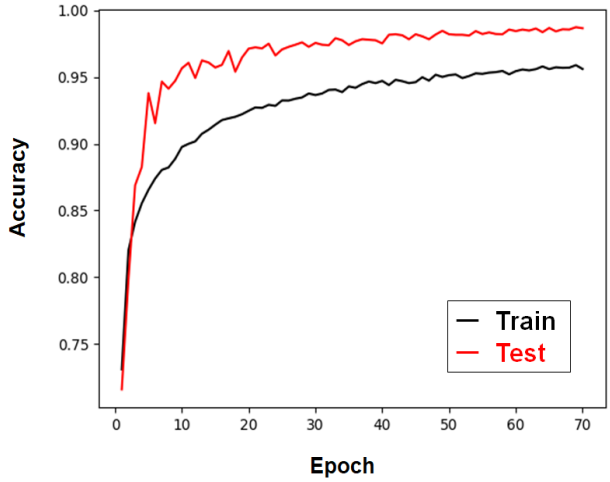

Figure 4. Learning accuracy result curves.

Next, 20,279 pictures total of children surrounded by the bounding box in **Figure 2** were prepared, including 7,657 pictures labelled "Stand", 5083 pictures labelled "Pull a rope," and 7539 pictures labelled "On a Swing". The hold-out method was used to train 70% of these three types of pictures and tested 30% for accuracy[18]. As the learning accuracy curves of both train and test were confirmed the reach over 0.9, the epoch was set to 70 (**Figure 4**).

Finally, the obtained computational model of three types of behaviors in test pictures summarized the evaluation for congruency between Human identification and Machin AI prediction in the confusion matrix, **Table 2**. As indicate rates in parentheses on the diagonal lines, it was confirmed that, at least within the tested children's pictures, the machine learning for three types of behavioral identification achieved almost 100% with human suggestions.

Table 2. Confusion matrix of test summary

Machine AI Prediction / Human identification	0 (Stand)	1 (Pull a rope)	2 (on a swing)	Total
0 (Stand)	**1856 (0.98)**	**20**	**21**	1897
1 (Pull a rope)	**1**	**1309 (1.00)**	**0**	1310
2 (On a swing)	**22**	**4**	**1862 (0.99)**	1888

4. Discussion

We hypothesized the possibility of discovering an example of spontaneous collaboration on a certain form in a regionally natural environment where citizens, students, and children gathered. The form was attempted to evaluate the existence of a cooperation around the natural swing that allowed both the rider and the pullers to enjoy one another. Those socio-psychological phenomena might be visualized by the extension of the swing's anomalous up-and-down lifting function. As a reproducible quantitative identification method that provides evidence of its collaborative nature, the human-taught machine learning-based behavioral identification technology possibly presented its potential in this study as generally 100% accuracy rates. The patterns of behavior might be considered both altruistic and collaborative, with the puller sometimes being more than one person, entertaining or scaring the rider, whose load is reasonably large. Experiencing that social interaction may be suggestable for today's children, who might be inhibited from learning in outdoor natural environments that have been shunned as high-risk With other statistical methodologies [19, 20–33], Deep learning, CNNs may be able to identify patterns of behaviors that are confounded by complex information.

This report may imply the possibility of application to core technologies for diagnosis and treatment of mental disorders such as developmental disorders, which are becoming an increasing social problem due to their intractable nature [34, 35]. Since there have been reports of involvement with delays in coordinated motor functions as well as mental problems in developmental disorders such as autism spectrum disorders[36, 37], the behavior around the swing in this report might be able to visualize the mind-body hybrid function during the required safely lifting of others up and down using full body strength, along with social behavior. A future evaluation system for mind-body development such as rope and load, the physics of movement, and the medical biology of skeletal muscle control, requires interdisciplinary and complex deliberation for human resource development[11, 28, 32, 38], that might be suggested in this report.

5. Conclusion

This study was based on limited sample numbers as a feasibility, however, a hand-made swing consisted of a wooden seat, rope, pulleys and supporting trees led children their collaborative behavior emergence. The swing extended the original function, in which a non-rider pulled the rope to lift the rider up and down. We attempted to develop an artificial intelligence based on video feature identification by using basic deep learning techniques under human teaching and the accuracy resulted in highly successful.

Codes recorded in GitHub

https://github.com/koshiba-lab-mono/swing-behavior-classifier

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Conflict of interests

We declare no conflicts of interest.

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