

# A Reinforcement Learning Approach to Control of a Quadrotor Biplane Tailsitter for Adaptive Landing Maneuvers

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## ABSTRACT

This paper presents a reinforcement learning (RL) based trajectory planning and control architecture for autonomous landing maneuvers of a quadrotor biplane tailsitter (QRBP). The RL controller replaces a gradient-descent based optimal trajectory planner and outer loop position controller of a standard QRBP control system, while retaining the inner loop for regulating attitude dynamics. The RL agents are trained in a simulated environment, using a curriculum learning approach for training an RL agent capable of landing on a moving Unmanned Ground Vehicle (UGV) with changing velocity. The RL architecture is capable of generating landing trajectories onto a moving ground vehicle, with computational costs suitable for real-time implementation. Further, the RL guidance architecture successfully completes the landing mission more consistently compared to a gradient-descent based guidance architecture when there is uncertainty in the path of the UGV.

## INTRODUCTION

Unmanned Aerial Systems (UASs) are seeing a growing interest as a technology that can overcome delivery, mobility, and sensing challenges for a variety of applications (Refs. 1, 2). While the majority of research and application has been focused on pure fixed wing or vertical take-off and landing (VTOL) platforms, an emerging research area involves transitioning, or hybrid UASs. These hybrid configurations incorporate the benefits of both fixed wing and VTOL aircraft, resulting in aerial vehicles that demonstrate the hovering and infrastructure-free takeoff/landing capabilities inherent to VTOL aircraft, alongside the efficient cruise operation and improved forward flight maneuverability inherent to fixed wing aircraft (Ref. 3). The tailsitter is a class of hybrid UAS that transitions between flight modes via a rigid body rotation, and is of particular interest due to the mechanical simplicity of the transition maneuver (Ref. 4). A specific example of a tailsitter UAV aircraft is the Quadrotor Biplane (QRBP), which incorporates two parallel wing sections mounted under four rotors in a quadrotor configuration (Ref. 5). The specific QRBP design used for this paper is the 3 lb. Common Research Configuration (CRC-3), which is depicted in Fig. 1.

The transition between flight regimes for tailsitter platforms involves complex aerodynamics, so a focus on autonomous guidance and control of the QRBP is vital for practical appli-



Figure 1: The 3 lb. Common Research Configuration (CRC-3) (Ref. 6)

cation of these platforms. This has been the focus of prior research efforts, such as in (Ref. 7) where Swarnkar *et al* designed a model-based control architecture based on both a quadrotor and fixed wing model approximation of the QRBP dependent on a mode-switching implementation, wherein different controllers are used to control the QRBP based on critical pitch angle. In (Ref. 8), a control architecture without

# Reinforcement Learning For Autonomous Quadrotor Helicopter

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