# RoboCup Rescue 2016 Team Description Paper Flyrene

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**Info**

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|---|---|
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RoboCup Rescue 2016 TDP collection:
https://to-be-announced.org

*Abstract*—**The Flyrene operates a UAV with a passive rotating spherical shell. The shell protects the UAV and also enables another ground locomotion with lower power consumption. The UAV carries a spherical camera and a laser range finder for obtaining visual and map information.**

*Index Terms*—**RoboCup Rescue, Team Description Paper,UAV, Ground and Air Locomotion**

## I. Introduction

OUR goal in the RoboCupRescue 2016 is to evaluate an unmanned aerial vehicle (UAV) with a passive rotating spherical shell, or a PRSS UAV [1]. The PRSS UAV, depicted in the figure 1, is specialized for search-and-rescue or inspection missions that require robots to explore narrow spaces and negotiate high obstacles because of the protection by the shell and the flying ability as an UAV. Furthermore, the PRSS UAV can roll on the ground with lower power consumption by using the shell like a wheel because the 3-DoF (degrees of freedom) gimbal between the UAV and the shell allows them to be independently rotate.

## II. System Description (TO BE UPDATED)

### A. Hardware

As shown in the figure 1, the hardware of the PRSS UAV can be devided into three parts; an internal UAV, a 3-DoF gimbal, and a spherical shell. The specification of the PRSS UAV are listed in the table I.

Because of those unique components, the PRSS UAV has two modals of locomotions; flying in the air and rolling on the ground. The former will be used to negotiate obstacles difficult to be got over. The latter will be used to move on relatively flat ground. In the RoboCupRescue 2016, we will use the both modals in a complementary manner.

The internal UAV is the only part powered by a battery. The battery supplies the power to all electric devices on the UAV. The gimbal and the shell are passive mechanisms and never consume the electric power.

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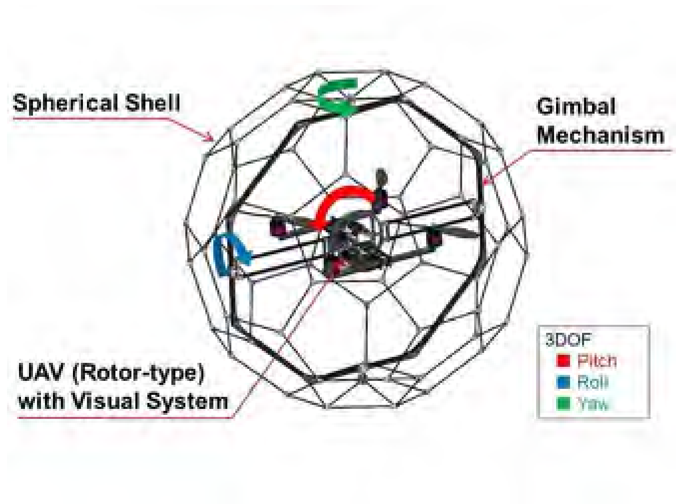


Fig. 1. The PRSS UAV can be devided into three parts; an internal UAV, a 3-DoF gimbal, and a shell. The structure of the shell is so-called fullerene, which gave us an idea of the team name. An introduction video of the PRSS UAV is available at https://youtu.be/c1fMsK-qBX4

All electric devices on the UAV are related to the propulsion or the information collection. A RC receiver, a flight controller, motor drivers, motors and propellers drive the UAV. A spherical camera, a laser range finder (LRF), and a single board computer collect visual or map information. The table III shows a hardware components list.

Some of electric devices are sensors and computers. The flight controller contains an IMU and a micro-controller for measuring or controlling the posture of the UAV. The single board computer records and transmits the visual inforation from the spherical camera and the local map information from the LRF.

### B. Software

The software is distributed in the flight controller, the single board computer on the UAV, and the laptop in the operator station. In this section, we will forcus the software in the last two devices because we use an off-the-self flight controller and have never modified its firmware. Some parts of the software we have developped depends on open-source packages listed in the table IV.

**ITEMS REGARDING REMAINING PARTS IN THIS SECTION UNDER DEVELOPMENT ...**

Explain how your software works. Create relevant subsubsections as needed. You might want to explain:

- low level control
- communication protocol (video, commands, data)

- localization
- mapping
- autonomy
- victim detection
- path planning
- navigation
- arm control
- arm planning
- ...

### C. Communication

**ITEMS REGARDING THIS SECTION UNDER DEVELOPMENT ...**

Please use this section to describe your plan for communicating with your robots (passive tether, active tether, radio, etc.) Double check the rules regarding restrictions and rules!

### D. Human-Robot Interface

**ITEMS REGARDING THIS SECTION UNDER DEVELOPMENT ...**

Explain how your robot is controlled. What does the operator see? In which ways can he interact with the robot? Also describe how a potential user should be trained and how you trained the operator for your team.

## III. Application (TO BE UPDATED)

This section covers the practical aspects of your system...

### A. Set-up and Break-Down

Please use this section to describe your plan for set-up and break-down of your the robots and the operator station.

### B. Mission Strategy

If not already covered in the Introduction, explain your overall strategy to the RoboCup Rescue Challenge. Also mention what you cannot or don't want to do.

### C. Experiments

Explain how you verify your system. Did you build any standard test methods for testing your robot? What kind of experiments and validations did you do with your hardware/ software/ overall systems? What did you learn?

### D. Application in the Field

Discuss how your system is applicable to the field of search and rescue. Where are its strength and weaknesses? What do you think would be possible to improve in the near and medium future towards using it in real scenarios?

## IV. Conclusion

The conclusion goes here. Brief summary, outlook to the competition, lessens learned from previous competitions, etc.

TABLE I
Aerial Vehicle

| Attribute | Value |
|---|---|
| Name | PRSS UAV |
| Locomotion | quadcopter |
| System Weight | 2.5 kg |
| Weight including transportation case | 5 kg ? |
| Transportation size | 1.0 x 1.0 x 1.0 m ? |
| Typical operation size | 0.8 x 0.8 x 0.8 m |
| Unpack and assembly time | 10 min |
| Startup time (off to full operation) | 3 min |
| Power consumption (idle/ typical/ max) | 20 / 300 / 400 W |
| Battery endurance (idle/ normal/ heavy load) | 200 / 7.5 / 10 min |
| Maximum speed | 5 m/s |
| Payload | 0.30 kg |
| Cost | 6000 USD |

TABLE II
Operator Station

| Attribute | Value |
|---|---|
| Name | PRSS UAV operator station |
| System Weight | 3.2kg ? |
| Weight including transportation case | 4.5kg ? |
| Transportation size | 0.4 x 0.4 x 0.2 m ? |
| Typical operation size | 0.4 x 0.4 x 0.4 m ? |
| Unpack and assembly time | 1 min |
| Startup time (off to full operation) | 2 min |
| Power consumption (idle/ typical/ max) | 20 / 40 / 60 W |
| Battery endurance (idle/ normal/ heavy load) | 6 / 3 / 2 h |
| Cost | 2000 USD |

## Appendix A
## Team Members and Their Contributions

- Yoshito Okada — Management
- Akihiro Ishii — Mechanical design
- Xiang Xiang — Mechanical design
- Carl John O. Salaan — Mechanical advice
- Takuma Ishii — Mechanical advice
- Akito Nomura — Software design
- Tatsuya Hoshi — Software design

## Appendix B
## CAD Drawings

See the figure 1 for a CAD drawing.

## Appendix C
## Lists

### A. Systems List

The system consists of an aerial vehicle and an operator station. See the tables I and II for details of them.

### B. Hardware Components List

See the table III for hardware components.

### C. Software List

See the table IV for software packages.

## Acknowledgment

This paper is partially based on results obtained from a project commissioned by the New Energy and Industrial Technology Development Organization (NEDO).

TABLE III
HARDWARE COMPONENTS LIST

| Part | Brand & Model | Unit Price | Num. |
|---|---|---|---|
| Drive motors | Maxon RE 50 200 W | CHF 870 | 4 |
| Motor drivers | | ? | 4 |
| Battery | TP7800-3SP+25 | ? | 1 |
| Computing Unit | Intel Edision | ? | 1 |
| WiFi Adapter | Built in computing unit | - | - |
| Flight Controller | DJI NAZA-M V2 | ? | 1 |
| IMU | Built in flight controller | - | - |
| Spherical Camera | RECOH THETA S | ? | 1 |
| LRF | Hokuyo UST-20LX | - | 1 |
| Battery Chargers | TP1430C | ? | 1 |
| Aerial Vehicle | enRoute EX450 | ? | 1 |
| Rugged Operator Laptop | ? | ? | 1 |

TABLE IV
SOFTWARE LIST

| Name | Version | License | Usage |
|---|---|---|---|
| Ubuntu [2] | 14.04 | open | OS |
| ROS [3] | jade | BSD | Middleware |
| OpenCV [4] | 2.4.8 | BSD | Spherical image prcessing |
| PRSS UAV GUI | 0.7 | closed source | Operator station |

## REFERENCES


[1] S. Mizutani, Y. Okada, C. J. Salaan, T. Ishii, K. Ohno, and S. Tadokoro, “Proposal and Experimental Validation of a Design Strategy for a UAV with a Passive Rotating Spherical Shell,” in *2015 IEEE/RSJ International Conference on Intelligent Robots and Systems*, 2015.

[2] “Ubuntu Official Website.” [Online]. Available: http://www.ubuntu.com/

[3] “ROS Official Website.” [Online]. Available: http://www.ros.org/

[4] “OpenCV Official Website.” [Online]. Available: http://opencv.org/