UniQuad: A Unified and Versatile Quadrotor Platform Series for UAV Research and Application

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***Abstract*—As quadrotors take on an increasingly diverse range of roles, researchers often need to develop new hardware platforms tailored for specific tasks, introducing significant engineering overhead. In this article, we introduce the UniQuad series, a unified and versatile quadrotor platform series that offers high flexibility to adapt to a wide range of common tasks, excellent customizability for advanced demands, and easy maintenance in case of crashes. This project is fully open-source at https://hkust-aerial-robotics.github.io/UniQuad.**

***Index Terms*—Aerial Systems: Perception and Autonomy; Aerial Systems: Applications; Engineering for Robotic Systems**

I. Introduction

Quadrotors are taking charge of an increasingly diverse range of tasks in both research topics and industrial applications, such as autonomous exploration [1], 3D reconstruction [2] and aerial delivery [3]. Different tasks may have varying requirements for the quadrotor platform in terms of equipped sensors, battery life, quadrotor size and payload capability.

Existing open-source quadrotor projects are mostly targeted at a specific emphasis and suitable for only a limited range of tasks. For example, early platforms such as ASL-Flight [4], FLA [5] and MRS [6] for autonomous flight tend to have a rather large size with a wheelbase around 500mm. This prohibits their usage in cluttered environments and limits the agent's agility. Agilicious [7] provides a high thrust-to-weight platform for agile flight tasks. The compactness achieved through a cramped hardware design restricts it to vision-based tasks using only visual sensors. Platforms with smaller dimensions [8]–[10] may not support heavier sensors like LiDAR or ferry additional payloads. As a result, research groups frequently need to develop new hardware platforms tailored for the specific task, which introduces significant engineering overhead and impedes research progress.

With the awareness of the growing diversity of quadrotor applications, we introduce a unified and versatile quadrotor platform series **UniQuad** that shares a common conceptual design with modular components. Note that the four models depicted in Fig.1 merely serve as examples of the platform series, which can be further extended and customized on your own choice. This platform series aims to alleviate engineering overhead for researchers working on diverse UAV topics and encourage reproducible real-world verification and application.

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Fig. 1. The quadrotor platforms in **UniQuad** series provided in this article, namely **Uni250L**, **Uni127C**, **Uni350CL** and **Uni250C** from left to right.

II. The UniQuad Series

The **UniQuad** series adopts a unified conceptual design along with modular components, providing versatility and flexibility for a wide range of UAV missions. Specifically, the conceptual design of the **UniQuad** series consists of three layers separated according to physical position. The *upper layer* offers spacious mounting space for various sensors, such as stereo cameras, event cameras, LiDARs and GPS units. This layer also contains an NVIDIA Jetson Orin NX[1] for high-level computational tasks, which can be substituted with other computing units such as Intel NUC, Raspberry Pi, LubanCat, etc. The *middle layer* holds the propulsion system driven by four brushless motors and the low-level flight controller Nxt-FC[2]. The *lower layer* can optionally carry additional payloads, such as gimbals or manipulators. In this article, we provide four examples of **UniQuad** series, namely **Uni127C**, **Uni250C**, **Uni250L** and **Uni350CL**, with specifications listed in Table I. For the detailed bill of material (BOM) and 3D CAD design files, please refer to the project page[3].

III. Experiments

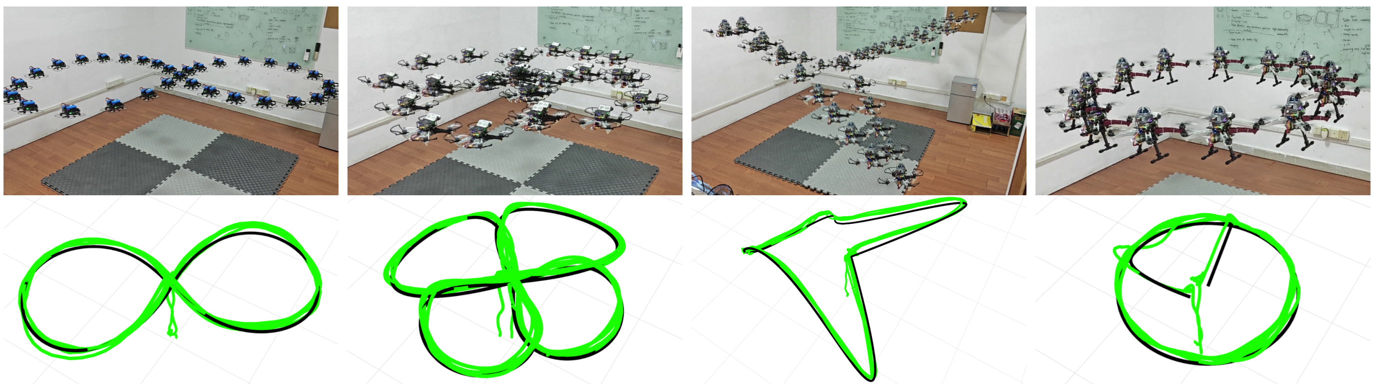
To validate the performance of the **UniQuad** series, we conduct trajectory following experiments, which is one of the fundamentals for UAV autonomous flights. During the experiments, all four **UniQuad** models are commanded to execute predefined trajectories without relying on external infrastructure such as motion capture systems or GPS. The

[1] https://www.nvidia.com/en-us/autonomous-machines/embedded-systems/jetson-orin
[2] https://github.com/HKUST-Aerial-Robotics/Nxt-FC
[3] https://hkust-aerial-robotics.github.io/UniQuad/

TABLE I
SPECIFICATION OF UNIQUAD SERIES

Model	Wheelbase	Motor†	Propeller	Weight	Battery Capacity	Equipped Sensor	TWR‡	Flight Duration
Uni127C	127mm	F1404 KV3800	Gemfan 3016	468g	4S 3000mAh 30C	Intel RealSense D430	≈ 2.77	7min
Uni250C	250mm	F60PRO KV2550	Gemfan 5043	848g	4S 2200mAh 45C	Intel RealSense D435	≈ 7.03	8.5min
Uni250L	250mm	F60PRO KV1750	Gemfan 5043	1258g	6S 3300mAh 50C	Livox LiDAR Mid-360	≈ 5.46	12min
Uni350CL	350mm	F90 KV1300	Sunnysky EOLO8	1526g	6S 3300mAh 50C	D435 & Mid-360	≈ 5.54	15.5min

† All motors are purchased from T-MOTOR (https://store.tmotor.com/categorys/f-series-motor)
‡ TWR: Thrust-to-Weight Ratio. The value is calculated using data obtained from the motor test report available on the T-MOTOR official website.



(a) **Uni127C, e=(0.04,0.02,0.03)** (b) **Uni250C, e = (0.02,0.04,0.01)** (c) **Uni250L, e = (0.02,0.04,0.03)** (d) **Uni350CL, e = (0.04,0.04,0.01)**

Fig. 2. Experiment results of the trajectory following experiments. The first row shows the composite images of the flight recordings. The second row illustrates the trajectory commands in black curves and the onboard state estimations in green curves. The average tracking errors(m) during the experiments in (x, y, z) axes are indicated in each subcaption respectively.

onboard state estimation is provided by VINS [11] for models equipped with stereo cameras and Fast-LIO [12] for LiDAR. As shown in Fig. 2, the results demonstrate that the **UniQuad** series successfully follows the trajectories with high accuracy and stability.

IV. CONCLUSIONS

This article presents the **UniQuad** series, a fully open-source and versatile quadrotor platform. This series shares a unified conceptual design with modular components, offering flexible and customizable solutions for a wide range of UAV missions. We demonstrate the **UniQuad** series' capability to track predefined trajectories with exceptional accuracy and stability. For more comprehensive tasks, the **UniQuad** series has showcased its potential in various autonomous flight projects, such as perception-aware planning [13] and autonomous exploration [1]. The **UniQuad** series is expected to serve as a valuable package, paving the path for real-world verifications and applications.

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