Development of Swarm Robots for Disaster Mitigation Using Robotic Simulator Software

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Abstract Swarm robotics come into the picture of replacing humans on life-risking jobs because of its decentralization concept, i.e. a damaged unit do not affect the entire system performance. Airborne type swarm robotics have high flexibility since they can bypass most obstacles. Swarm robotics can be utilized to scout unknown terrain, target searching or S.A.R applications. In this project, simulation to visualize the swarm quadcopters' performance onto an assigned environment using robotic software simulator called V-REP software is presented. Robotic simulator software take account of real-life physics which increases the accuracy for simulation and retrieves reliable results from the simulation. Hence, robotic simulator software could replace real-life testing for at least initial ideas exploration to real-life situation.

Keywords Swarm robots · Quadcopter · V-REP software

1 Introduction

The main purpose of the project is to design and demonstrate swarm robots cooperation for disaster mitigation using robotic simulator software called V-REP which is available at http://www.coppeliarobotics.com. The quadcopters type is chosen due to highly flexible flying robot performing a Search-And-Rescue application on victim detection.

In addition, a robotic simulator software is required to demonstrate the performance. The software, V-REP is chosen due its variety of functional options and its utmost capability is to simulate robots under an environment. It has free version

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therefore it is a suitable software chosen for academic-based project. Before utilizing the software, a design of the quadcopter was created using a CAD software, SolidWorks. The design can be imported into V-REP for any further modifications. This project is chosen since most of researches in swarm robot applications are usually focused on development of the swarm and control algorithms [1–8].

2 Development of the Project

The finalized model in CAD software is saved as a .STL format from SolidWorks and imported into V-REP software. A camera concept is attached onto the quadcopter's lower base and a green sphere was added to provide a reference point. Once the V-REP model is finished, the relevant joints and common shapes were hidden onto another layer. They are not necessary for viewing during simulation. Figure 1 shows the finalized V-REP model design.

2.1 V-REP Environment Design

The environment in V-REP was designed using the available objects from its library. The scenario portraits a disaster environment assumed to be dangerous when accessed by humans. Other decorations include fires and trees were added. The main obstacles would be the terrains that cover the whole map. The quadcopter units will have a deploy station and a path planned route for each unit. Figure 2 shows the finalized environment.

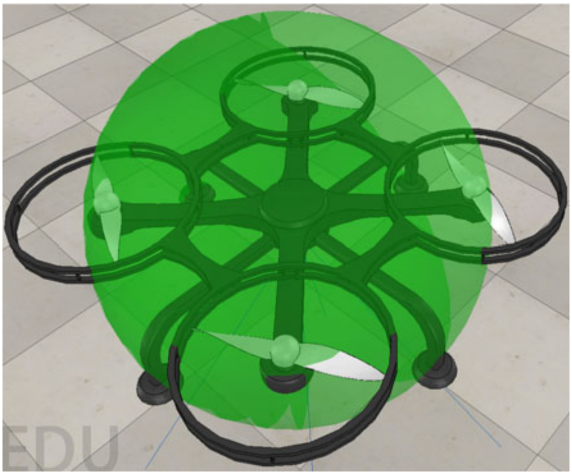

Fig. 1 Hierarchy list and quadcopter V-REP model

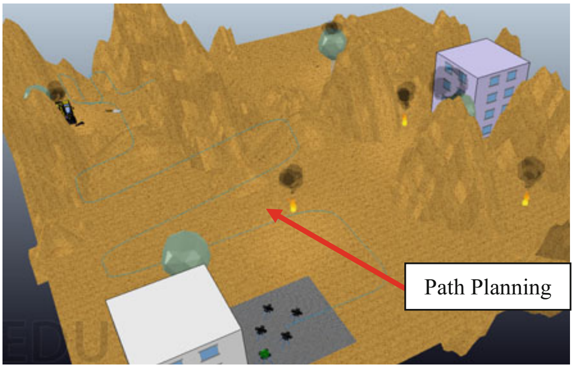

Fig. 2 V-REP environment finalized

2.2 Quadcopter Programming Algorithm

The determined algorithm will perform target-following and balancing process. The translational and rotational axis takes account of parameters such as gravity, return value velocity, rotational matrices, and mathematical functions that utilizes all these parameters. To counteract with gravitational fall, a compensation must be done to prevent the body from falling. Equation (1) below shows the sum of forces is relatively smaller than the gravitational force, *mg*, where m is body mass and *g* is gravitational accelaration.

$$\sum F = (\mathrm{mg}) + (-0.95\,\mathrm{mg}) = 0.05\,\mathrm{mg} \tag{1}$$

Note. g is a negative value by default.

Based on Eq. (2), when *control error, e,* approaches infinity, the counteracting force f would be zero. This means that at far distance between target and quadcopter, no counter forces should be applied since it is desired to reach the target at minimum time. When *control error* approaches 0, the force f will counteract with the body if it overruns the target. The law to regulate the body is achieved under translational section.

$$f = m \times -v \times \left(\frac{\mathrm{C}_1}{\mathrm{C}_1 + \left(\frac{e}{\mathrm{C}_2} \right)} \right) \tag{2}$$

where v is velocity, and C_1 and C_2 are constants found by tuning.

3 Results

3.1 Quadcopter Balancing Performance

The balancing algorithm shows the outcome in terms of displacement and velocity. All axis can be generalized in Fig. 3 below (upper figure) for displacement versus time and (lower figure) for velocity versus time.

3.2 Environment Simulation Results

The final form of detection stage would result in a triangular manner, or also known as a closed form shape to surround the detection. Figure 4 shows the final stage of detection. The final unit controlled by keyboard is also shown (attached green blob).

3.3 Camera Balancing Performance

Camera roll pitch balancing might differ from the quadcopter body because of the video quality detection set to 64-bits. However, the camera is still able to keep track of its target as shown in Fig. 5.

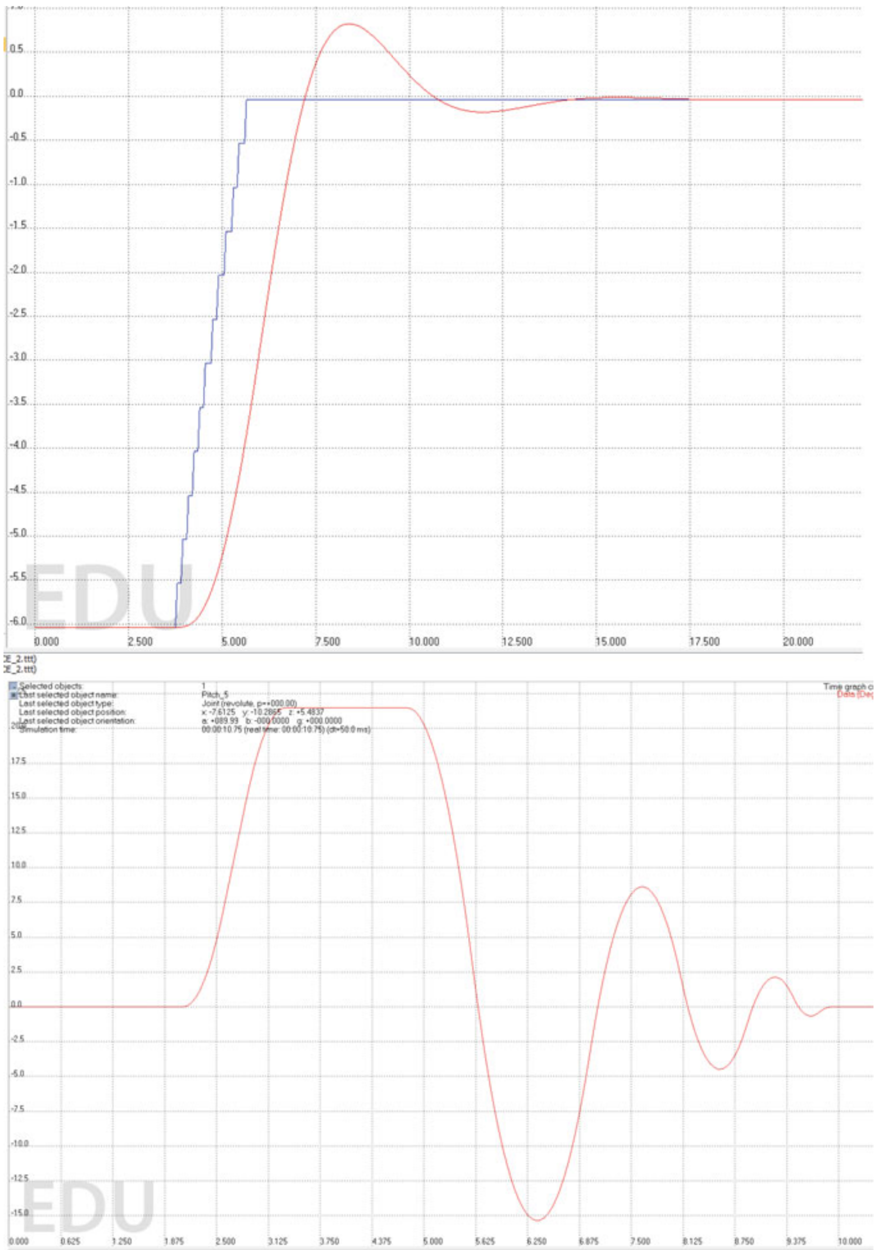

Fig. 3 Quadcopter control performance

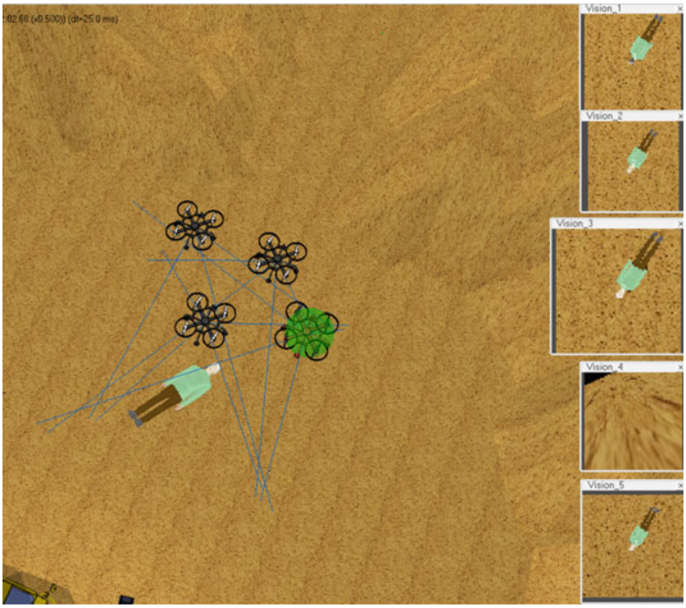

Fig. 4 Post-detection stage

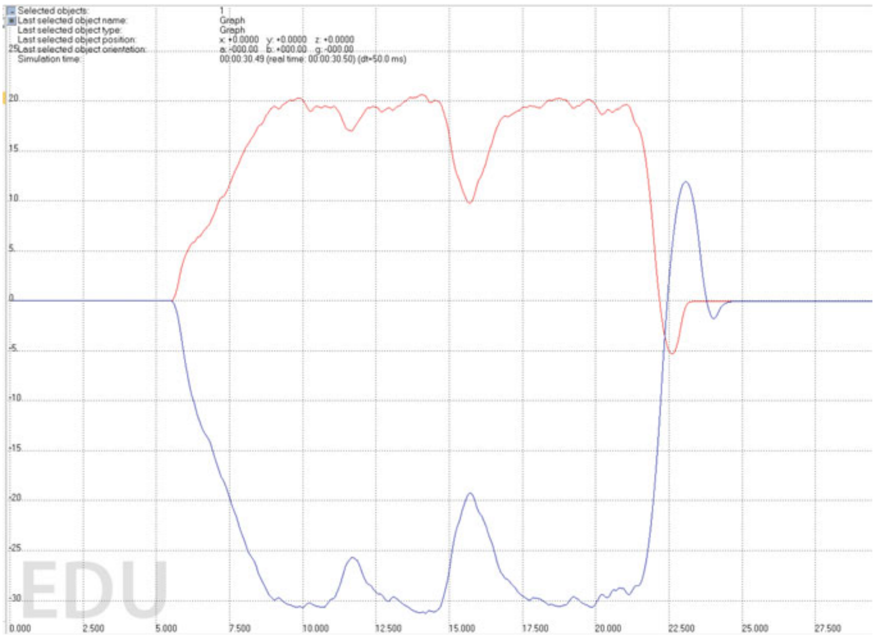

Fig. 5 Camera roll (*Red*) and pitch (*Blue*) balancing

4 Conclusions

To conclude, the quadcopter is chosen as the flying object in swarm robotics because it's highly flexible and cost efficient. Its performance can adapt to mostly disastrous conditions due to its small size and light weight. The camera concept attached mimics the thermal vision scanning. One of the available methods to illustrate this type of scanning would be colour density (RGB).

The performance of the quadcopter are heavily based on physic concepts that involves nature's effect such as inertia and gravitational. Collision safety was implemented to prevent collision with any obstacles rather than just quadcopters. Hence, the environment created will allow the quadcopter units to prove its performance based on the proposed algorithms.

Finally, this is useful demonstration to show the concept of swarm robots and their applications using V-REP software simulation. Virtual simulation for other types of robot structure and algorithms are therefore plausible in the next stage.

References

1. Kushleyev A et al (2013) Towards a swarm of agile micro quadrotors. Auton Rob 35 (4):287–300
2. Zhu X, Liu Z, Yang J (2015) Model of collaborative UAV swarm toward coordination and control mechanisms study. Proc Comput Sci 51:493–502
3. Moudy M (2012) Swarm-copters senior design project: simulating UAV swarm networks using quadcopters for search and rescue applications. Eagle Feather 9
4. Pugh J, Martinoli A (2007) Inspiring and modeling multi-robot search with particle swarm optimization. In: Swarm intelligence symposium, 2007. SIS 2007. IEEE
5. Stormont DP, Kutiyanawala A (2007) Localization using triangulation in swarms of autonomous rescue robots. In: IEEE international workshop on safety, security and rescue robotics, 2007. SSRR 2007
6. Chovancová A et al (2014) Mathematical modelling and parameter identification of quadrotor (a survey). Proc Eng 96:172–181
7. Tan Y, Zheng Z-Y (2013) Research advance in swarm robotics. Def Technol 9(1):18–39
8. Liu Y, Nejat G (2013) Robotic urban search and rescue: a survey from the control perspective. J Intell Rob Syst 72(2):147–165