

# Implementation Of Vision-Based Landing Target Detection For VTOL UAV Using Raspberry Pi

Ei Ei Nyein, Hla Myo Tun, Zaw Min Naing, Win Khine Moe

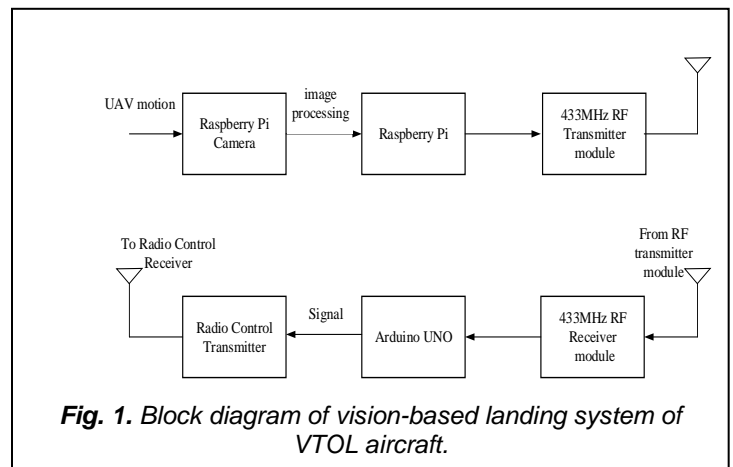
**Abstract:** This paper presents development and implementation of a real-time, vision-based landing system for VTOL UAV. We use vision for precise target detection and recognition. A UAV is equipped with the onboard raspberry pi camera to take images and raspberry pi platform to operate the image processing techniques. Today image processing is used for various applications, in this paper it is used for landing target extraction. And vision system is also used for take-off and landing function in VTOL UAV. Our landing target design is used as the helipad "H" shape. Firstly, the image is captured to detect the target by the onboard camera. Next, the capture image is operated in the onboard processor. Finally, the alert sound signal is sent to the remote control (RC) for landing VTOL UAV. The information obtained from vision system is used to navigate a safe landing. The experimental results from real tests are presented.

**Index Terms:** VTOL, Raspberry Pi, vision system, image processing, landing target, template matching.

## 1 INTRODUCTION

Recently, there has been growing interest in developing unmanned aerial vehicles (UAVs) based on vision sensors for military, agriculture, transportation, civil applications. For most of unmanned aerial vehicle, vision sensors are the basic equipment, which are also widely used during landing function. Vision-based navigation system is needed for UAV operations where GPS-denied environments. This system is designed using open source computer vision open CV library. The library is written in C, C++, python, Java, etc under windows, Linux, OSX, Android, and ios. OpenCV-Python is the Python API of OpenCV. The OpenCV library contains over 500 functions that span many areas in vision. Our system uses python language because it is a free, interpreted language available on multi-platforms including Windows, Mac and Linux. This work uses open CV program which can be integrated only with the Raspberry Pi. The main features of Raspberry Pi are Broadcom BCM 2837 Arm-53 processor (900MHz), 1GB RAM, on board USB 4.0 ports. And it has GPIO where its header consists of 40 pins. These pin could be connected to RF transmitter module for making alert signal, or even servo motor drivers. Raspberry Pi processor board is the best option for an individual interested in low cost Arm processor. It has many inbuilt features and many ports which make camera, keyboard and mouse, Wi-Fi dongle can be connected which gives the feeling of working on a system. Providing a wide range of processors based on a common architecture that delivers high performance and cost efficiency. Firstly, Linux OS is installed into the Raspberry Pi board. It has the ability to boot from Micro SD card and appropriate code is written in Python language for the target detection using the Open CV libraries. The visual data is captured by the Raspberry Pi camera and this data is processed in the Raspberry Pi processor by using image processing technique. The objective of this system is to develop vision-based landing system of vertical take-off and landing (VTOL). In this paper, camera is used as a vision sensor for UAV. Firstly, the Pi camera takes the images and then send the Raspberry Pi processor to make image processing, when the user want to land. If the camera senses the landing target, the radio frequency (RF) transmitter module transmits the 433MHz signal by using Pi board. At the ground, the radio frequency (RF) receiver module receives 433MHz signal. And then, arduino uno board alarms the sound signal by joining the receiver module. By this method, the user knows, "This is the best time to land". He commands to land via RC transmitter.

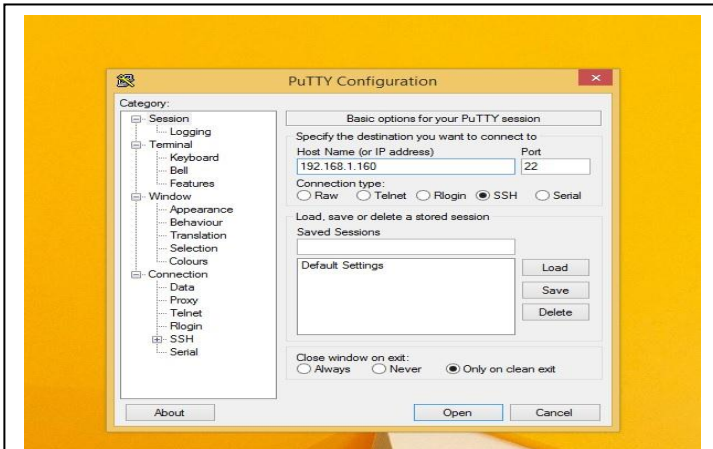
Finally, the landing function is operated. The vision-based landing system proposed in this work is presented in Figure 1.



## 2. SOFTWARE IMPLEMENTATION

In our system, Raspberry Pi is used as the main processor by using image processing techniques. The latest version of Raspbian Jessie is used on the board. Raspbian is the desired operating system for the Raspberry Pi. In order to install Raspbian operating system (OS), Raspbian and Win32DiskImager software in the computer is needed. And plug the USB memory card reader into our computer. From this software, image file or OS file is installed into the SD card via SD card reader. Firstly, Raspberry Pi processor is supplied 5V, 2A with power bank. After installing the OS to the board connect all the necessary hardware components and switch on the power supply with the power bank and starts booting up the board. We need to set up Wi-Fi network and so communicate with Wi-Fi adapter has internet access. From "ifconfig" command has IP address. In this system, IP address number is 192.168.1.160. In the same network, this IP address login with putty software. We need to write the raspberry pi by username and password to login on the terminal window via SSH protocol. Terminal in Raspbian is the equivalent of command prompt in Windows. We will use 'terminal' to execute the programs. Before the software installation Raspberry Pi system must update and upgrade the packages such as `sudo apt-get update` and `sudo apt-get upgrade`. And it must be installed the open CV library. And other packages that are used for sending and receiving signal code need to install such as 433imutils. It creates a folder as a `sudo nano`

mainprogram.py. In this file we need to write the program code according to the detection image file. Its mainly work on the python software.



**Fig. 2.** IP address via SSH protocol



**Fig.3** Connection of putty

### 3 HARDWARE IMPLEMENTATION

In this paper, some hardware components are required to perform vision-based landing system. They are

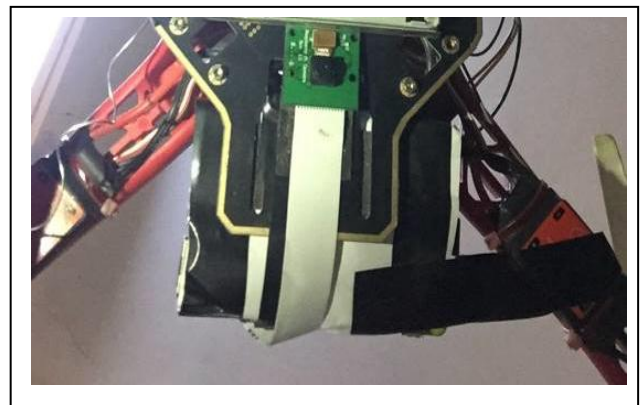
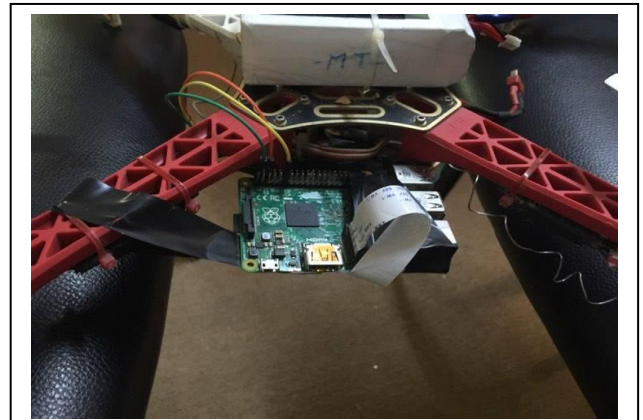
- Raspberry Pi processor
- Raspberry Pi camera
- 433MHz radio frequency (RF) transmitter/receiver module
- Arduino Uno

#### 3.1 Raspberry Pi Board and Raspberry Pi Camera Module

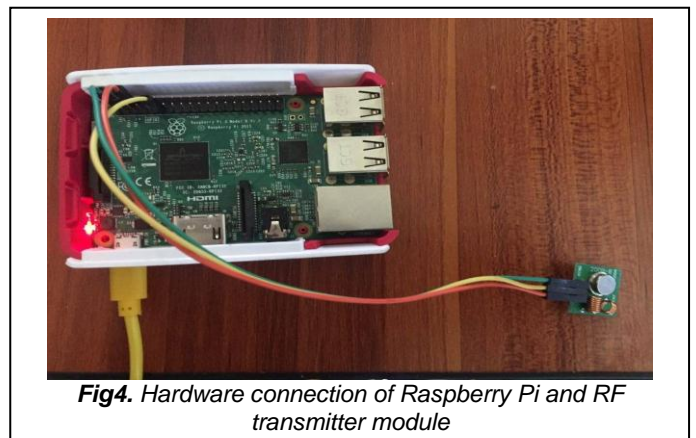
Raspberry Pi camera module is connected to BCM 2837 processor on Raspberry Pi board via camera serial interface (CSI) connector. This interface was designed especially for interfacing to cameras. Pixel data is carried from the camera back to the processor. This Pi camera has 5-megapixel resolution and maximum image transfer rate is 1080P: 30fps or 720P: 60fps. In this paper, the camera captures the images around the UAV environment with 50fps for detecting the landing target. The camera attaches to Raspberry Pi by way of a short ribbon cable on the VTOL UAV test-bed.

#### 3.2 Raspberry Pi and 433MHz RF Transmitter Module

In order to send the signal, we use 433MHz RF transmitter module and raspberry pi. This transmitter module has pin numbers 3. They are power supply, ground and data output. Physical GPIO pin number 11 connects as a data output with data pin on RF module, pin number 2 on Pi connects to voltage supply on RF module and pin number 6 connects to ground on RF module. From the raspberry pi connection is transmitted 433MHz to the arduino. We use wiring pi and a modified version of 433 Utils for raspberry pi. To send RF signals code, we use codesend.cpp from a raspberry pi to other connected devices using the GPIO pins, an arduino and a 433MHz rf transmitter/ receiver module using the terminal, Python.



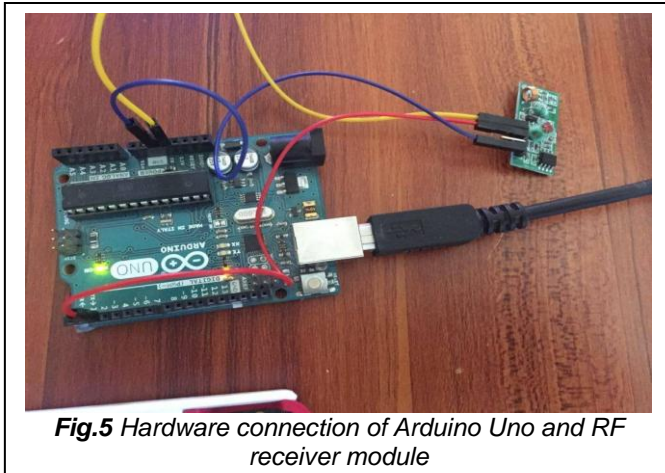
**Fig.4** Raspberry Pi camera attaches on VTOL UAV



**Fig4.** Hardware connection of Raspberry Pi and RF transmitter module

### 3.3 Arduino Uno and 433MHz RF Receiver Module

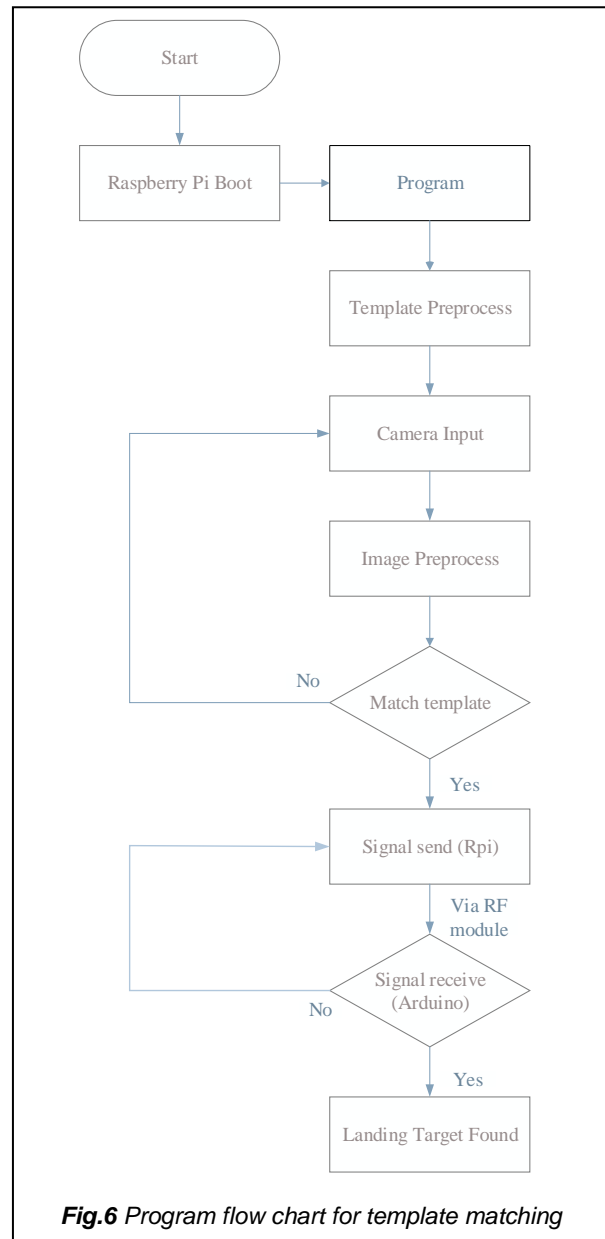
In order to receive the detected signal, we use 433MHz RF receiver module and arduino uno. Unlike Raspberry Pi, Arduino Uno pin numbers are connected directly to other devices such as RF module. Data, supply voltage and ground pin numbers are connected to RF transmitter module. Baud rate for serial communication for arduino is set to 9600bps. The detected signal code is received from the Raspberry Pi connection. At the time, the green LED is lighting up when the target is detected. We use the RC switch library on the Arduino Uno and we have to listen on the RF receiver in order to get the command. To get up running with the 433MHz rf transmitter/receiver module to send wireless RF signals.



**Fig.5** Hardware connection of Arduino Uno and RF receiver module

### 4 FLOWCHART OF VISION SYSTEM

The flow chart of vision-based target detection using template matching method is shown in figure 6. This method is used to find the location of a template image in a larger image. Template matching is a basic foundation for simple object recognition. A template is a small image. After booting the raspberry pi board the vision algorithm start run. Vision algorithm is designed by image processing method such as template matching method. This algorithm uses open CV library and python language to operate the program. The detected target shape for this case is the helipad H that is found when equality the two images First of all, the template image file is placed on the raspberry pi processor to match. This template image is resized and preprocessed by using image processing techniques. And then the input image is captured with the onboard raspberry pi camera. Before the matching process, the input image must be resized in order to be equal-sized with the template. The images are first converted to grayscale image. After that, the target can be identified by comparing with the ones in the template. And then, we compute the Canny edge representation of the image, using the exact same parameters as in the template image. Both the template and input image were matched on the edge map representations.



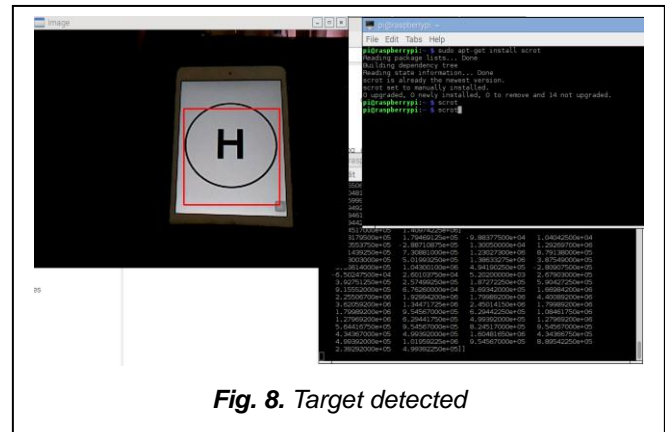
**Fig.6** Program flow chart for template matching

And then, we make a check to ensure that these two images are compared by using template matching with correlation coefficient. Correlation is a signal-matching technique. If the template image is larger than the input image, then the program will just break from the loop. If not, the program will perform matching the two images. At the time, the processor can detect the target for landing VTOL UAV. If the target is detected, the raspberry pi processor will send the alarm signal. If the target is not detected, the raspberry pi processor will not send alarm signal. Therefore the landing target found, the alarm signal is sent to the arduino board from raspberry pi processor via 433MHz RF transmitter/receiver module. The control task to land UAV is handled by the manual radio control (RC) on the ground. At the time the controller is known target ready to land for VTOL UAV.

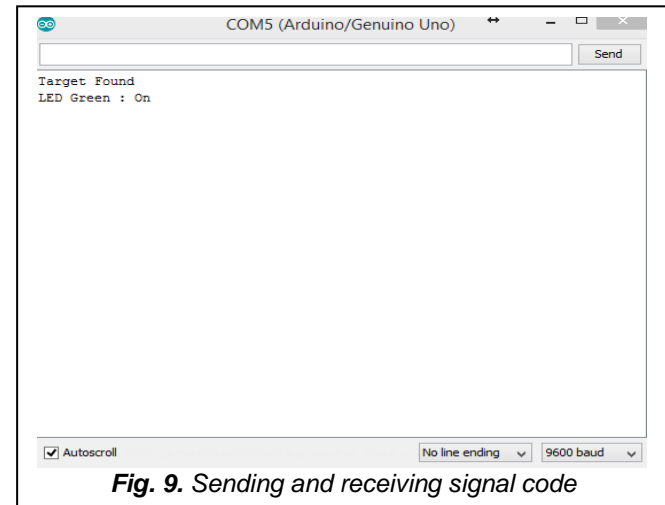


**5 EXPERIMENTAL RESULTS**

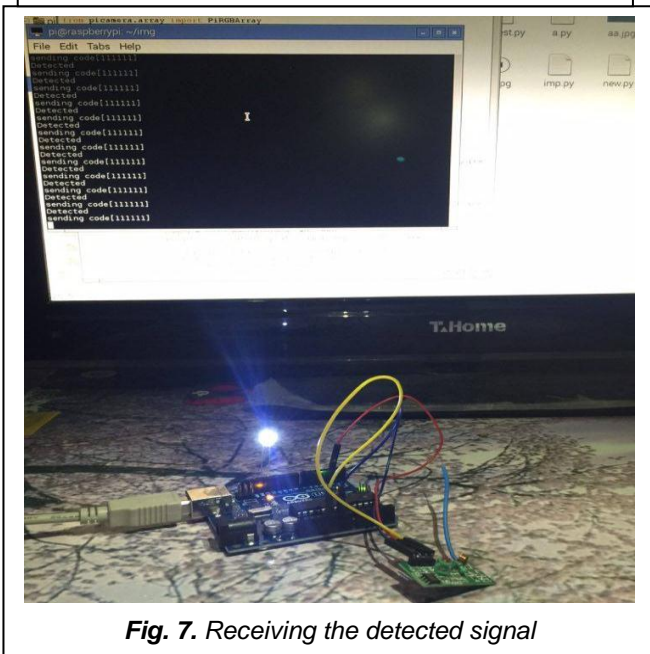
In the experiments, we performed on the drone to get result of vision-based landing target detection. The raspberry pi camera, raspberry pi board and 433MHz RF transmitter module are attached to the drone. And the Arduino Uno and 433MHz RF receiver module is placed on the ground. When the aircraft starts take-off, the pi board is powering up with power bank and the camera is capturing around the environment of the aircraft. The RC controller performs the drone to arrive the target. In this work the onboard camera is searching the target to land the aircraft. As soon as the aircraft is arrived on the target, the processor performs the image processing. When the target is detected, the transmitter module is sending the alarm signal. As the alarm signal, the green LED is "ON" and sound signal rings up to know the RC controller. At the time, the receiver with arduino is arrived the detected signal on the ground via RF transmitter/receiver module. This signal is a message signal "target found". Those messages are displayed on the serial monitor from the receiver. We develop and debug our vision system using open CV with python language for searching the landing target. Below figure shows the snapshots of the target detected and tested result in the real time.



**Fig. 8. Target detected**



**Fig. 9. Sending and receiving signal code**



**Fig. 7. Receiving the detected signal**

**6 CONCLUSION**

We have presented the development of a real-time vision-based system for detecting a landing target. The vision is simple, fast and computationally inexpensive. This work proposed vertical take-off and landing unmanned aerial vehicle (VTOL UAV) applications with vision based landing system. Our vision system is designed using Raspberry Pi as a host. It uses free software including open CV library and python language. Template matching is used for target recognition. In this paper, vision algorithm is designed by using image processing techniques such as template matching method. The template image is an image file (JPG, PNG format).

Template file must be calibrated according to the input image from the camera. The calibrated template size is small, it gives accuracy for finding target but the processing time speed is slow. The calibrated size large, it is fast for finding to match images. Through information from the onboard processor, the system generates commands for the UAV landing. The performance of the system are demonstrated on the conducting the experiments with the results.

## References

- [1] Srikanth Saripalli , James F. Montgomery and Gaurav S. Sukhatme, " Vision-based Autonomous Landing of an Unmanned Aerial Vehicle," In proceedings Of IEEE International Conference on Robotics and Automation pp 2799-2804, May 2002., Washington D.C., USA
- [2] Felipe Leonardo Lobo Medeiros, Vitor Conrado Faria Gomes, Marcia Rodrigues Campos de Aquino, Diego Geraldo, Marc os Eduardo Lopes Honorato,Luiz Henrique Moreira Dias, " A Computer Vision System for Guidance of VTOL UAVs Autonomous Landing," 2015 Brazilian Conference on Intelligent Systems, 978-1-5090-0016-6/15 \$31.00 © 2015 IEEE DOI 10.1109/BRACIS.2015.53
- [3] Gary Bradski and Adrian Kaehler, Learning OpenCV. O'Reilly Media, Inc., 1005 Gravenstein Highway North, Sebastopol, CA 95472
- [4] Simon Monk, Raspberry Pi Cookbook, Published by O'Reilly Media, Inc., 1005 Gravenstein Highway North, Sebastopol, CA 95472
- [5] Priyanga .M, Raja ramanan .V, "Unmanned Aerial Vehicle for Video Surveillance Using Raspberry Pi", Volume 3, Special Issue 3, March 2014
- [6] Cory S. Sharp Omid Shakernia S. Shankar Sastry, "A Vision System for Landing an Unmanned Aerial Vehicle," Submitted to 2001 IEEE International Conference on Robotics and Automation
- [7] Farid Kendoul ·Kenzo Nonami · Isabelle Fantoni ·Rogelio Lozano, "An adaptive vision-based autopilot for mini flying machines guidance, navigation and control," Received: 2 February 2009 / Accepted: 3 August 2009 / Published online: 21 August 2009 © Springer Science+Business Media, LLC 2009
- [8] Priyanga .M, Raja ramanan .V, "Unmanned Aerial Vehicle for Video Surveillance Using Raspberry Pi", Volume 3, Special Issue 3, March 2014
- [9] Youngjoo Kim, Wooyoung Jung Hyochoong Bang, "Visual Target Tracking and Relative Navigation for Unmanned Aerial Vehicles in a GPS-Denied Environment," Postprint submitted to International Journal of Aeronautical and Space Sciences