

Problem Description

The goal of this project is to land a drone autonomously and accurately on a safe landing pad. Our contribution to the previous work is to also leverage the gimbal-mounted camera for tracking, and to provide a new family of embeddable and computationally inexpensive April Tag markers.

Landing is a hard part of autonomous drone flight because it is risky and requires high precision. GPS alone does not provide a sufficiently accurate position estimate for landing, so we have to use other means. Fiducial markers can allow a drone to recognize a landing pad cheaply and relatively reliably. Previous methods have used a fixed, downward facing camera to identify fiducial markers on a landing pad, with the disadvantage that they can easily lose track of it. This project presents a method of autonomous fiducial landing with a gimbal-mounted camera that can track the marker, giving the advantage that the drone doesn't lose sight of the landing pad easily, but with the disadvantage that the drone must accurately detect not only the position, but also the orientation of the landing pad. The orientation is particularly hard to accurately detect because of the camera's limited pixel resolution and distortions.

Methods

Flight Control Software

DJI provides proprietary flight control software on its drones, and we interact with it through a **Mobile SDK** interface to give high level commands (i.e. ``go left," ``go forward," ``land," etc). With no input the flight control software keeps the drone almost perfectly still.

Localization & Tracking with April Tag 48h12

We use a fiducial marker system called April Tag to locate the landing pad in real time using the drone's onboard camera. The system can determine a marker's **pose** (position + orientation) in space with respect to the camera. Using coordinate system transforms, we can rotate the pose by the inverse of the pitch and roll components of the orientation, and this gives the position of the drone in the coordinate frame of landing pad (ignoring yaw). From this, we can determine which direction the drone must move in order to approach the landing pad. The drone uses the yaw of the landing pad to align itself once it is sufficiently close in order to make the landing pad easier to track. The April Tag system also determines the (x, y) pixel positions of the centers of any detected markers, which are normalized in the interval $[-1, 1]$. This makes it easy to track the landing pad (i.e. keep its (x, y) pixel positions near $(0, 0)$) so that it is centered in the camera frame and not lost during approach.

Marker System

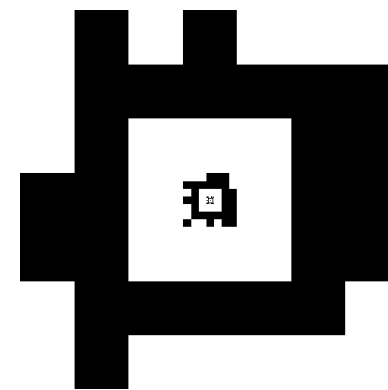


Figure 1:The landing pad with 3 embedded April Tags of the 24h10 family.

System Design & Equipment

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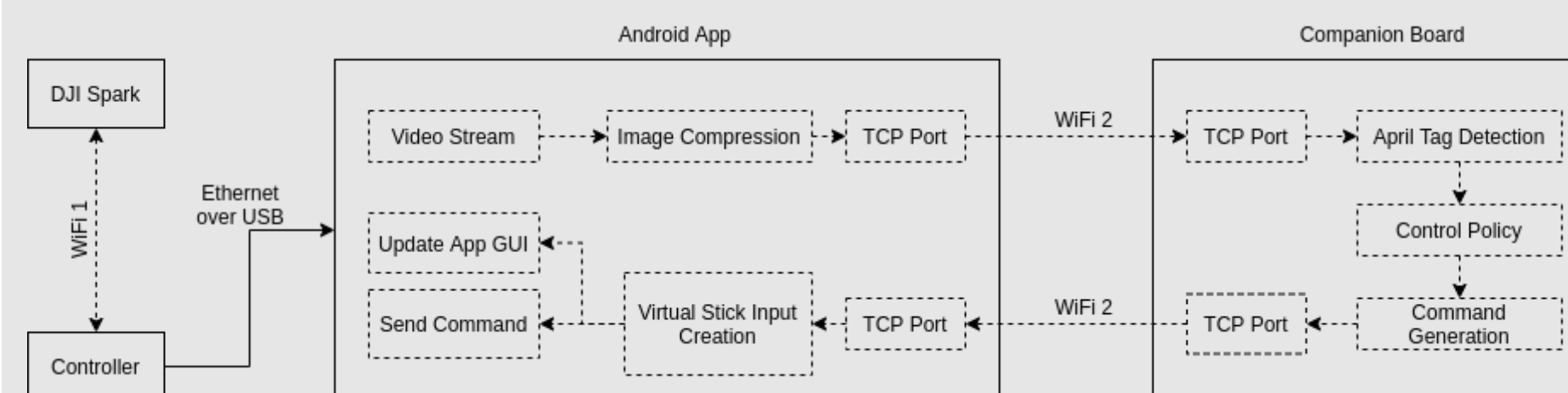


Figure 2:System data flow.

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Results

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References

- [1] Claude E. Shannon.
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