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Author(s)	Narváez Fuertes, Eduardo
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学 位 論 文 内 容 の 要 旨

博士の専攻分野の名称 博士（工学） 氏名 Eduardo Narváez Fuertes

学 位 論 文 題 名

VTOL-UAV Docking System for Heterogeneous Multi-Robot Team
(異種ロボットチームのための VTOL-UAV ドッキングシステム)

Work by heterogeneous robot teams such as unmanned aerial vehicles (UAVs) and unmanned ground vehicles (UGVs) is extremely useful in exploration and navigation tasks of unknown environments. In particular, a team consisting of a vertical takeoff and landing unmanned aerial vehicle (VTOL-UAV) and a robust unmanned ground vehicle (UGV) can demonstrate high performance, but the problem is that the energy consumption of the VTOL-UAV is large. In this research, a sensing system and an operation platform that enable autonomous docking with an aerial robot is studied in order to realize charging work by a unmanned ground vehicle. This system allows aerial robot teams to collaborate safely and efficiently with ground robot teams for temporary energy replenishment, overcoming flight time limitations and exploring unknown environments for longer periods of time.

This dissertation is organized as follows.

Chapter 1 introduces an overview of conventional research on heterogeneous robot teams, and describes the significance of this research and problem setting.

Chapter 2 describes the docking system for VTOL-UAVs and unmanned ground vehicles equipped with manipulators. This paper proposed an automatic tracking algorithm using a camera attached to the tip of the manipulator, and showed a path generation method based on robot kinematics. The proposed method is a combination of a predictive approach and an optimized approach, and is a control method that realizes robust, safe, and reproducible docking. In this chapter, the algorithms and mathematical methods of which enables above docking are also described. After showing the flowchart of them, explains the theoretical approach for constructing the main control scheme and the steps required to execute it. Furthermore, a new docking device is devised and made it possible to realize practical docking.

In Chapter 3, in order to evaluate a heterogeneous robot team with autonomous docking function, experiments on a computer using the Robot Operating System (ROS) and Gazebo simulator, and experiments using actual robots are conducted. This experiment is designed to obtain the efficiency of the system to be calculated by measuring the distance traveled by each robot platform and detecting the relative position of the end effector and UAV marker during the tracking and contact phases. As a result, it is possible to calculate the energy consumption of the UAV inside and the energy cost for the docking process. In the simulation, heterogeneous robot team which consist of VTOL-UAV and UGV search for an unknown environment. Based on an actual robot, UGV has a docking system which consist of a 6-DOF manipulator. Furthermore, on the way to the destination, docking was executed multiple times to confirm the validity of the proposed method. Then, based on the established algorithm, an experiment with an actual machine was conducted. These results show that the docking

device devised in the above works extremely accurately.

Chapter 4 is a conclusion, summarizing this research and describing issues to be tackled in the future.