Individual Status Recognition System Assisted by UAV in Post-Disaster

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Abstract—When natural disasters occur, there is a possibility of having many injured people in the disaster area. In the meanwhile, rescue teams have to aid these injured individuals as fast as possible. In this study, we proposed a recognition system of individual status to help rescue teams. Employing Unmanned Aerial Vehicles (UAVs) system after disaster occurrence gives many advantages. For instance, a UAV can cover a wide area and provide aerial photographs in a short period. This study aims to classify whether an individual status is standing, sitting, or lying on the ground by using supervised machine learning. Experiments revealed that the system is able to recognize all three types of individual status with an accuracy of 95.6%. Moreover, the authors confirmed the usefulness of using a UAV to recognize individuals in the post-disaster scenario.

Keywords—Unmanned Aerial Vehicles, status recognition, disaster response, rescue missions, deep learning, image processing

I. INTRODUCTION

Japan is exposed to natural disasters such as earthquakes, tsunamis, typhoons, and volcanic eruptions. When such disasters occur, buildings collapse and secondary disasters may cause significant social loss, besides the damage of the infrastructures and with a lot of injured people. Therefore, disaster preparedness measures and disaster prevention education societies are studying case based on previous experiences, and scenarios. Although these efforts helped to reduce the damage compared to previous incidents, further countermeasures are vital. For example, the damage after the huge earthquakes along the Nankai Trough earthquake may be beyond rational expectations [1]. There are proposed systems suggests using the Internet of Things (IoT) and Unmanned Aerial Vehicles (UAVs) in post-disaster. These systems help to identify the damage and provide a real-time monitoring system of the disaster area. When a disaster occurs, people need to evacuate to shelters, and rescue teams have to survey the damaged area, looking for injured people and refugees. Nevertheless, it depends on the disaster scenario. There are problems such as a delayed evacuation plan or getting stopped due to severe injury. These concerns can be resolved by using IoT and UAV. In this paper, authors proposed a system that utilized a machine learning technique on image data obtained by multi-rotor UAV framework to recognize individual status, assuming a daytime scene after a disaster.

II. RELATED RESEARCH

Although UAV technology is expected to provide a promising future for many humanitarian applications such as disaster responses application. Further, UAV deployment is not exclusive to military applications, which is known for [2]. In the previous work, authors introduced a multi-UAVs system for disaster response and highlighted the advantages of integrating UAV into an M2M communication system [3]. Also, a method of producing safe evacuation routes on an updated map after tracking pedestrians and scanning the area using UAV has been proposed in work [4]. The experiments revealed that a map could be generated. However, the problem in that proposed system is that authors have only focused on walking and moving status. After, the disaster, there might be a lot of injured people who unable to walk or even stand. Therefore, it is necessary to have information about these people as soon as possible.

In another related work, authors proposed a method to recognize only the status of lying by using helicopter UAV framework on a doll that considered as a real person [5]. On the other hand, we used a multi-rotor UAV that has many advantages over the helicopter UAV framework and fixed-wings, namely the simplicity and the maneuverability [6].

This paper proposed a new system that can recognize the status of injured people are in the disaster area and report them to rescue teams. After disaster occurrence, it is possible to improve human detection accuracy by deploying UAV frameworks since UAV can provide aerial photography coupled with low attitude mission. The recognition methods in this work are extended to three case scenarios to determine the status of the injured person through the captured aerial image.

III. PROPOSED SYSTEM

A. System Design

Figure 1 illustrates the proposed system in this study. First, UAV scans the disaster area and provide aerial images while sending these data to the server. If the server detected an individual during scanning mission, the status of the person will be classified according to the developed classification method. After detection, a specific color will be assigned for the detected person and the location of the detection will be uploaded to a map. Finally, this map will be shared with rescue team.

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training data and 120 verification data was used to create a learning model. In order to prevent over-learning, authors prepared a verification data and evaluated the learning model before implementations. Also, the training data has been extended to compensate for the small number of data sets. The learning model was created while expanding the data and by using ImageDataGenerator included in the Keras module.

IV. RESULT AND DISCUSSION

A. Implementation of learning model

Authors evaluated the created learning model by verification the data. Figure 2 demonstrates a learning process in this study. The vertical axis represents the accuracy and loss values of the learning model, and the horizontal axis is an epoch number representing how many times the learning has been repeated. Authors set epoch number as 20. The curve of val_acc shows the accuracy of the prediction and validation data from the learning model, and the curve of val_loss illustrates the loss of how far away from the validation data. As the number of epochs increased, the value of val_acc is also increased. Finally, the graph shows a high accuracy value of 95.8%. However, appropriate learning accuracy can be obtained without causing an over-fitting since the value of val_loss is gradually decreasing.

![Fig. 2. Learning process of recognition model](image)

B. Experiment of Individual Status Recognition

By implementing the created learning model, the experiment of individual status recognition has been conducted on a total of 45 test data and 15 cases for each status that represented in Chapter three Section C. Table I lists the recognition results for each status experiment. Further, the Confusion Matrix is shown in Table II. This system shows an accuracy of 95.6%. According to the experiments, the conditions of standing and lying status could be easily recognized in low flight altitude. For instance, in Figure 3 (a) the system recognized Standing condition with 64.7% and 34.6% of Sitting status. In Figure 3 (b) Lying condition has been detected with 67.6% and sitting condition is detected with 31.7% which is the actual condition. In Figure 3 (a), the proposed system considered a standing condition since the image of the person is sitting on the bench seems to the classification model and the UAV camera angle as a standing condition.
condition. In Figure 3 (b), the system classified that the subject's posture was misrecognized as "lying" because his body was parallel with the ground.

<table>
<thead>
<tr>
<th>Predicted Labels</th>
<th>Lying</th>
<th>Sitting</th>
<th>Standing</th>
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</thead>
<tbody>
<tr>
<td>True Labels</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lying</td>
<td>15</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Sitting</td>
<td>1</td>
<td>13</td>
<td>1</td>
</tr>
<tr>
<td>Standing</td>
<td>0</td>
<td>0</td>
<td>15</td>
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V. CONCLUSIONS

In this study, the authors proposed a new system model to detect individual status using multi-rotor UAV frameworks. Then, the authors evaluated the proposed system model and recognition of an individual status using CNN from aerial images data on real flight experiments, proposing a pseudo scenario of a post-disaster. The experiments revealed that although a high accuracy of 95.6% could be obtained from the developed system model, incorrect recognition results have been detected in some cases. Nevertheless, in order to make the proposed system more practical, it is necessary to consider other feature extraction methods. Besides, the efficient methods of collecting aerial images are also needed to provide valuable and useful recognition data. Authors in this paper developed a system model and evaluated through real flight experiments, proposing a solution for autonomous recognition system using deep learning and image processing that can support helping refugees and rescue teams in post-disaster case scenario.

REFERENCES