# Precise Visual Landing Aid in GNSS-Denied Environment for VTOL UAVs

GÖRİNİŞ

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## Introduction

Unmanned Aerial Vehicles (UAVs) are frequently used in various fields for civilian and military purposes. UAVs depend on navigational aid such as Inertial Navigation System (INS) and Global Positioning System (GPS). However, in military operations like surveillance, etc. GPS could be jammed and also GPS is not sensitive enough for precise landing on a target.

This project introduces a real-time, robust, autonomous visual-based precise landing system in GPS-denied environments.

## Description

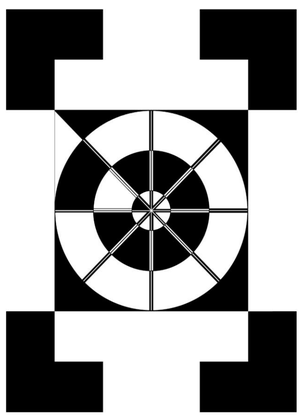
A prototype system can be constructed as follows; a downward-facing camera will be implemented at the bottom of the UAV.

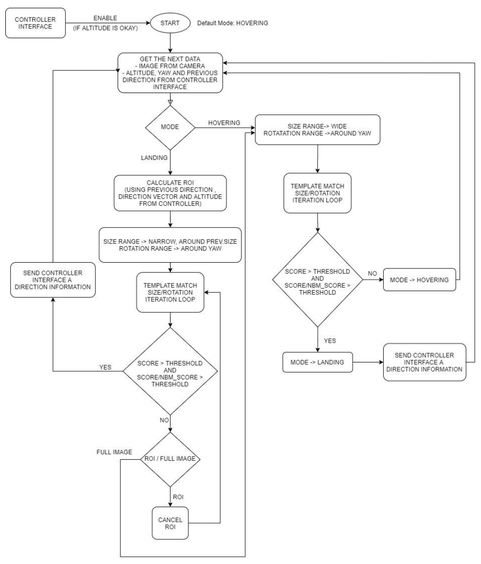
Assuming the UAV is in the range of the target landing area, it starts to take images of the ground. Using an image process based target detection algorithm, it autonomously navigates itself to the target as it loses altitude, and finally accomplishes the landing task.

## Solution Methodology

To the locate landing pad position in the image, a template-based matching technique called normalize cross-correlation is used. The working principle of NCC is cross-correlating template image within the target image. The result is a matrix of scores between 0 and 1, where the maximum score indicates most similar match between the target image and the template.

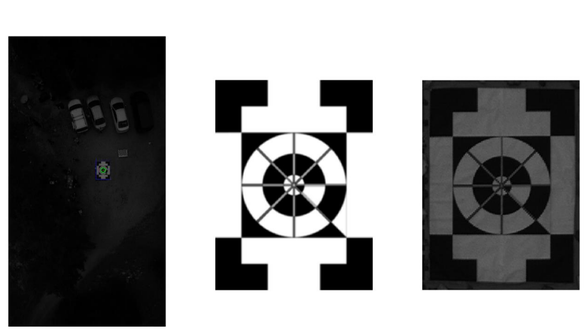
$$\gamma(u,v) = \frac{\sum_{x,y}\left[f(x,y)-\overline{f}_{u,v}\right]\left[t(x-u,y-v)-\overline{t}\right]}{\left\{\sum_{x,y}\left[f(x,y)-\overline{f}_{u,v}\right]^2\sum_{x,y}\left[t(x-u,y-v)-\overline{t}\right]^2\right\}^{0.5}}$$



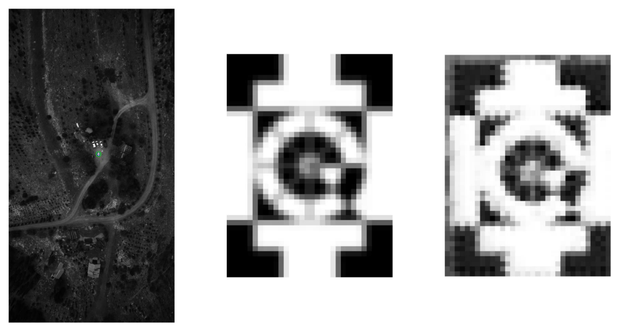



## Results and Discussion

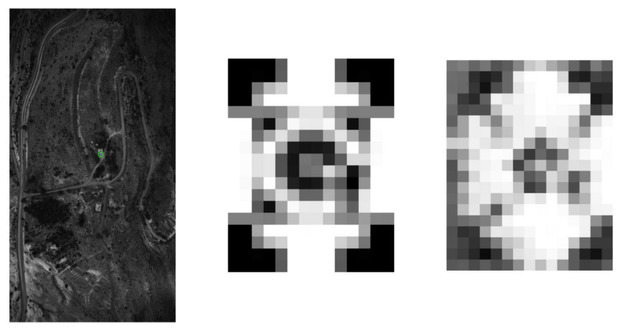
The algorithm simulated on a real dataset (provided by ESEN ) which captured from a drone flight. The landing pad is located for different altitudes. Example target images, searched templates and match results are given below.



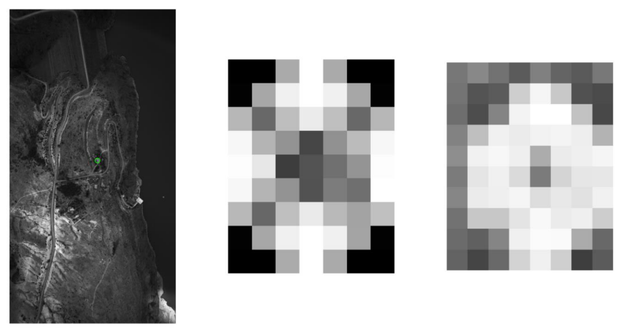
16m altitude , 72.79% match



100m altitude , 93.48% match



235m altitude , 83.00% match



500m altitude , 84.37% match

For the future work, image processing can be improved by using GPU based calculation with specialized hardware and real-time landing algorithm can be tested in an autonomous flight.

## References


- P. H. Nguyen, K.W. Kim, Y. W. Lee and K. R. Park "*Remote Marker-Based Tracking for UAV Landing Using Visible-Light Camera Sensor,*" Division of Electronics and Electrical Engineering, Dongguk University, Seoul, Korea, 2017
- Lewis, J. P., "Fast Normalized Cross-Correlation," Industrial Light & Magic, 2003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