International Journal of Innovation in Computer Science and Information Technology
Vol.1, NO.1 , P:47 - 53
Received: 28 Nov 2018
Accepted: 27 Feb 2019

FPCNN based Image processing for autonomous Quadcopter control

Hamed Pourmohammadi Emamiyeh
Hamedpourmohammadi88@gmail.com
MahsaBarghiMehmandari
Mahsabarghimehmandari@gmail.com

Abstract
In this paper, an image processing technique based on FPCNN is proposed for autonomous Quadcopter landing. In the UAV field, take-off and landing are two important processes, as any little miss operation in each of them will cause a crash. In some cases, the operator needs to take-off and land automatically. Hence an automatic process can improve the efficiency of Quadcopters. An environment detection method, decision-making unit and actuators that control the unit are necessary for achieving this goal. In this paper, Image Processing and FPCNN (Implemented in MATLAB) are used for detecting the zone of landing, decisions for controlling the motor are made through an interface board which receives instructions from MATLAB and transfer them to the main controller board. By using this method, Quadcopters can land on the specified area, which is defined 1*1 m plate and there is H in the middle of it, without operator intervention. Details of the proposed method are presented in different sections. Results state the efficiency of the method.
Keywords: Autonomus Quadcopter, FPCNN, Image Processing, landing, take-off

1.Introduction

The role of robots specifically aerial robots named UAV has obviously increased. A popular UAV is a Quadcopter that its structure is shown in figure 1. As can be seen, a UAV contains Chassis, motors, a control unit, sensors and in some cases cameras.

Figure (1) Structure of UAV

The development of autonomous MAVs is a challenging topic in both the research community and the commercial market [1,2,3]. With respect to today's rapidly developing algorithms, the improvement in processor performance has made almost all the equipment fully-automated [4]. By using all these algorithms, autonomy is a problem in mobile robots, robotic arms, and drones. In Quadcopters, autonomy can be separated into some branches. One branch is autonomous take-off and landing [5,6].In some missions because of various reasons such as miss operation of video transferring system, the operator is not able to see the drone landing or take-off place In these cases, an autonomous process will be very helpful. An accurate autonomous take-off or landing depends on sensors and image processing. Another principle part of any robotic system, especially flying ones, is a power unit. As in drones, losing battery is equal to crash. In

some auto-landing projects, image processing used for detecting the place which set for battery charging that drone detects and land there when the battery is going down [7]. All these operations must be wireless and drone either can do the process itself or send the image to another processing unit and then receive instructions from that unit [8]. Several image processing algorithms such as edge detection or feature extraction have been used for detecting the landing area [9,10]. In this paper feedback pulse coupled neural network (FPCNN)is used for this aim. The rest of the paper is organized as follows: Image processing and Artificial Neural Network are summarized in section 2. Section 3 will explain FPCNN. The efficiency of the proposed method on a Quadcopter and related hardware is presented in section 4. Finally, the conclusion is given in section5.

2. Image processing and Artificial Neural Network

A. Image Processing

Image processing is a method to perform some operations on an image, in order to get an enhanced image or to extract some useful information from it. Nowadays, image processing is among rapidly growing technologies. It forms a core research area within engineering and computer science disciplines too. Image processing basically includes the following three steps:

- Importing the image via image acquisition tools;
- Preprocessing for improving the quality of images or removing noise;
- Processing image based on the desired result.

There are various algorithms and methods used in image processing based on different goals. Image segmentation, feature extraction, edge detection, and classification are some of them. Aim of this paper is segmenting the image of the environment to detect the take-off or landing area and send it to the processing unit for making the decision. Among the several segmentation methods, ArtificialNeural Network is chosen in this paper and the next subsection will describe it.

B. ArtificialNeural Network

In Artificial Neural Networks (ANNs), the learning is realized by the adaptation of the network weights based on the input data and the corresponding desired outputs. This algorithm is a pattern for processing information and data that acts like a human neural network. A neural network contains simple elements that operate in parallel form in the vicinity of each other. Hence an artificial neural network can be made according to natural neural networks and by setting each connection, determine the communication between elements. Determining the bias, weight, and structure of connections will result in our desired goal. As shown in figure 2 network adapts itself by matching between input and goal to achieve our desired output. In this paper, FPCNN is used for segmenting the image of the environment for detecting the desired area and the description of that is given in the next section.

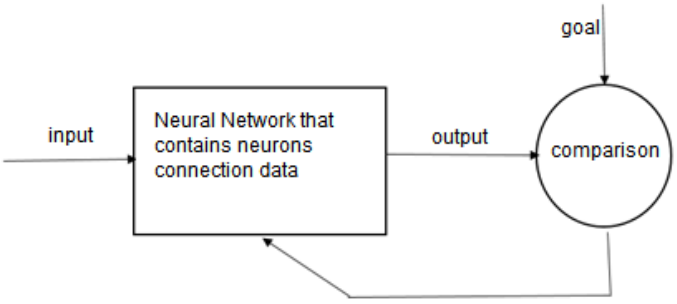

Figure (2) Neural NetworkBlock Diagram

3. FPCNN method

Image segmentation and defining the region of interest (ROI) is an important approach and the most time-consuming part of image analysis and processing, which can divide the image into different parts with certain distinctions. FPCNN is considered as a very powerful front-end processor for an image recognition system. The FPCNN based image segmentation process for defining the ROI can be viewed as a region growing method where seed pixels are identified by neurons that fire during primary firing and the region growing is accomplished spatially connected neighboring neurons through secondary firing. In other words, in this method, first seed pixels are selected and then pixels in the vicinity of them will be considered and according to determined features, some pixels add to the region and this process will be continuing until all the pixels with same features add to the region. This process is shown in figure 3.

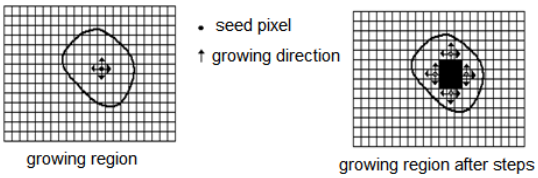

Figure (3) Region Growing Method

In FPCNN architecture, given in figure 4, every neuron is made up three sections: receptive, modulation and pulse generation sections. Also, the output information is sent back to the input.

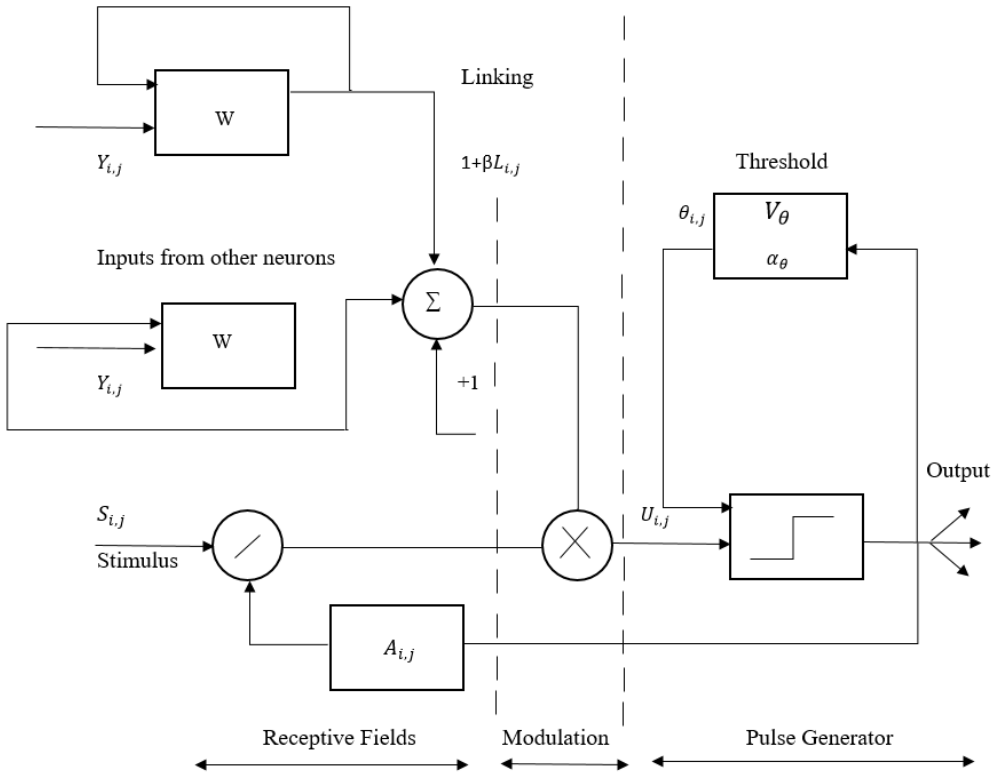

Figure (4) FPCNN Structure

This network produces a dynamic output that contains edges and segmentation information. This is performed by continual iterations of the input and output signals using the EQs. (1) - (6).In these equations, i and j are the number of neurons, n is iteration, S is external excitation of neurons, F is feeding input, L is communication function between neurons, U is activity function, θ is a dynamic threshold, V_L, V_θ, V_F are constant domain values. In FPCNN, the coupling is communication between neurons. The advantage of this method is the immutability of algorithms against rotation or dilation in image. Hence this method is useful for situations that we have pattern recognition or classification.

$$F_{i,j}[n] = e^{-\alpha_F} F_{i,j}[n-1] + V_F \sum_{k,l} w_{i,j,k,l} Y_{i,j}[n-1] + S_{i,j} \quad (1)$$

$$L_{i,j}[n] = e^{-\alpha_L} L_{i,j}[n-1] + V_L \sum_{k,l} m_{i,j,k,l} Y_{i,j}[n-1] \quad (2)$$

$$\theta_{i,j}[n] = e^{-\alpha_\theta} \theta_{i,j}[n-1] + V_\theta Y_{i,j}[n] \quad (3)$$

$$A_{i,j}[n] = e^{-\alpha_A} A_{i,j}[n-1] + V_A Y_{i,j}[n] \quad (4)$$

$$S_{i,j}[n] = \frac{S_{i,j}[n-1]}{A_{i,j}[n-1]} \quad (5)$$

$$Y_{ij}[n] = \begin{cases} 1, & U_{ij}[n] > \theta_{ij}[n] \\ 0, & U_{ij}[n] \leq \theta_{ij}[n] \end{cases} \quad (6)$$

A code based on equations above is written in MATLAB. The results of the implementation of this code for detecting the desired area are given in the next section.

4. Experimental Results

In order to evaluate the performance of the proposed method, a test was done. In this trial exam, the zone of landing was a 1*1 m white plate with a black “H” on it, or a black plate with a white “H” in reverse. Quadcopter should detect the area through the written code in MATLAB, next send the results to the control unit for making a decision and finally has an accurate autonomous landing.
For an exactlanding on the determined place the H was set in the middle of picture and by varying the pixel’s place, we send instructions to the interface board and set the right land position. In th following,all the process will be described in details.

The Quadcopter used in this study, shown in figure 5, consists of two mechanical and electrical parts. In the mechanical part, a chassis, made from carbon plates, is designed for assembling mainboard, interface board, and sensors. An aluminum part is used for installing motors and other equipment, the carbon fiber plate is placed in the center and the motors are assembled on the corners. In the electrical part, control unit, actuators, sensors, data communication unit, and interface board are used.

Figure (5) Proposed Quadcopter

All parts send their data to the control unit and receive the instruction from that. Here a Pixhawk board, shown in figure 6, is used as the main control unit. This controller is a high-performance autopilot-on-module suitable for fixed-wing, multi-rotors, helicopters, cars, boats and any other robotic platform that can move. This controller has the ability to control 8 brushless motors and set the USART, CAN and I2C communication protocols.

Figure (6) Pixhawk Board

The recorded video is sent from the drone to MATLAB and information after processing must be resent to the drone. So a communication unit is needed. Here, HM-TRP series are selected that are low cost, high-performance transparent FSK transceiver with operating at 433/470/868/915 MHz, high output power, high sensitivity, long transmission distance, and high communication data rate with auto set up for communication change and data receiving and transmission control. The communication module is shown in figure (7).

Figure(7) HM-TRP module

Another part of the electrical unit is an interface board that plays a vital role in the system. We design an interface board for making possible the data communication between drone and PC. As mentioned above, the main controller of the drone is Pixhawk

and it is not able to send or receive wireless data. The interface board, send the optical flow data with the communication unit to PC and then the data is received by MATLAB with a serial port. MATLAB import those data in the path planning algorithms and again send the result to the drone. After receiving data with the drone, the interface board sends it to fight control and changes will be applied. The interface board consists of an ATMEGA 128 as a processor. Interface board has the ability to connect with an IMU and ultrasonic sensor and controlling 4 servo motors. The most important application of this board is to send and receive data and instruction in auto land and auto take off with image processing. It's working frequency is 11.0592 MHz. The board is shown in figure 8.

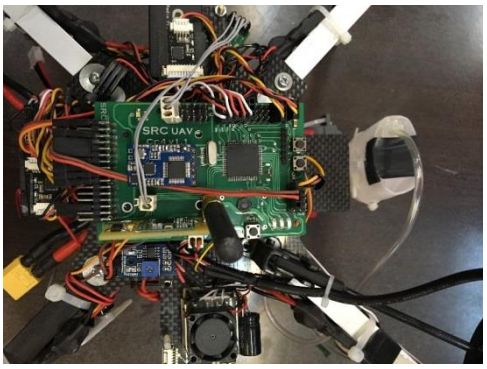

Figure (8) Interface Board

The results of detecting the desired landing area for both white and black plate are given below in figure 9.

a b

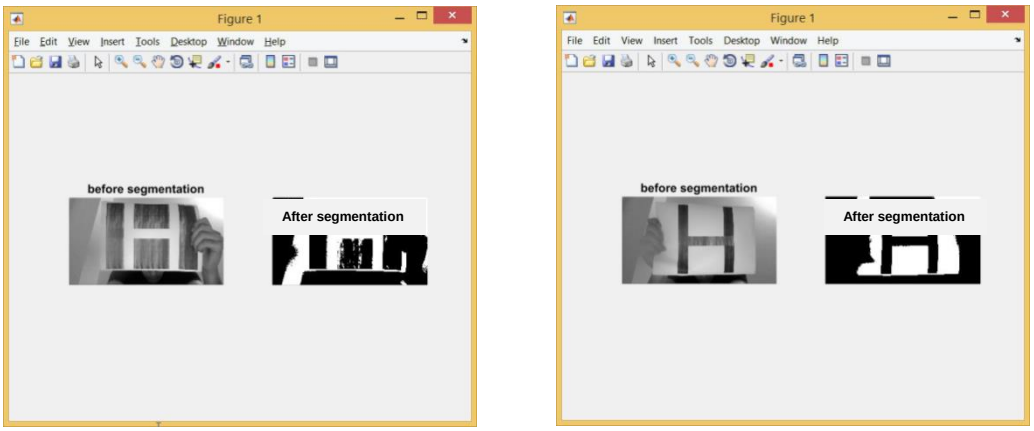

Figure (9) a. Blacke Plate with white H, b. White Plate with Black H

5. Conclusion

In recent years, by using image processing and machine vision techniques, the performance of robots have improved. In this paper, an image processing method based on FPCNN implemented and tested in experiments. The algorithm results were sent to the interface board and the Quadcopter was controlled based on the decisions made by the controller. Using FPCNN algorithm, MATLAB and transfer data between Quadcopter and MATLAB is a new method in this field wich led to the effective operation.

Refrences

[1] Y. ai Bi, J. Li, H. Qin, M. Lan, M. Shan, F. Lin, andB. M. Chen. An mav localization and mapping system

based on dual realsense cameras. In International microair vechicle competition and conference, 2016.

[2] J. N. Lee and K. C. Kwak. A trends analysis of domesticresearch in unmanned aerial vehicle image processing.
KISM Fall Conference, 2:221–224, 2013.
[3] T. Moranduzzo and F. Melgani. Automatic car counting method for unmanned aerial vehicle images. IEEE
Trans. Geoscience and Remote Sensing, 52:1635–1647,2013.
[4] J. N. Lee and K. C. Kwak. A trends analysis of domesticresearch in unmanned aerial vehicle image processing.
International Journal of Computer, Electrical, Automation, Control and Information Engineering, 8(2):271–274,2014.
[5] S. Lange, N. Snderhauf, and P. Protzel. Autonomouslanding for a multirotor uav using vision. In In SIMPAR
2008 Intl. Conf. on Simulation, Modeling and Programming for Autonomous Robots, pages 482–491, 2008.
[6] K. E. Wenzel and A. Zell. Automatic take off, hoveringand landing control for miniature helicopters with
lowcost onboard hardware. In Autonome Mobile Systeme,2009.
[7] T. G. Carreira. Quadcopter automatic landing on a docking station. 2013.
[8] D. Hanafi, M. Qetkeaw, R. Ghazali, M. Than,W. Utomo, and R. Omar. Simple gui wireless controller of
Quadcopter. International Journal of Communications, Network and System Sciences, 6(1):52–59, 2013.
[9] D. C. Wyld, Bahram Lavi Sefidgari, and Sahand Pourhassan Shamchi. Auto landing process for autonomous
Flying robot by using image processing basedon edge detection. 2014.
[10] C. A. Munoz. Object tracking using autonomous quadcopter. 2014.
[11] B. L. Sefidgari. Human body detection and safety caresystem for a flying robot. Second International
Conference on Advanced Information Technologies and Applications, 3(9):317–325, 2013.
[12] H.W. Ho, G.C.H.E. de Croon, and Q.P. Chu. Humanbody detection and safety care system for a flying robot.
Pages 121 – 128, 2016.