International Journal of Advanced Culture Technology Vol.4 No.4 81-86 (2016)
https://doi.org/10.17703/IJACT.2016.4.4.81

IJACT 16-4-13

OnBoard Vision Based Object Tracking Control Stabilization Using PID Controller

Vinayagam Mariappan[1], Minwoo Lee[2], Juphil Cho[3], and Jaesang Cha[1†]

[1]Media IT Engineering, Seoul National Univ., 0f Science and Tech., Seoul, Korea
[2]Graduate School of Nano IT Design Fusion, Seoul National Univ., 0f Science and Tech., Seoul, Korea
[3]Dept. of Integrated IT & Communication Eng., Kunsan National Univ., Kunsan, Korea
vinayagam_m@hotmail.net, alsdnya@gmail.com, stefano@kunsan.ac.kr, †chajs@seoultech.ac.kr

Abstract

In this paper, we propose a simple and effective vision-based tracking controller design for autonomous object tracking using multicopter. The multicopter based automatic tracking system usually unstable when the object moved so the tracking process can't define the object position location exactly that means when the object moves, the system can't track object suddenly along to the direction of objects movement. The system will always looking for the object from the first point or its home position. In this paper, PID control used to improve the stability of tracking system, so that the result object tracking became more stable than before, it can be seen from error of tracking. A computer vision and control strategy is applied to detect a diverse set of moving objects on Raspberry Pi based platform and Software defined PID controller design to control Yaw, Throttle, Pitch of the multicopter in real time. Finally based series of experiment results and concluded that the PID control make the tracking system become more stable in real time.

Key words: *Object Detection, Object Tracking, TLD, PID, Onboard Vision System, Automatic Multi-Copter Control*

1. Introduction

In recent years, unmanned aerial vehicles (UAVs) named as drones or multicopters is a most very active field of research due to the increasing accessibility. The favorable ability to hover and take-off and land vertically of multicopters made a huge progress in surveillance, military application, asset monitoring, rescue tasks and agriculture.

However, multicopters localization remains faces challenges especially in GPS denied or confined locations. Positioning the aerial flight relative to another object is a common task that is difficult to achieve. To achieve localizing position of aerial flight on the object in GPS denied or confined locations this paper, propose a multicopters with onboard vision based robust and autonomous object tracking system.

The autonomous multicopter is built in with ability to capture stabilized video and potential to significantly

Manuscript Received: Nov. 30, 2016 / Revised: Dec. 5, 2016 / Accepted: Dec. 10, 2016
Corresponding Author: chajs@seoultech.ac.kr
Tel: +82-02-970-6431, Fax: +82-02-974-6123
Media IT Engineering, Seoul National Univ., 0f Science and Tech., Seoul, Korea

redefine future objectives in the development of state-of-the-art object tracking methods and maintain a desired relative location to a static or dynamic object. This is achieved by multicopter designed with a onboard vision system which have the capability to do the required computational processing.

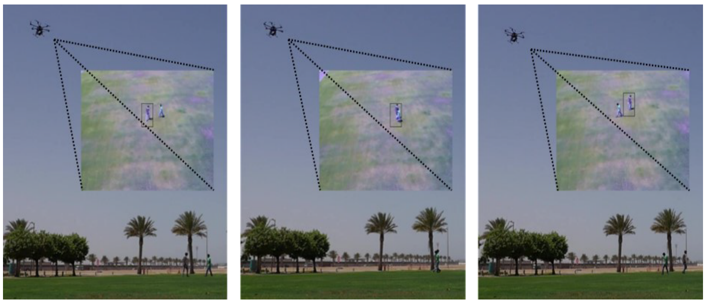

Figure 1. Multicopter Visual Human Tracking [6]

The tracking system usually have the problems like the system is not in real-time because the system cannot track the object interested suddenly along with direction it moves on and may cannot can't find object immediately if object is loosed in some interval of time.

This paper presents the Object tracking system with PID controller to predict exact object position when object in movement or became disappear or undetected by the camera immediately. This paper used appearance based TLD algorithm using online learning to detect and track the object

2. Vision Based Object Tracking

To implement, the vision-based tracking system to track moving or static target on multicopter, the system need to builtin with two controllers. The Object Tracking Controller to detect the object to track and PID controller is designed for stability. This design adopt the vision based robotic research fields by doing experiments required to design a control structure on visual navigation and localization using on-board cameras in control feedback.

2.1 Object Tracking Algorithm

The current target detection and tracking methods can be divided into the following several categories: (1) Statistical model-based algorithms (2) Knowledge-based algorithms (3) Model-based algorithms: such algorithms (4) Neural networks-based and expert systems-based algorithms. However, the real-time of such algorithms is so poor.

Online object tracking has long been a popular topic in computer vision in current days to overcome real time. A large number of trackers have been proposed [8, 9], and the recent publication of benchmark data sets containing large numbers of sequences and standardized quantitative evaluation metrics is accelerating the pace of development in this field. After analyzing theoretical principles and implementation mechanisms of the On line object tracking algorithm, this paper presents a method to improve the performance of the TLD algorithm. TLD algorithm [7] is a single-target algorithm which can track target for a long time.

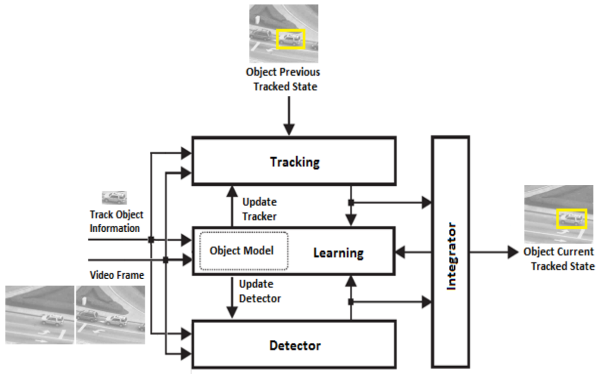

Figure 2. TLD Algorithm Block Diagram [2]

The TLD framework decomposes the long-term tracking task into three sub-tasks: tracking, learning and detection. Each sub-task is addressed by a single component and they operate simultaneously (See Figure 2).

- Tracker: Follows the object through the frames.
- Detector: Localizes all the appearances that have been observed so far and corrects the tracker if necessary.
- Learning: Estimates the error and updates it to avoid these error in the future.

The advantage of the TLD algorithm can be summarized as the following two aspects: (1) combining detection with tracking to deal with the issue of missing or deformed; (2) utilizing an improved semi-supervised learning method to update the detection and tracking module to enhance the performance of stability, robustness, and reliability.

2.2 Pid Algorithm

PID is a control loop feedback mechanism that continuously computes an error value as the difference between a measured value and a desired value, trying to minimize the error over time [5]. Proportional Integral Derivative is an algorithm that consists, as its name suggests, of three basic coefficients: proportional, integral and derivative which are varied to get optimal response.

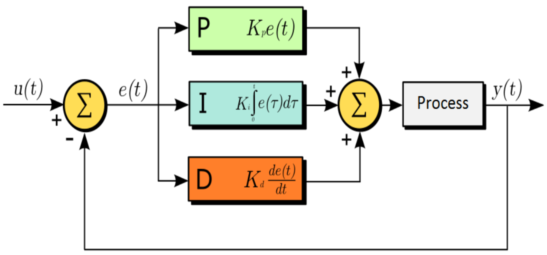

Figure 3. PID Controller [5]

The PID controller calculation (algorithm) involves three separate parameters; the proportional, the integral and derivative values. The proportional value determines the reaction to the current error, the integral value determines the reaction based on the sum of recent errors, and the derivative value determines the reaction based on the rate at which the error has been changing. The weighted sum of these three actions is used to adjust the process via a control element such as the position of a control valve or the power supply of a heating element.

3. Object Tracking Based Controller Design

The proposed onboard Object Tracking based controller design is implemented on multicopter using Raspberry Pi with native camera sensor interface. The modular open source framework of Raspberry Pi Software framework allows integration of any image based object tracker within its pipeline. The image was down scaled from 1024x768 to 320x240 pixels to decrease computation cost, which was found to be an effective resolution within the designed operating range.

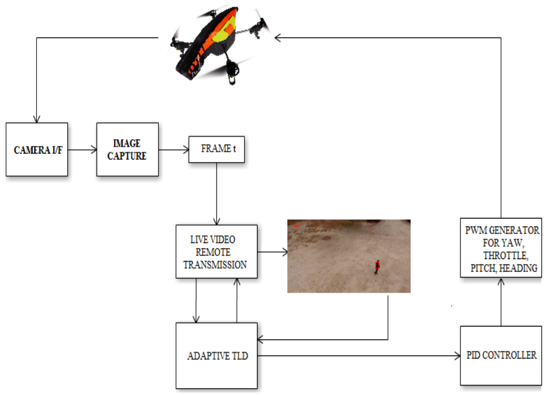

Figure 4. Object Tracking based Controller Flow Diagram

The Adaptive-TLD tracker initialized with object need to be track from remote user and tracking runs in an independent thread that is updated predicted object with current video frames received by the camera and send the information to PID Controller thread module.

The x and y pixel error between the current frame detected target's bounding box center and the center of the video frame is used as input for a fully-tuned PID controller. The PID controller estimates the Yaw, Throttle, Pitch, range, and heading to control the multicopter movement as per the velocity its operating. The output consists of two PWM signals translated as x and y-movement by the flight controller for he Yaw, Throttle, Pitch, range, and Heading. The correction occurs at the speed of the camera (30fps), incrementally adjusting the position of the multicopter until the target is centered in the FOV of the camera.

4. Results And Analysis

An on board real-time object tracking multicopter system implemented on Raspberry Pi for both image processing and flight control as shown in Figure 5.

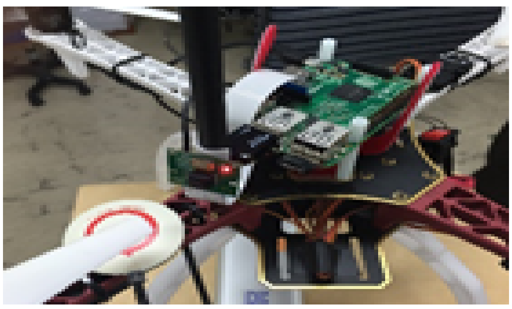

Figure 5. Onboard Vision System using Raspberry Pi

In this work, the multicopter is uses the OpenCV based computer vision algorithm framework to implement the Adaptive TLD based online object tracking algorithm and output of the real time implementation is shown in Figure 6.

Figure 6. Onboard Vision Tracking Video Stream

The software based Embedded PID Controller designed on Raspberry Pi to estimate the Yaw, Throttle, Pitch, range, and Heading to control for multicopter exact displacement from current position and based on respective PWM signals are generated to control the multicopter movement.

The combined controller was also tested to follow a dynamic object and was observed to be successful in tracking at a walking pace of approximately m/s. The controller is therefore robust to a level of uncertainty but could be extended to accommodate a dynamic object in outdoor settings.

5. Conclusions

An onboard real-time object tracking multicopter system model implemented on Raspberry Pi for both flight control and image processing. The Open TLD based Modified TLD using Adaptive Appearance Model used for object tracking algorithm developed based OpenCV framework. The software defined PID controller developed to control to control the multicopter moving parameters. The Modified TLD based online vision tracker supports the position error between the multicopter and the object to track in real time in order to control the multicopter by using PID controller the tracking system error decrease ±few pixel in tracking object position. This design gives the tracking object be more stable and real time with designed PID controller.

Acknowldegement

This work was supported by ICT R&D program of MSIP/IITP. [B0101-16-1344 , Development of Multi-Copter CAM System Operating on Broadcasting Vehicle]

References

[1] Horner, David, Yi, Su, "Development of an Automatic Object Tracking Camera System Using Multiple Metrics", 2004.

[2] Vinayagam Mariappan, Jaesang Cha, "PoseViwe Point Adaptive Object Tracking Via Online Learning Approach", *International Journal of Advanced Smart Convergents*, Vol.4 No.2, 2015

[3] Goulding, Jim,"Linear Regression (research note)", *Goldenberg, Hehmeyer & Co.)*, 2004.

[4] Endah S. Ningrum, "Implementation of Reactive Navigation for Autonomous Mobile Robot in Environment".

[5] *www.wikipedia.com/PID_control.html,* Feb12 2009.

[6] A. Qadir, J. Neubert, W. Semke, and R. Schultz, Mar 2011, ch. On-Board Visual Tracking with Unmanned Aircraft System (UAS), 0.

[7] Z. Kalal, K. Mikolajczyk, and J. Matas, "Tracking- Learning-Detection." *IEEE transactions on pattern analysis and machine intelligence,vol.*, 34, no. 7, pp. 1409–1422, Dec 2011.

[8] X. Li,W. Hu, C. Shen, Z. Zhang, A. Dick, and A. V. D. Hengel. *A survey of appearance models in visual object tracking. TIST*, 4(4):58, 2013.

[9] D. A. Ross, J. Lim, R.-S. Lin and M.-H. Yang. *JIIBC Incremental learning for robust visual tracking. IJCV*, 77(1-3):125–141, 2008

[10] B. Babenko, M.-H. Yang, and S. Belongie, "Visual Tracking with Online Multiple Instances Learning." *IEEE transactions on pattern analysis and machine intelligence,*, vol. 33, no. 8, pp. 1619–1632, Dec 2010.

[11] Denys Bohdanov "Quadrotor UAV Control for Vision-based Target Tracking Task," *Graduate Department of Aerospace Engineering,* 2012.