UNIVERSITY OF NEBRASKA AT OMAHA
INFORMATION SCIENCE & TECHNOLOGY

MANTIC LAB

Vision-Based Mobile Robotic Platform for Autonomous Landing of Quadcopters

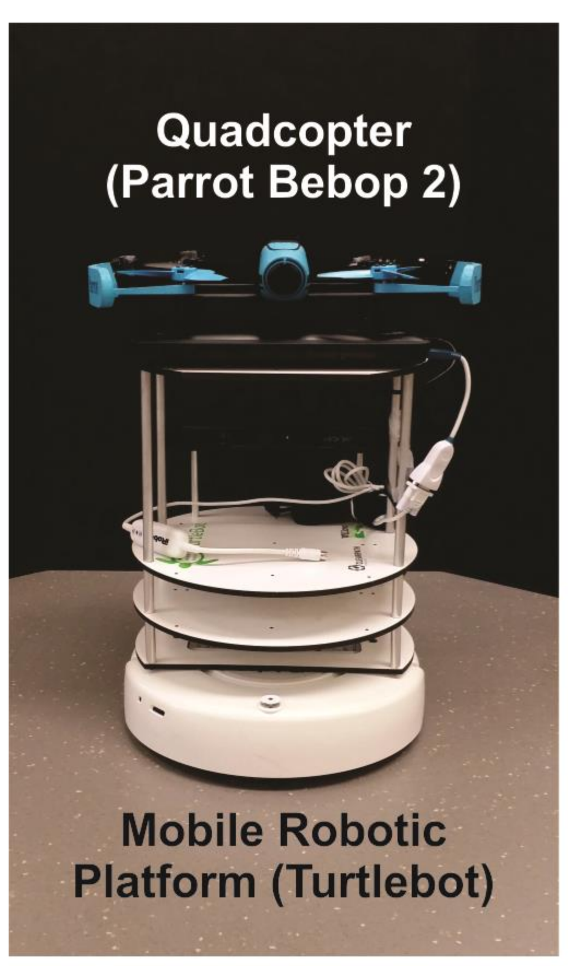
Timothy Joe[1], José Baca[2]

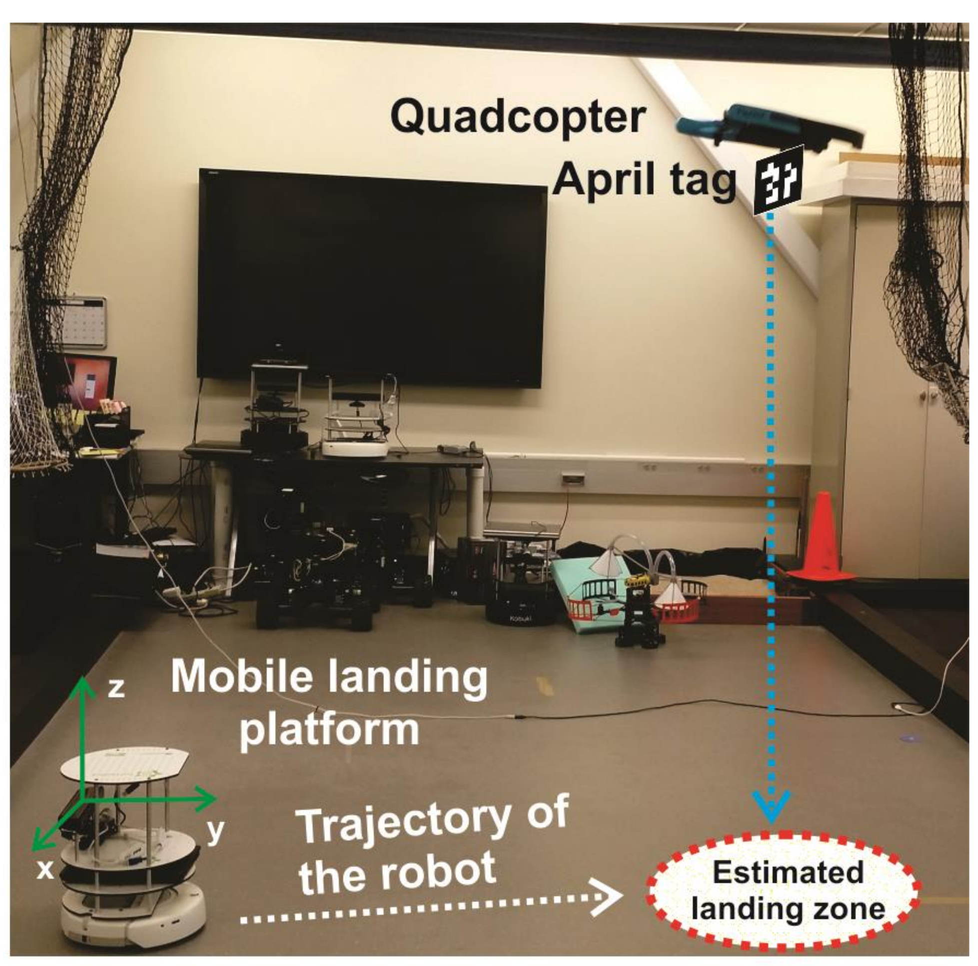
[1] Construction Management, College of Engineering, University of Nebraska-Lincoln, USA

[2] Advisor, Computer Science Department, University of Nebraska at Omaha, USA

ABSTRACT:

This project deals with the development of a vision-based control algorithm to assist quadcopters in the landing process. For demonstration purposes, the approach has been implemented in a mobile robotic platform (turtlebot). In this project, the objective is to use the mobile robot as a landing platform. The camera on-board the mobile robot detects the quadcopter (AprilTag attached to the flying robot) and keeps track of it. Based on this idea, the proposed approach estimates in real-time the landing zone. Once this zone is calculated, the mobile robot moves towards this area, stops under the quadcopter, and acts as a landing pad. Similarly, this approach can be implemented on the quadcopter to autonomously help in its landing process. The system does not only see possible usage in defense and protection of military combatants, but also in further development of communications systems between Unmanned Aerial Vehicles (UAVs) and other robotics systems.





Problem:

Modern, antipersonnel land-mines pose a huge threat against our armed forces in areas of conflict and warzones. Per recent estimates, landmines are killing and maiming more than 2000 innocent civilians per month. While mine sensor-focused research has been intensive, there has been relatively less attention given to the problem of automating the detection and removal procedure. Recently however, autonomous landmine detection using robotic systems has been increasingly researched as an alternative.

When dealing with a team of robots consisting of ground and aerial robots, the aerial robots need to land for recharging or refueling. But if the terrain is uneven or not a suitable platform for an aerial robot to land, we can autonomously position a ground robot underneath the aerial robot for it to land on. In order to do this, we have a ground robot equipped with camera and an aerial robot marked with a marker such as an AprilTag. The ground robot must use it's camera to identify the AprilTag on the aerial robot to estimate the distance it has to move and position itself as a landing platform for the aerial robot.

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APPROACH:

The vision-based algorithm combines the utilization of OpenCV (Open Source Computer Vision), Robotics Operating System (ROS), and the Turtlebot robotic platform to perform executable code and act as a mobile, robotic platform for a quadcopter. Using AprilTag detection, a camera is able to detect a small tag attached to any given surface, in this case a quadcopter. OpenCV is used to compute visual data retrieved from the camera into an interface that depicts the coordinates to the prospect quadcopter in relation to the Turtlebot. ROS then acts as an intermediary interface to allow communication between the program and the Turtlebot to coordinate the robot into the correct location.

Distance estimation to tag

Triangle similarity principle is used to find the distance from the camera to the tag. The triangle similarity principle is given by the following equation:

$$F = \frac{PD}{W}$$

where P is the pixel width of an image of a tag of width W, where the image was taken at a distance D from the camera. Once the focal length is found, we can use this to find the unknown distance (D') from the tag.

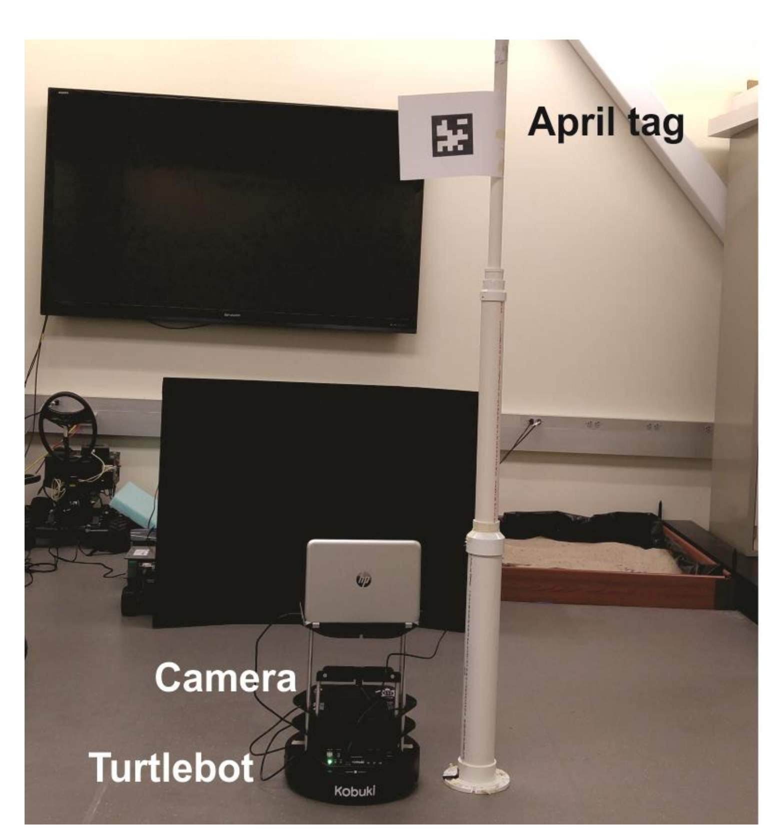
$$D' = \frac{WF}{P}$$

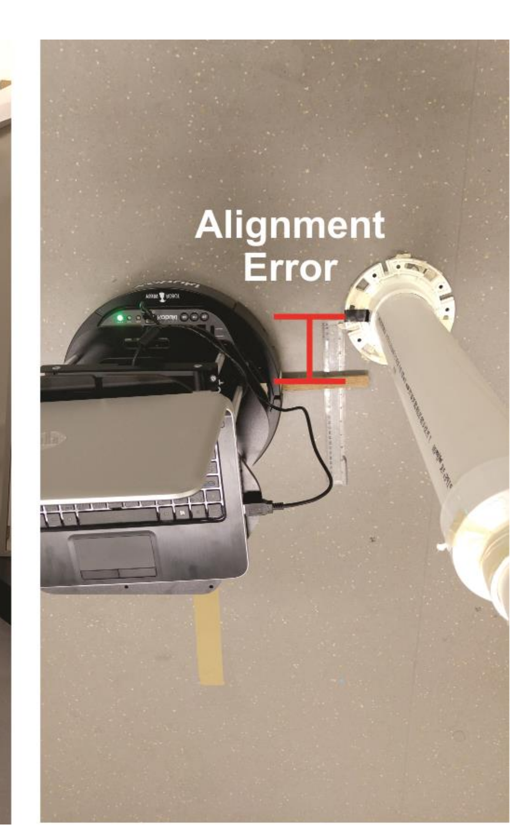
Ground distance estimation to aerial robot

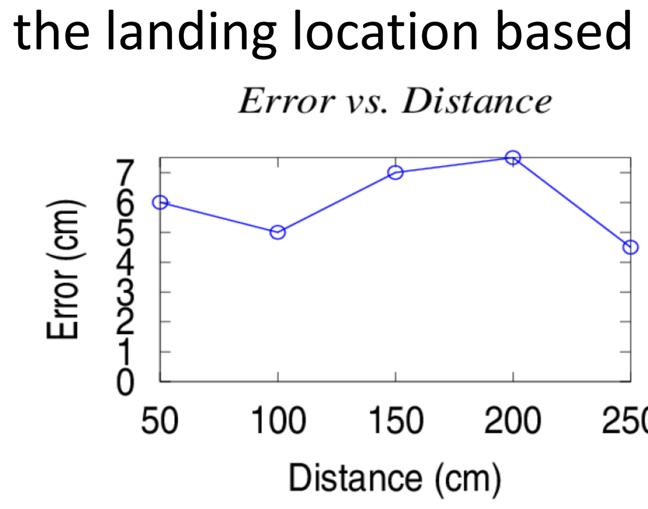
To find the distance to the aerial robot's landing location, we need to find the aerial robot's height from the ground. To do this, we will first determine a function that uses the distance of the tag from the center of our image and D', found earlier, to estimate a real world height H of the tag from the ground. The distance to the landing location can now be determined using the Pythagorean theorem:

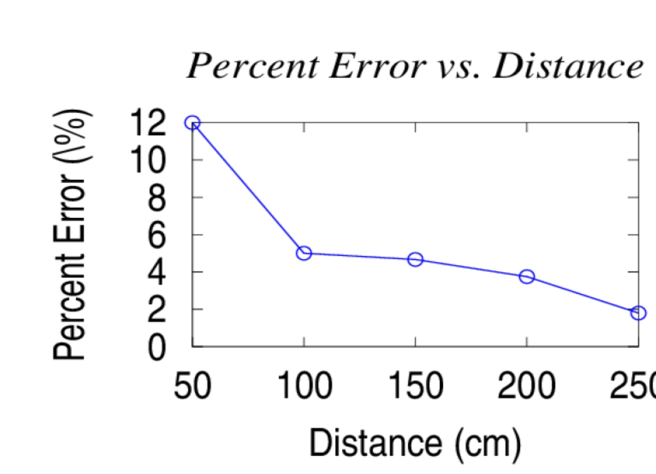
$$X = \sqrt{(D')^2 - H^2}$$

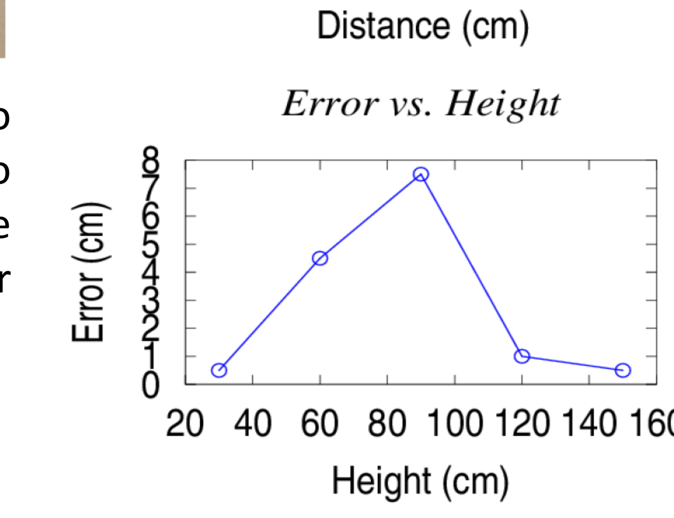
The ground robot will now use it's odometry to go to the landing location based on the estimated distance.











The objective of calculating the landing zone coordinates is to ensure that the mobile robot is taking the exact route necessary to intercept the quadcopter. The algorithm used to determine distance and coordinates shows potential of being used in other robotics systems outside of this project.

tjoe@unomaha.edu; jbacagarcia@unomaha.edu