Real Time UAV Teleoperation and Collision Avoidance using Potential Fields in Underground Mines

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Abstract

An Unmanned Aerial Vehicle is equipped for remote operation in an underground mining environment. Strict spacial constraints require active collision avoidance to preserve the Unmanned Aerial Vehicle. Previous literature identifies the Artificial Potential Field algorithm as a candidate for local collision avoidance. The artificial field models obstacles as a repulsive force acting on the vehicle, while the pilot provides an attractive force. Thus, the net effect of these artificial forces is to avoid obstacles and follow pilot commands. However, computing the requisite gains that will prevent collisions while providing pilot authority is previously performed through trial and error. This study aims to develop a tuning methodology to determine these gains given some knowledge about the Unmanned Aerial Vehicle, environment and sensing stack.

To test the methodology, as well as perform a physical validation of the previously-simulated success of the Artificial Potential Field algorithm, an Unmanned Aerial Vehicle is equipped with **LiDAR!** and onboard computing. The Unmanned Aerial Vehicle is then flown amongst simple obstacle configurations to confirm the interactions between the Artificial Potential Field algorithm, the tuning methodology and the obstacle. The Unmanned Aerial Vehicle avoided a 0.4 m wide box in the direct piloted path with a minimum proximity of 0.77 m, and safely passes through a 2.2 m wide gap in a wall of obstacles with a minimum proximity of 1.1 m. The Unmanned Aerial Vehicle is also flown for 10 m in a mock mine tunnel 3 m wide without collision, but with oscillatory motion. By reducing the gains through the tuning methodology, the oscillations are largely damped.

These results suggest that the Artificial Potential Field algorithm is a suitable candidate for collision avoidance, confirming the simulated results. The tuning methodology is also verified on a physical platform, with the caveat being the inverse relationship between collision risk and pilot authority.