Implementation of single shot detector for object finding in drone platform

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Abstract. The developing of object detection for many purpose has come to various techniques. Some of those works also implement to solve our daily life problem. Those development which are state-of-the-art are mostly applicable with many pros than others. In this paper we use one of state-of-the-art of object detection to control a quadcopter i.e. Single Shot MultiBox Detector (SSD). SSD is used to detect an object as quadcopter target for approach mission. SSD also use to keep an eye of the target. The target is represented in shape of ROI location. This ROI or a bounding box location is used as feedback of the control system of quadcopter which will guide the quadcopter to approach. The mission is considered as success if the quadcopter is stopped at minimum range 1 meter toward target. This works shows the successful of object detection implementation by serving IMU responses and measured distance to object responses.

1. Introduction
Image processing and Artificial Intelligence work together to create an robust, fast, and accurate object detection. Current works has lead to many object detection method [1, 2] that has various advantageous (pros) and disadvantageous (cons) and also measured under specific circumstances i.e. datasets [3, 4], number of object[5], etc. Instrumentation and measurement of physics field must take a contribution by implement these development to any application with physics factor that will also test and will give more deliberation for future development of object detection. We test one of object detection technique i.e. Single Shot Multibox Detector (SSD)[6] as feedback of Proportional-Integral-Derivative (PID) control system implemented in a Lab-scale Quadcopter (The Copter). SSD has two variants i.e. SSD300 and SSD512. We use SSD300 variant because of its average precision 74.3% on PASCAL VOC2007+VOC2012 and average detection time 16.95 ms[6] on PASCAL VOC2007 Test. We give a test of those result when SSD method implemented in onboard-scheme which limited to our copter lifting ability to carry a computation hardware. A Single Board Computer (SBC) which don’t has high-end computational ability but has lightweight to be lifted by our copter. We use Odroid XU4 as SBC for our experiment. Quadcopter also has many pros and cons on its application [7]. The control system, PID already implemented on quadcopter[8] and a technique to fine tuning PID on quadcopter[9]. Also, we choose PID control system because of its closed loop system. A closed loop system will give multiple measurement which will give consistency and details of test results.
2. Experiment

Single Board Computer (SBC) is used as the computation hardware for SSD to detect object. The object detection will detect person object. Person object has general size and shape all of over the world, hence, the experiment result would be general anywhere it test. Also, person object can be found easily anywhere we look to our environment that will give ease to make person dataset. One of common person dataset that available for scientific purpose is [10]. We use Pascal VOC dataset of VOC2007-VOC2012 which also available for scientific purpose. We choose Pascal VOC dataset because the original paper of SSD use this dataset with both dataset year’s to test their method. We train SSD by Pascal VOC dataset but with only person object for computationally lighter. Then we design a scheme for integrate SSD object detection with the control system. Figure 1 below is block diagram of how our works integrate SSD object detection with PID control system.

![Figure 1. Block diagram of our control system to approach object. Integrate of SSD detection, template matching, and PID Control System](image)

System above is embedded on the SBC. The control system start after person object has found (target) then the closed loop control system works to control the copter to approach object. The “init line” only run once at start of approaching attempt and “loop line” will run until object is approached (mission completed). The SSD continuously detect person object on image and the target is chosen by template matching method. At first run, the system choose most closest object which indicated by larger size of bounding box. The first most closest object will be registered as target template for template matching algorithm match with another detected object on next loop and forth. This combination technique will keep an eye to the same object on every approach attempts. Both SSD and template matching will give Region of Interest (ROI i.e. Bounding Box) as detection result. The detection result is continuously fed to the control system for every loop until the object is approached. This detection result is in pixel unit and 1 pixel isn’t same as 1 meter as our set point, therefore we calibrate this detection result to get 1 meter of set point in pixel unit also. We get 1 m distance to object is represented by bounding box with size 483 pixel width’s and 606 pixel height’s with image’s size 480x640 pixels. Then we use these size of bounding box referenced as 1m distance as PID set points and detected bounding box size as PID process values. During the loops of control system we records IMU data of copter and size of target
bounding box since its started to approach. Also we record every frame taken by camera for verification purpose but we don’t show on this paper for shorten of this paper.

3. Experiment Results

During the loop of “loop line” as shown in figure 1 the system records IMU data and target bounding box. We process the recorded IMU to obtain copter orientation quaternions. The orientation quaternions is processed to euler angles which contains roll, pitch, and yaw of copter. Figure 2, 3, and 4 below is plot of roll, pitch, and yaw of copter during approaches to target.

Figure 2. Copter roll during approaches to target  
Figure 3. Copter pitch during approaches to target  
Figure 4. Copter yaw during approaches to target

Figure 2 shows copter roll range only for about 4 degree. This range indicates copter orientation wasn’t too tilt at left-right axis. The chart seems spike to maintain its tilt still but the tilt change range only about a degree which won’t take any account to copter movements. Figure 3 indicate copter head is bow down for about 15-20 degree. At first of approach its head remain below 0 degree which shows copter head is head up. The copter head is bow down as shown at detection number 5’s until object is close and the head is spike to maintain its position remain close to target. The figure 4 shows the copter only yaw to a certain angle and remain at its current heading. We verify those responses by replay the recorded frame. Another procedure to see copter movements is by record the process value of the control system. Figure 5 below is plot of recorded process value.

Figure 5. Plot of recorded process value, or called the PID responses  
Figure 6. Benchmark of SSD detection time on SBC in this experiment

Figure 5 above is the control system reponse i.e. PID responses of copter on approach the target. Responses above collected after did fine tuning of PID parameters. We use [9] to tune the PID. 1 detection number represent 1 times detection. We can get the PID responses characteristics such as rise time and settling time. From figure 6, we average that chart to conclude a detection takes about 226.27 ms. Therefore, In our experiment we measures the control system rise time is 9.542 s, and settling time is 14.24 s. If we calculate the rise by average detection time of figure 6, we obtains the rise is 7.467s and the settling time is 12s. These difference between measured and calculated characteristics is caused
by the load of SBC. The benchmark is takes under idle load of SBC hence the average detection time will be faster than under heavy load of control the copter. Also, these characteristics is obtained under condition that the SBC isn’t has high-end computational ability. Therefore, we could expect a faster responses for onboard application if the copter could lift up a high-end computation hardware which probably has more payload, and also assume the copter has speed as same as this experiment payload.

4. Conclusion and Future Works
This research shows an implementation of current develop of image processing and deep learning i.e. Single Shot Multibox Detector (SSD).

4.1. Conclusion
We successfully utilize SSD to give an assist for quadcopter (The copter) to find and approach to an object (target). The assistance of SSD was as feedback of copter control system. A closed loop control system i.e. PID was used to control the copter to approach and also to find the target. Our PID characteristics has rise time 7.467 ms, and settling time 12s by calculate using the PID response chart. In other hand, measured rise time and settling time under live measurement are 9.542s and 14.24s. This shifting is caused by difference process load condition of the SBC.

4.2. Future works
Our works only test one object detection technique, hence, there is no comparison of this result to another works with another object detection e.g. [1, 2]. Another object detection would has different computation requirements which also has different aptitude in terms of detection time, accuracy, and precision. Furthermore, there is no comparison of this object detection in other implementation under another circumstance, such as under steady condition, implemented in land vehicles, other autonomous application, etc. All of those application certainly would have different physics factor which also has different role to the system.

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