RoboCupRescue 2015 - Robot League Team <CMU Lab (JAPAN)>

Seita Sukisaki, Takumi Sugiura, Mharis , Muhammad, Miao Qi , Takuya Watanabe , Hajime Nobuhara

University of tsukuba
1-1-1 Tennodai, Tsukuba, Ibaraki
305-8577, Japan
Mail: sukisaki@cmu.iit.tsukuba.ac.jp
Web: http://nobuharaken.com/

Abstract. For the 2015 Robocup-Rescue competition, the Computational intelligence and Multi-media laboratory (CMU lab for short) of the University of Tsukuba has developed UAV (Unmanned Aerial Vehicle). The developed UAV basically can be controlled by teleoperations and it can take aerial photographs of the field that is useful for initial investigations in the disaster management. Furthermore, our UAV has arms with camera and sensors and they can observe various information of victims, rapidly and precisely. This report is detailed descripts of our UAV.

Introduction

The CMU lab of University of Tsukuba develops a rescue robot of UAV (Unmanned Aerial Vehicle) Type, and our purpose is to ride on the strength of UAV for disaster management, rescue activities, especially, it can be worked in the real environments. Our team also aims to show that our UAV solve the drawback of the UGV (Unmanned ground vehicle) type robot. The CMU lab team has been founded since 2014 in order for RoboCup-Rescue competition, especially, 2015.

1. Team Members and Their Contributions

Team members are composed of CMU laboratory members.
Team Members and Their Contributions

- Seita Sukisaki — Controller development, Mechanical design, Operator
- Takumi Sugiura — Controller development, Mechanical design
- Haris Muhammad — Image processing unit design
- Takuya Watanabe — Image processing unit design
- Miao Qi — Image processing unit design
- Hajime Nobuhara — Advisor
- University of Tsukuba — Sponsor

2. Operator Station Set-up and Break-Down (10 minutes)

One operator is needed for setting up and operating the UAV, and he/she has to carry the UAV (2kg) and the grand-station (notebook computer) and the wireless router and their electronic power supplies.

The initialization processes are as follows (within 10 minutes):

1) Arrangement of the UAV, the grand-station, the wireless router (within 3 minutes)
2) Active the UAV, the grand-station, the wireless router (within 3 minutes)
3) Connection of between the UAV and the grand-station (within 1 minute)
4) Checking their sensors (within 2 minutes)

3. Communications

We will use IEEE802.11a and 802.11n and will wait to be assigned with a channel/band from the organizers during the competition.

Table 1. communication protocol

Rescue Robot League		
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MODIFY TABLE TO NOTE ALL FREQENCIES THAT APPLY TO YOUR TEAM		
Frequency	**Channel/Band**	**Power (mW)**
5.0 GHz - 802.11a/n	Auto	10
2.4 GHz - 802.11b/g	Non	
2.4 GHz – Bluetooth	Non	
2.4 GHz – Other	Non	
1.2 GHz	Non	
900 MHz	Non	
40 MHz	Non	
27 MHz	Non	
<FILL IN OTHER>	Non	
<FILL IN OTHER>	Non	

4. Control Method and Human-Robot Interface

Our purpose is to effectively find a lot of the victims as possible, with in short time, and the following system is proposed in order to achieve them.

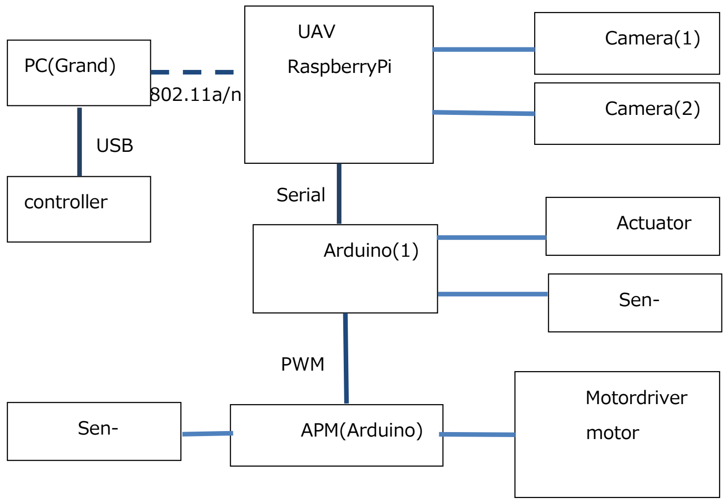

Fig 1. System Flow

The grand-station (notebook computer) is used by the operator, to do the teleoperation of the UAV. The grand-station can visualize the video that is transmitted from the camera of UAV. The UAV is equipped with the RaspberryPi to communicate with the grand-station. We will do the login to RasberryPi from the grand-station via IEEE802.11a/n, and can observe all information of sensors of UAV. At the same time displays the images sent from the robot , and checks the state of the robot by using the monitor shown in Fig.2.

Fig 2. Robot Control GUI

We will use the interface of the tele-operation as the radio-control transmitter or PS3 controller, and the grand-station will receive the control signal from those interfaces and it will send the signal to RasberryPi of UAV. Then, the RasberryPi will transmit the control signal to the Arduino(1), and the Arduino(1) will transmit the control signal to APM (flight controller) as the PWM. Finally, the APM will control each motor driver of the UAV.

Fig 3. Controller1

Fig 4. Controller2

・4-1 Communications ethod

Controller - PC (Grand): transfer the amount operated by USB communication.
PC (Grand) - RaspberryPi: IEEE802.11a / n to directly manipulate the RaspberryPi by remote desktop.
RaspberryPi - Arduino (1): transfer the operation from the ground by the serial communication.
Arduino (1) - APM: control the motor by the PWM output.

・4-2 Raspberry Pi

We will use the RaspberryPi for the communication and Camera control. Because the Linux OS is installed in RaspberryPi, the Camera, IEEE802.11a/n wireless standard and TCP/IP protocol can be used.

・4-3 Arduino(1)

The Arduino(1) has two purpose, and first one is to do the communication between the Raspberry Pi and APM. The second one is to control the arm that can find the victims by own sensors. The Actuator is the servo motor to control the arms of UAV. Sensor (1) will be mentioned in 6-3 and 7.

5. Map generation/printing

We believe that it is available aerial photographs taken from the sky a disaster area as MAP. This is because it is difficult to UGV, it can be said to be a great advantage of the UAV. Aerial photos is easy to image the scene for reality to the faithful than the illustrations. As actual results of laboratory, we have been successful in creating a 3DMAP of farmland is outdoor environment.

Furthermore, by performing image processing, we believe that it is possible to more clearly express the disaster site. Specifically, it is a strategy that will continue to develop even a technique for marking a wall from aerial photographs. Also, it displays the self-position in real time on a map that is generated from the aerial photograph, when it is found the victim is being investigated a technique for recording.

6. Sensors for Navigation and Localization

We represent the stable control method of the UAV, and Web camera, APM, and ultrasonic sensor. The descriptions of these devices are as follows:

・6-1 APM

The APM unit is the microcomputer composed of 3D accelerometer, 3D gyroscope, 3D magnetometers, barometer. We can program the APM by using the Arduino as the open source environment, and easily to control the UAV based on it.

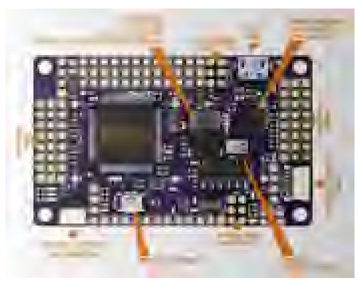

Fig 5. APM

・6-2 Webcam

Fig 6. Webcam

Specifications:
2M pixels (1920 * 1080pixel)
120 ° wide-angle glass lens F value : 2.8
USB connection WEBcamera
Weight : about 210g

・6-3 US sensor

The ultrasonic sensor is observe the distance from the UAV and the ground/wall etc, and this distance information can be used for stable hovering. The stable hovering of UAV is useful for the precise works for the victim rescue.

Fig 7. US sensor

Specifications:
Power supply voltage : 2.5 ~ 5.5[V]
Current consumption : [2mA]
Measurement frequency : 20 times / 1 [s]
Size: vertical 22.1[mm] × 19.9[mm] × width thickness 16.4[mm]
Weight: 4.3 [g]

7. Sensors for Victim Identification

We will try to get more detailed information of victims by using temperature sensor, CO_2 sensor, camera, LED, and microphone.

・7-1 We will use the temperature sensor as follows:

Fig 8. temperture sensor

Specifications:
· SMBus compatible digital interface
· There PWM output function
· High accuracy of 0.5 ° C over wide temperature range (0 to + 50 ° C for both Ta and To)
· Measurement resolution of 0.02 ° C

・7-2 We will use the CO_2 sensor as follows:

Fig 9. CO_2 sensor

・**7-3 We will use the CO2 sensor as follows:**

For tight spot, we will use the following camera and in that time, we will use LED under the low illumination condition that are often appear din the disaster management.

Fig 10. camera module

Specifications:
Fixed focus
5 megapixel (2592 × 1944)
Maximum Video Resolution : 1080 p
Maximum frame rate : 30 [fps]
Size : 20 × 25 × 10[mm]
Weight : 2[g]

・**7-4 We will use the standard microphone as follows:**

Fig 11. microphone

8. Robot Locomotion

We will show the detailed technical specs of our UAV. Our UAV, especially body is composed of CFRP frames and developed by ourself. The UAV has four propellers, high performance motors, and Li-PO 3S 4000mAh x 2. That is why, our UAV is small and lightweight 1kg, and high kinetic performance.

Fig 12. UAV Robot pic.

Fig 13. UAV Robot CAD

9. Other Mechanisms

・**9-1** Arm

Is inserted in a narrow space , to mount the arms as shown in Fig.7 to verify the presence and condition of the victims . Arm has high flexibility because it has three servo motors . The tip of the arm is attached each sensor, such as a temperature sensor that was introduced in the previous item .

Fig 14. UAV Robot arm CAD

・**9-2 For safety**

For safety, we will use propeller guard, correspondence in the case of communication lost, or run out of battery. Here, we will make the propeller guard shown in CAD Sec.8.

In the case of communication lost or noise or we receive abnormal signal, the UAV stay for a while. If the communication cannot be recovered, the UAV is landed automatically, by Arduino (1). To avoid the run-out of battery, the RaspberryPi always checks the battery level and shows such the information to operator. Furthermore, if operator loose the control, the RaspberryPi automatically controls the UAV to avoid the crash.

10. Team Training for Operation (Human Factors)

We need the flight training by using the controller that is used in real competition, also, the stable hovering of UAV and control of arms. The operator should know the detailed technical specs of the UAV and consider the communication delay and occlusion problem of camera.

11. Possibility for Practical Application to Real Disaster Site

We have not test the UAV in the real environment of disaster, however, if we will confirm the applicability of our UAV through the Robocup2015, we will try to apply our system to real environment.

12. System Cost

Described the approximate costs required to make the robot

Table 2. System cost

Name	Part	Price in JPY	Number	Price Total in JPY
RobotFrame	Material&processing	200000	1	200000
Battery	Hyperion Li-Po 3S 4000mAh	7000	6	42000
FlightController	APM2.5	20000	1	20000
Motordriver	ESC 30A	2000	4	8000
Motor	T-MOTOR MN3110-17 700KV	12000	4	48000
Feather	XSC1155TM MCCPT	2400	2	4800
Camera1	BSW20KM11BK	3000	1	3000
Camera2	Camera Module for Raspberry Pi	4000	1	4000

RaspberryPi	RaspberryPi B+	4700	1	4700
Arduino	Arduino UNO	3500	1	3500
WLANrouter	WHR-1166DHP	4400	1	4400
WLANadapter	GW-USNANO2A	1000	1	1000
CO2 ensor	ANXS-GAS	2500	1	2500
US sensor	LV-EZ1	3700	5	18500
Temperture sensor	MLX90614	2000	1	2000
Controller	DUALSHOCK3	6000	1	6000
Servo motor	WR-MG90S-SET	1900	2	3800
Servo motor	S03T/2BBMG/J	1600	1	1600
Total			JPY	377800

References

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