Chapter 22
A Framework for RF-Visual SLAM for Cooperative Multi-Agent System

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ABSTRACT

This chapter provides a framework for radio frequency visual simultaneous localization and mapping problems for a team of agents consisting of three blimps and beacons. In a cooperative system, each agent must establish reliable data sharing during a mission. Under these conditions, a framework was proposed which allows each agent to share the local information using peer-to-peer networking schemes. The RF-vSLAM algorithm seeks to acquire a map during navigation, simultaneously localizing itself using the map and received signal strength indicator information to predict the distance between agents. In this chapter, the authors address the problem of detection features using SIFT algorithms. The authors have considered the sea surface as the working environment. In this research, the framework consisted of two types of agents, where beacon representing the static agent and blimp representing the homogeneous mobile agent. The communication exchange between these two types of agents is an environmentally friendly monitoring system that preserves natural value of the selected area.

INTRODUCTION

Interdisciplinary field of science and technology fuse new knowledge and experiences in robotics and mechatronics. The team-based mechatronic and nature mimicking solution offer optimizes engineering solution for multi-agent system (Habib, 2007a). This research work is inspired by the bird flocks' orientation and navigation, through the ability to successfully find the destinations during the migration. Mostly, the birds' migration occurs during the day and the birds may recognize the natural landforms such as mountain ranges, rivers, and lakes. They used it as visual landmarks and form mental maps.

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Researchers have claimed that bird flocks orient more accurately than single birds (Tamm, 1981). In groups, they always have space among themselves at varying distances along with intra-group spatial relations; they have the ability to calibrate their position and orientation with each other (Nagy et al., 2010; Fernández-Juricic, Beauchamp, & Bastian, 2007; Cavagna & Giardina, 2014). Hence, this idea has been founded giving great impact to be used in the navigation mission. Thus, a team of multi-agent system offers higher potential to achieve a mission with faster completion time than a single agent.

The navigation for autonomous agents in unknown and changing environments required a map and efficient localization technique to enable them to perceive the surrounding data (Habib, 2007b). However, each design varies depending on the application requirement, types of sensors, and techniques. This work has considered the cooperative multi-agent system to be used for observation and monitoring system for the marine application. However, to navigate in the open sea space with fewer landmarks, could contribute higher uncertainty to the agents. The wind-generated waves are the most prominent feature of the ocean surface with the appearance of sporadic whitecaps that contribute to the different features representation (Kosnik and Dulov, 2011; Babanin, 2009). Therefore, the cooperative framework approach proposed here is based on landmarks-based navigation using the Simultaneous Localization and Mapping (SLAM) approach. This work introduced several beacons to act as a landmark that help the mobile agents to calibrate themselves during flight. This approach is inspired by the bird's techniques using landmarks as a navigation direction. This idea of the beacons helps the agent to detect interest point features, especially when dynamic sea surface topography is used as a background.

This chapter deals with the problem of Cooperative Simultaneous Localization and Mapping framework with the aids of vision and radio frequency signal for monitoring the coral reefs area. The term RF-vSLAM is formed as a combination of the word Radio Frequency (RF), Visual and Simultaneous localization and Mapping (SLAM). The RF-Visual SLAM means performing localization and mapping problem of navigation in an unknown environment using the camera and RF devices. In this framework, each blimp builds a local map and simultaneously localizes using the maps. In addition, each blimp is able to check their way point with the help of beacons. The feature based approach used in this chapter utilizes the Extended Kalman Filter (EKF) estimation techniques to predict the pose of the blimp and the location of the features. The point features in the environment are extracted from monocular camera data using SIFT as detector and descriptor. The monocular camera is chosen due to payload limitation of the small size UAVs/blimp; the weight is a critical issue to be considered. This works also deals with dynamic environment of the sea surface topography and dynamic objects of the beacons moving around in a watch circle radius which depending of mooring depth and length.

Background

Simultaneous localization and Mapping (SLAM) is a process in which a vehicle can build a map of an environment and at the same time use the map for localization. In SLAM, both the trajectory of the platform and the location of all landmarks are estimated online with no prior knowledge of location. Mapping now has been extended too many application domains. The domain include interiors (Marck et. al., 2014); (Choi, Kim, & Kim, 2014), (Neto et al., 2013); exteriours (Lu, Hu, & Uchimura, 2009); (Cho, Beag, & Park, 2013), aerial (Bershadsky & Johnson, 2013) ;(Fossel et al., 2013) and underwater (Pfingsthorn et al., 2013); (Burguera, Oliver, & Gonzalez, 2010); (Mallios et al., 2014); (Fairfiled, Kantor, & Wettergreen, 2007). However, the selection of SLAM technique depends on several factors such as type of sensors involved, environment explore, mapping types, data association method and platform