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A Multimodal MAV for Situational Awareness in Near-Earth Environments

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1 Introduction

Small Unmanned Air Vehicles (UAVs) such as AeroVironments Puma, are designed for military support at the tactical level. These miniature UAVs can be rapidly deployed via a hand or bungee launch. Most commercial unmanned aircraft currently in service are autonomous in the sense that they can be programmed to follow GPS waypoint routes and can be updated in mid-flight. Typical missions include surveillance, reconnaissance, bomb damage assessment, and search and rescue. Although most missions are carried out at extremely low altitudes (e.g. 20100 meters), the UAV flight control systems do not have collision avoidance capabilities. Furthermore, flight in these low altitude or near-Earth environments, such as urban areas and mountainous terrain, often degrade GPS signals.

Autonomous flight in near-Earth environments requires a system with high maneuverability, endurance, slow cruise velocity, and novel sensing and collision avoidance techniques. Some groups are investigating flight in indoor or cluttered areas [3] [4] and others are focusing on the outskirts of urban environments [1] [2]. The focus of this research is to bridge the gap between the two communities and develop a system capable of flying in both domains. This adds an additional design constraint in that the aircraft must be small enough to fit through narrow openings and passageways such as doorways.

Prototyping an unmanned aircraft to fly in near-Earth environments requires a maneuverable aircraft to avoid collisions in densely populated obstacle fields. To meet this design specification, a secondary flight mode was incorporated into a fixed-wing aircraft to preserve its endurance and maneuverability while adding the capability of hovering. This novel MAV platform is well suited for flight in near-Earth environments as the hovering flight mode can be used to navigate in and around urban environments (see Fig. 1). Autonomous control of the secondary flight mode and the transition into it is achieved using a quaternion feedback controller. Quaternions are not vulnerable to singularities at 90 degrees and thus can be used to control the aircraft in its high-alpha flight mode. Finally, an infrared and ultrasonic sensor suite is applied to circumnavigate buildings and detect doorways. Upon detection, the control algorithm implements reactive path planning to traverse them autonomously. Entering a dangerous environment to gather intelligence autonomously is the ultimate goal of this research and will provide an invaluable resource to any command and control team.

Figure 1: A fixed-wing MAV transitions to hovering mode to gently maneuver itself through a small opening of an urban structure. *Inset*: once inside, the onboard wireless camera is used to capture and transmit surveillance images.

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