Title

Human-Aided Collaborative Air-Ground Robotic Systems for Large Outdoor Environments

Abstract

The collaborative robotics industry, currently valued at nearly $1.4 billion, is anticipated to witness a remarkable growth rate of 30% over the next seven years. This growth is underscored by the expanding application of robotics in agriculture, a sector already boasting a $7 billion market size, and the increasing demand for automation in material handling and ground movement, identified by McKinsey as a key industrial automation use case. The integration of Unmanned Aerial Vehicles (UAVs) with Unmanned Ground Vehicles (UGVs) epitomizes the potential of collaborative robotics, offering enhanced navigational effectiveness and decision-making capabilities through rich aerial data. This not only enables rapid environmental mapping but also significantly expands operational coverage areas, presenting a compelling case for the accelerated adoption of air-ground collaborative systems. Despite occupying a relatively small market share currently, the unique advantages and untapped potential of UAV-assisted ground vehicles suggest that the adoption rate of these technologies may surpass current expectations, which has already helped to begin a new era of efficiency and innovation in robotics.

This thesis explores the integration of Unmanned Aerial Vehicles (UAVs) and Unmanned Ground Vehicles (UGVs) in collaborative robotics to achieve efficient and accurate large-scale outdoor mapping and navigation. Addressing challenges in autonomous exploration and navigation, the study develops a novel system that leverages online aerial Simultaneous Localization and Mapping (SLAM), semantic labelling, and advanced localization techniques using GPS and 2D lidar. Employing standard Robot Operating System (ROS) packages for seamless planning and navigation, this research not only advances the capabilities of individual UAV and UGV systems but also demonstrates the enhanced performance and utility of their integration. Through comprehensive experiments and analyses, the system showcases significant improvements in environmental mapping and autonomous navigation, contributing to the fields of robotics and autonomous systems.

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