Vision-Based Target Tracking For Unmanned Aerial Vehicle Surveillance

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Abstract

This Research paper provides knowledge about vision-based target tracking of faces using Python Open Computer Vision library which is coordinated by Raspberry Pi with an onboard affixed camera on the UAV. An Unmanned Ariel Vehicle (UAV) with flying capabilities was developed using KK2.1.5 Motherboard, Electronic Speed Controllers, Propellers of 4.5 degrees of pitch coordinating with 1000KV Brushless DC Motors for rotation, Camera with 1080p wide-angle lens, and various other required components. The UAV is controlled by a CT6B transmitter and receiver. The load characteristics of the UAV were simulated in Ansys Software. The Camera installed on the UAV coordinates with the program in the raspberry pi using the VNC Viewer application in the PC with the interface of the WiFi network. In the starting stage, the images are captured in numerical like 1,2,3 and so on; and in one of the programs a name can be set for each image file number. When the images are captured by the camera, they are converted into grayscale, cropped to the frontal face, and saved in the dataset folder. Local Binary Pattern Histogram (LBPH) Algorithm was used to develop this project. Using LBPH, the images were taken will be cropped to the perfect face in a rectangular shape which is then used for the tracking. This program is mainly used for known faces which the number can be set according to the program. The face will be recognized with the help of the “haarcascade_frontalface_default.xml” file that has all the required data for recognizing the frontal face. There will be a “TrainingData.yml” file which is saved in the Recognizer folder which consists of the data required to train an image to be tracked.

Key words: UAV, Face Tracking, LBPH, Haarcascade, OpenCV, Ansys

Introduction

The Unmanned Aerial Vehicle (UAV) is the formal name of a drone. It is the aircraft that is like a flying robot controlled manually by a human or fly autonomously through the code which will be pre-loaded into the embedded system. The sensors that we use, will purely depend upon the requirement of the UAV in which domain/field we use it and it also consists of different designs, shapes, sizes accordingly. In the year 1933, the navy had used drones for firing practices. Later on, with the advancements in navigation sensors, UAVs had become an important part of military or defense forces. And now its applications got expanded in other fields related to mining, monitoring, agriculture, product deliveries, scientific activities, etc. [1,2,3].

In this project, we are going to design vision-based target tracking for UAV surveillance [4,5] and its main aim to track preprogrammed faces with an onboard affixed camera, with the help of a quadcopter. Unlike, in the past face tracking was illegal because of onboard cameras. As per government norms regarding UAV we have developed a quadcopter with a 1080p resolution camera to track faces with 60 percent accuracy with an altitude of 15 meters.

UAV Configuration and Explanation:

A. <u>Aluminum frame (4*43cm)</u>

The frame is made of extra-strength aluminum material to avoid crash landings. The supporting board is a high compound of high-strength material, which carries wiring of ESC, Raspberry pi, Motherboard, and battery safety. Stretched X-Frame, reduces the air disturbance and has high tensile strength.

B. <u>Propellers(10*4.5cm)</u>

Drone propellers provide lift for the aircraft by spinning and creating an airflow, which results in a pressure difference between the top and bottom surfaces of the propeller. Varying the speed of these propellers allows the drone to hover, ascend, descend, or affect its yaw, pitch, and roll. With a brushless direct current motor, each propeller can create about 2kgs of thrust.

C. Brushless direct current motors (1000 KV)

- 1000 KV motor upholds smooth flight and it is most apt for aerial photography
- BLDC motor comprises two main parts, a rotor, and a dictator. For this lustration, the rotor is an everlasting magnet with two poles, whereas the stator consists of copper coils. We are all familiar that, if the current is applied through a coil, it will produce a magnetic field and the magnetic field lines or the poles depend upon the current direction.

D. Electric speed controller (30 amps)

- The brushless motor movement or speed by activating the suitable MOSFETs (Metal Oxide Semiconductor Field Effect Transistor) to create the rotating magnetic field so that the motor rotation is controlled by an ESC (Electronic Speed Controller).

E. Lithium polymer battery (2200mah)

- It is made with a very slim outline and is made in a variety of shapes and outlines. It has a higher energy density for a given weight in WH/kg.
- Has low weight
- Higher top usage temperature to some extent.

F. Camera (5mp with 1080p resolution)

FINGERS 1080 Hi-Res is webcam goals with its crystal clear, full HD resolution and ideal head-and-shoulders frame for video capturing. It takes your video streaming or recording beyond the next level with a built-in premium USB Mic and a true 1080p wide-angle lens. With studio-like lighting and full HD capability, the 1080 Hi-Res webcam lets you view or shoot more. It is set to captures 30 frames per second.

CT (Channel Transmitter) 6B Transmitter and receiver (2.4Ghz)

The UAV will be directed from the ground by remote control. The transmitters have two trim buttons or a slider per stick, several switches, and a power button. Transmitters and receivers need a frequency range to operate and the frequency is 2.4 GHz, with digital spectrum modulation 2.4GHZ.

Modes & Channels

- A transmitter is categorized by the number of channels it uses to control the UAV. Information about the throttle or up/down position of your left stick requires one channel. Similarly, the rudder or right/left position of your left stick requires one channel. Having left and right sticks, therefore, requires 4 channels.
- It controls longitudinal, lateral, vertical, positions of the drone with respective roll, pitch, and yaw. It’s also called a control joystick. If we are not satisfied with the controllers, we can change as per our convenience like change them to vice versa of given controls by using USB given should be connected to transmitter and program in a computer.

G. Raspberry pi

- It has an updated 64-bit quad-core processor running at 1.4GHz with built-in metal heatsink, dual-band 2.4GHz and 5GHz wireless LAN (Local Area Network), faster (300 Mbps) Ethernet, and PoE capability via a separate PoE (Power Over Ethernet) HAT (Hardware attached on top). It has 1GB of RAM, a faster dual-band 802.11 b/g/n/ac wireless LAN, Bluetooth 4.2, and significantly faster 300Mbit/s Ethernet.

Figure 1: Raspberry Pi

H. Motherboard (KK 2.1.5 Multirotor control board)

- This controller manages the flight of multi-rotor UAVs such as Tri copters, Quadcopters, Hex-copters, etc.
- The Processor of the control board is an Atmel Mega644PA 8-bit AVR RISC (Reduced Instruction Set Computer)-based microcontroller with 64k of memory.
- Its purpose is to stabilize the UAV during flight. It is achieved by taking the signals from onboard gyroscopes and passes these signals to the processor.
- Then the processor will process the signals to the UAV according to the user input from the transmitter, which in turn will send signals to the Electric speed controllers and helps to stabilize the UAV.
- The motherboard also uses signals from the transmitter and receiver and passes these signals together with stabilization signals to the IC via the aileron; elevator; throttle and rudder according to the user inputs.
- Once this information gets processed, it is sent to the electronic speed controllers which in turn adjusts the rotational speed of each motor to control the UAV.

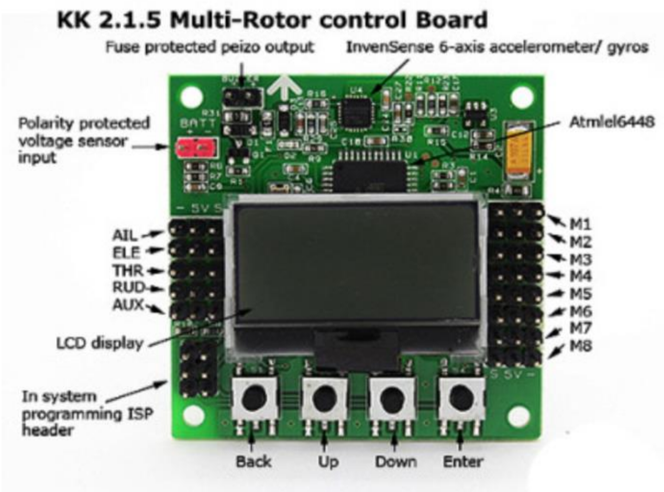

Figure 2: KK 2.1.5 Mother Board

Local Binary Pattern Histogram:

- Local Binary Pattern (LBP) is a simple yet very efficient texture operator which labels the pixels of an image by thresholding the neighborhood of each pixel and considers the result as a binary number [6,7,8].

1. Parameters: the LBPH uses 4 parameters: Radius: the radius is used to build the circular local binary pattern and represents the radius around the central pixel.

Neighbors: the number of sample points to build the circular local binary pattern. Keep in mind: the more sample points you include, the higher the computational cost. It is usually set to 8.

Grid X: the number of cells in the horizontal direction. The more cells, the finer the grid, the higher the dimensionality of the resulting feature vector. It is usually set to 8.

Grid Y: the number of cells in the vertical direction. The more cells, the finer the grid, the higher the dimensionality of the resulting feature vector. It is usually set to 8.

2. Training the Algorithm: First, we need to train the algorithm. To do so, we need to use a dataset with the facial images of the people we want to recognize. We need to also set an ID (it may be a number or the name of the person) for each image, so the algorithm will use this information to recognize an input image and give you an output. Images of the same person must have the same ID. With the training set already constructed, let's see the LBPH computational steps.

3. Applying the LBP operation: The first computational step of the LBPH is to create an intermediate image that describes the original image in a better way, by highlighting the facial characteristics. To do so, the algorithm uses a concept of a sliding window, based on the parameters radius and neighbors [9].

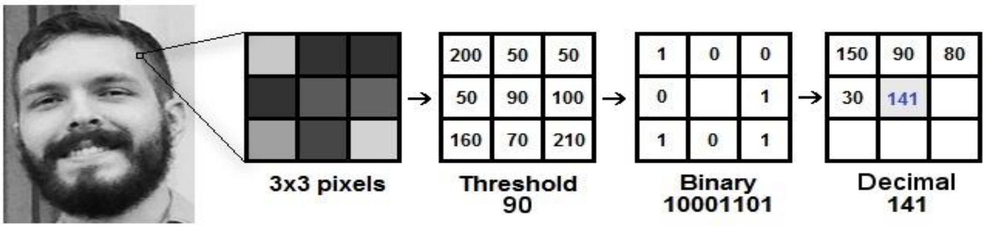

Figure 3: LBPH Working

Future Developments:

The above-discussed limitations can be fulfilled by maintaining good and stable internet connectivity. For the UAV to track above a certain height, some of the major components like the motherboard and onboard camera have to be upgraded. When upgraded further, this can be used as the best surveillance technique [10,11].

Conclusion:

The developed model for the project, "Vision-Based Target tracking for UAV Surveillance" [4,5] can be developed further, and can be used as a surveillance method within the higher official's houses to detect the threat for security reasons. And this can also be used in the streets, traffic surveillance, and so on for the betterment of society.

References

1. R. He, A. Bachrach, M. Achtelik, A. Geramifard, D. Gurdan, S. Prentice, J. Stumpf, and N. Roy, "*On the design and use of a micro air vehicle to track and avoid adversaries*", the International Journal of Robotics Research, 2009.

2. G. Bevacqua, J. Cacace, A. Finzi, and V. Lippiello, "*Mixed-initiative planning and execution for multiple drones in search and rescue missions,*" in Twenty-Fifth International Conference on Automated Planning and Scheduling, 2015.
3. K. Kanistras, G. Martins, M. J. Rutherford, and K. P. Valavanis, "*Survey of unmanned aerial vehicles (uavs) for traffic monitoring,*" in Handbook of Unmanned Aerial Vehicles. Springer, 2015, pp. 2643–2666.
4. H. Cheng, L. S. Lin, Z. Q. Zheng, Y. W. Guan and Z. C. Liu. "*An Autonomous Vision-Based Target Tracking System for Rotorcraft Unmanned Aerial Vehicles*", Feb, 2021.
5. W. Smeulders, D. M. Chu, R. Cucchiara, S. Calderara, A. Dehghan, and M. Shah, "*Visual tracking: An experimental survey,*" IEEE Transactions on Pattern Analysis and Machine Intelligence, vol. **36**, no. 7, pp. 1442–1468, 2014.
6. Aftab Ahmed, Jiandong Guo, Fayaz Ali, Farha Deeba, Awais Ahmed "*LBPH Based Improved Face Recognition At Low Resolution*", May, 2018.
7. Abhishek Pratap Singh, SunilKumar S Manvi, Pratik Nimbal, Gopal Krishna Shyam "*Face Recognition System Based on LBPH Algorithm*", May, 2019.
8. T. Ojala, M. Pietikäinen and D. Harwood, "*A Comparative Study of Texture Measures with Classification based on Featured Distributions,*" Pattern Recognition, vol. **29**, no. 1, pp. 51-59, January 1996.
9. Zhao and R. Chellappa "*Robust face recognition using symmetricshape-from-shadingg*" Technical Report, Center for Automation Research, University of Maryland, 1999.
10. Revaud, M. Douze, S. Cordelia, and H. Jégou, "*Event retrieval in large video collections with circulant temporal encoding,*" in CVPR, 2013.
11. J. F. Henriques, J. Carreira, R. Caseiro, and J. Batista, "*Beyond hard negative mining: Efficient detector learning via block-circulant decomposition,*" in ICCV, 2013.