Assessing Damage in Disasters Using Drones with Biometric Information Obtained from Wearable Devices

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Abstract: In recent years, the number of mountaineering accidents and damages caused by large-scale disasters are rapidly increasing. Therefore, several technologies have been proposed to provide support for disaster relief including the use of drones. In this research, as a project in enPiT2021 summer school, we employed a virtual world of a damage around a river during a disaster and implemented our proposed rescue solution using drones and biometric information. We calculated danger level of the disaster victims using the biometric information obtained from wearable device attached to them, which were used to implement a rescue plan by the order of danger levels. As a result, we confirmed that our proposed solution was effective as we successfully rescued people in the simulated disaster environment.

Keywords: ROS, Wearable Device, Drone, Biometric Information

1. Introduction

In recent years, the scale and damage of disasters such as mountain climbing accidents and river flooding have been increasing [1]. In order to cope with such disasters, many technologies have been proposed to operate drones in autonomous flight that incorporates GPS technology, self-positioning technology that enables autonomous flight even in places where GPS is not available, Simultaneous Localization and Mapping (SLAM) technology for operating drones using, and 3D mapping technology [2].

In the 2021 summer school organized by enPiT [3], a lecture on system development for disaster relief using drones was conducted based on this background. During the summer school, lectures on control theory, requirements analysis using UML, control theory for autonomous drone flight, and development exercises of Robot Operating System (ROS) [4] for application development were given on the first day. Then the student participants were assigned to perform a group work as a PBL task to develop a river monitoring system for detecting people in danger by autonomous drone flight, assuming a disaster. In the development of the system, a virtual world was constructed on Gazebo, a ROS simulator, in which a drone was sent around the world to detect abnormal situations such as people in the disaster. The drone circled the world twice, the first time to cover the entire river, and the second time to capture detailed images of the disaster area.

The co-authors, six student members of Sugaya Laboratory, Shibaura Institute of Technology, of this paper participated as a team in this PBL with a proposal, "Assessing Disaster Conditions and Identifying Priority Rescuers by Combining Biometric Data and Drones". This proposal won the first prize in three categories of enPiT: overall evaluation of flight technology, disaster concept, and overall evaluation of presentation, as a result of proposing a new scenario. Specifically, assuming that the disaster victims is wearing a wearable device that can measure heart rate variability (HRV), the drone receives the HRV transmitted from the wearable device, calculates the degree of danger of the victims, and then proceeds to rescue them according to the degree of danger.

In autonomous drone flight, there are no specific criteria for where to search. Therefore, our proposal was evaluated as an idea to effectively and efficiently determine the status of disaster victims especially when a large area is targeted. Therefore, we believe that it is useful to summarize our proposal and discuss its effectiveness for future possibility of real application.

2. Design

We designed our proposed system using use case diagram (Fig. 1). Initially, a user, a drone, and a wearable device were placed assuming a disaster as target scenario. Next, we defined the actions (behaviors) of the system as instructions to the drone and the acquisition of biometric information from the wearable device. Next, we explained the behavior of the system using these definitions as follows: The user sends flight information such as settings and takeoff instructions to the system. In response, the system sends flight instructions to the drone, displays the coordinates, and takes pictures of the disaster area. When the wearable device obtains biometric information (i.e. heart rate [5]) from the human body, the system calculates the degree of danger and sends it to the user.

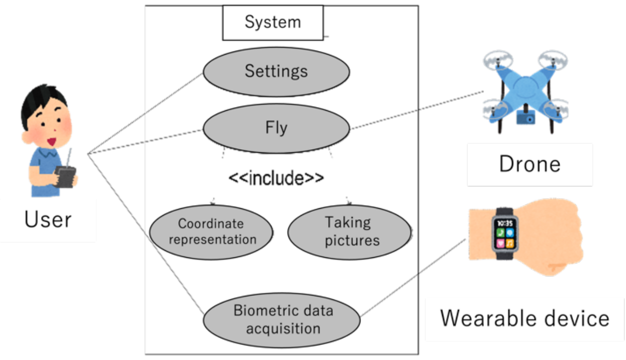

Fig.1: Overall view of the propsed system.

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2.1 Events

An event is a representation of an interaction between the system and an actor such as a user or a drone. We firstly assumed that there are a system, a user, a drone, and a wearable device as actors, and the interaction among them is an overall event. The detail of events in our proposal are described as follows:

(1) Configuration: The user (rescuer) enters the input settings of the running system. The user sends the settings to the drone through the system, and finally the drone receives the settings and notifies the user of the completion of flight preparation through the system.

(2) Flight: For the flight support for the drone, the user instructs the drone to take off through the system. Then, the drone circles around the disaster area. After completing the lap, the drone lands and sends a landing completion signal to the system. The system notifies the user that the landing is completed as well as the errors in case the drone is unable to complete a lap around the disaster area or when the drone is unable to land.

(3) Coordinate display: This is an event that informs the user of the current coordinates of the drone. The drone transmits the current coordinates to the system and the user.

(4) Camera: This is an event when a camera image is displayed from the drone to the user through the system.

(5) Biometric information: This is an event when the wearable device sends the biometric information to the system, and then the system calculates the degree of danger of the victims from those biometric information.

3. Experiment

In this proposal, we used a virtual world on Gazebo, a ROS simulator distributed by enPiT, and developed a system for capturing disaster victims and understanding the disaster area by circling the world using a drone. The world was constructed in a mountainous area with a river at its center. Five victims were set near the river. This time, the drone flew twice; the first time to circle the entire world and the second time to capture each victim on camera. The state machine diagram for the drone flight is summarized in Fig. 2. The states of the drone are declared as follows: “takeoff” denotes taking off, “land” denotes landing, and "go" denotes flight.

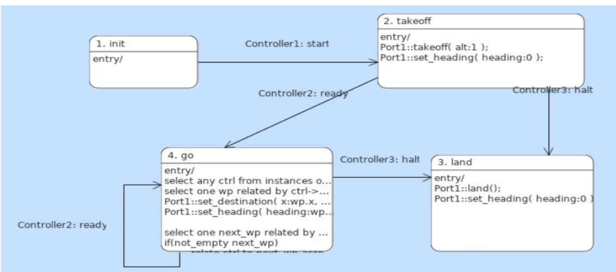

Fig.2: State machine diagram for flying a drone.

In this study, we acquired biometric information from the wearable device and calculated the coordinates and the danger degree in the first round. Then in the second round, we went around each of the victims in the order of danger degree and took pictures. The sample biometric information of the five victims used in this study is illustrated in Fig. 3.

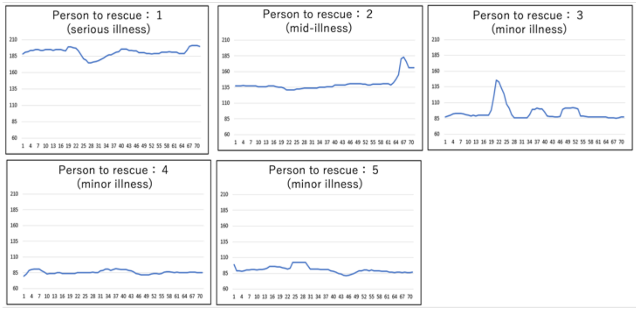

Fig.3: Sample biometric data of each person in need of rescue.

The biometric information used in this study is the heart rate (HR). Those with a high HR are defined as those at high risk. In this case, the first person was defined as seriously injured, the second as moderately injured, and the others as slightly injured. Fig. 4 summarizes the pictures taken during the flight.

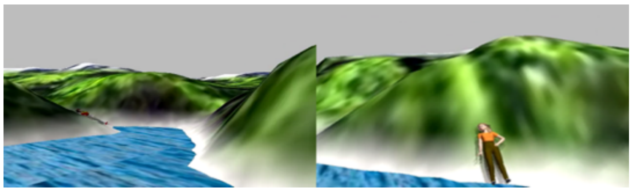

Fig.4: Pictures taken during flight

From the flight results, we were able to ascertain the situation around the disaster area, calculate the danger degree of each disaster victim, and confirm that they are rescued in the order of danger degree.

4. Conclusion

In this research, a drone circling a disaster area acquired biometric information from a wearable device, calculated the degree of danger based on the acquired biometric information, and patrolled for people in need of rescue in the order of the degree of danger. We were awarded for proposing such a new idea. However, the system can still improve even more. The method for judging the degree of danger of a person needs to be studied, for example, other heart rate variability indices should also be employed in addition to HR. In addition, more precise flight models and flight algorithms are needed to make these algorithms practical, and these studies will enable us to propose more useful flight methods

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