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Vision and Infrared Sensor based Distance Estimation for Micro Aerial Vehicle Navigation

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Abstract

To know the distance of things without using the old school methods of scales are something that's fascinating. Technology development has led to bringing numerous methods to find the distance of an object using computer technology. The method most used is the one involving camera. This method has proved to work well but one of the major drawbacks is in identifying the image. On the other hand, distance sensors help us accomplish this task more efficiently. Therefore, this research work is based on how a camera and a distance sensor is used to measure the distance of an object or an obstacle.

Keywords : Object Detection, MAV, Distance Estimation.

1 Introduction

An optical system's focal length is the inverse of its optical power; it quantifies how strongly the system converges or diverges light. Light is converged by a system having a positive focus length, while light is diverged by a system with a negative focal length. The rays are bent more sharply in a system with a shorter focal length, bringing them closer to the focus or diverging faster. A positive focal length defines how far in front of the lens a point source must be positioned to form a collimated beam, while a negative focal length specifies how far in front of the lens collimated (parallel) rays are brought to a focus in the particular scenario of a thin lens in air. The focal length of a broader optical system has no intuitive meaning; it is merely the inverse of the optical power of the system.

Longer focal length (lower optical power) leads to higher magnification and a narrower angle of view in most photography and all telescopy, where the subject is essentially infinitely far away; conversely, shorter focal length or higher optical power leads to lower magnification and a wider angle of view. In applications where magnification is done by getting the object close to the lens, such as microscopy, a shorter focal length (greater optical power) results in higher magnification since the subject may be brought closer to the center of projection.

Navigating a Micro Aerial Vehicle (MAV) in indoor corridor is a challenging task, it depends on the onboard sensor information for navigating safely. The here presented approach uses the camera sensor for estimating the distance of the object and detection of the object. Until date, the work in this field has used various methods for deriving the optical flow but the tensor method is the time saving one and has the accuracy rate higher than the other methods[2].The Global Positioning System (GPS) is not suitable for interior localization, despite its efficacy outdoors, since the signals broadcast by GPS-satellites cannot be received accurately within buildings [3]. In order to construct indoor localization systems, various technologies such as Wireless Sensor Networks (WSN) are used.[4-8]

Object detection in computer vision is a consistently evolving method, new algorithms are outperforming the previous one. Computer vision system will first gather the data of the object in frame and then collects the data of the background. After detecting the object, it is possible to obtain

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additional information such as the precise instance, trace the object over an image sequence, and retrieve information about the discovered object. In this modern world were technologies are rapidly evolving, and we are in a situation that sometimes it is hard to recognize some objects. The tensor flow method will easily distinguish the items and increases the highlights with high accuracy rate.[1]

The camera sensor identifies the item in the frame as well as the distance between it and the camera. The Raspberry Pi module is used to process the whole module. The Tensor flow approach is used to compute object detection. The image's focal length is used to compute the distance. The MAV can be navigated by using processed image frames. The camera recognises the object in the frame and can also tell you how far away it is. This information is crucial for properly manoeuvring the drone in a confined space.

The distance of an object can be calculated not only with camera but several sensors are also available in the global market which can calculate the distance. The here presented paper explains about the proximity sensor which is used to measure the distance.

Without the requirement for physical contact, a proximity sensor recognises the existence of nearby items. A proximity sensor often creates an electromagnetic field or a beam of electromagnetic radiation (infrared, for example) and monitors the field or return signal for changes. The thing that is being detected is the proximity sensor's target. For various proximity sensor targets, different sensors are necessary. A capacitive proximity sensor or a photoelectric sensor, for example, may work with a plastic target, but an inductive proximity sensor requires a metal target.

Due to the lack of mechanical parts and physical contact between the sensor and the perceived item, proximity sensors can have a high level of dependability and long useful life. Machine vibration monitoring also uses proximity sensors to assess the variation in distance between a shaft and its support bearing. This is frequent in sleeve-type bearings in big steam turbines, compressors, and motors. As a touch switch, a proximity sensor with a relatively narrow range is frequently utilized.

2 Method of approach

2.1 Camera

The distance of the object from sensor can be calculated by getting the coordinates from the object detection function. With the help of that the distance of the object in focus can be calculated using the formulae. By using the reference image, the focal length of the object in the frame is calculated.

focal_length = (width_in_rf * measured_distance) / real_width.

Using focal length, the distance between the object and the camera is found.

distance = (real_object_width * focal_length) / width_in_frame

2.2 Proximity sensor

The distance of the object from the sensor is calculated using the volage difference. The Analog to Digital Converter convert the Analog input given by the sensor to Digital signal. The voltage is converted to digital value and calculated using formula

dist = 16.2537 * v**4 - 129.893 * v**3 + 382.268 * v**2 - 512.611 * v + 301.439

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3 Equipment description:

3.1 Camera

Raspberry pi camera 5mp is used to capture the video and then the video is converted into image frames to extract the optical flow vectors. With the help of the optical flow vectors, it is easy to navigate the MAV. The camera shows flow around the object, HSV image and the diluted image of the object or the obstacle in its area of visibility. The camera can identify the object or the obstacle and can estimate its distance with the developed algorithm. The specifications of the camera are stated in table 1.

Fig 1- Raspberry pi camera

The dimension of the raspberry pi Camera used is 25x24x9 mm with the weight of 3g. A camera of 5 megapixel with three different video modes (1080p30, 720p60 and 640 × 480p60/90) is attatched to the module. Linux integration, V4L2 driver available in the camera module. The camera sensor is an OmniVision (OV5647) sensor. The resolution of the camera sensor is 2592 x 1944 pixels. The sensor image area is 3.76 x 2.74mm. The pixel size of the camera sensor is 1.4 µm x 1.4 µm. The Optical size of the camera sensor is 1/4". Dynamic range of the sensor is 67 dB @ 8x gain. The sensitivity of the sensor is 680 mV/lux-sec. The sensor's Depth of field is approx. 1 m to infinity. The focal length of the camera is 3.60 mm +/- 0.01. The Horizontal field of view and the vertical field of view of the camera sensor is 53.50 +/- 0.13 degrees and 41.41 +/- 0.11 degrees respectively. The focal ratio of the sensor is 2.9.

3.2 Raspberry Pi 4

The raspberry pi 4 is an incredibly powerful platform in an exceedingly small package its credit card sized and perfect for embedded systems. It is very useful for the project's which are in need for the display and interface. The specifications of the raspberry pi board are stated in table 2.

Fig 2 – Raspberry pi model 4 B

The processor in Raspberry pi model 4 is Broadcom BCM2711, Quad core Cortex-A72 (ARM v8) 64-bit SoC @ 1.5GHz. The Random Access Memory(RAM) of the Raspberry pi model 4 is 2GB LPDDR4-3200 SDRAM. For the connectivity purposes the Raspberry pi model 4 offers 2.4 GHz and 5.0 GHz IEEE 802.11ac wireless (Wifi), Bluetooth 5.0, BLE, Gigabit Ethernet, 2 USB 3.0 ports and 2 USB 2.0 ports. The Video and Sound support that the Raspberry pi model 4 offers 2 × micro-HDMI ports,2-lane MIPI DSI display port,2-lane MIPI CSI camera port and 4-pole stereo audio and composite video port. Raspberry pi model 4 has a multimedia support H.265 (4kp60 decode), H264 (1080p60 decode, 1080p30 encode)OpenGL ES 3.1. Raspberry pi model 4 has an SD card support (Micro-SD card slot for loading operating system and data storage). Power input is 5V DC via USB-C connector (minimum 3A*)5V DC via GPIO header (minimum 3A*).

3.3 Proximity sensor

The proximity sensor detects the object without any physical contact through a reflected light ray. This type of proximity sensor is used as Distance infrared (IR) sensor. The sensor detects the distance using light transmission and IR.

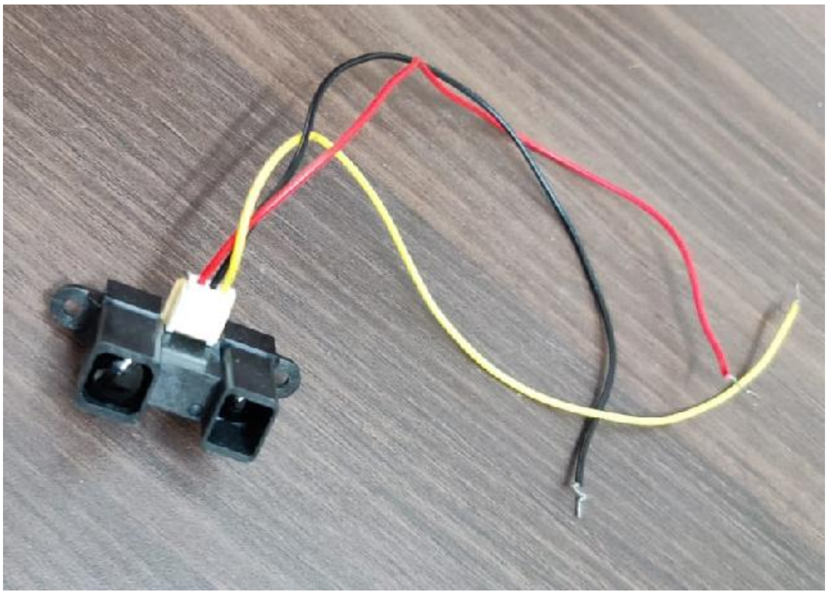

Fig 3 – picture of the proximity sensor

The Proximity sensor of model GP2Y0A02YK0F (20 to 150 cm). The operating voltage of the sensor is 4.5 ~ 5.5(VDC). The range that the sensor offers for measuring the distance of the object is 20 ~ 150 (cm). The length, width and height of the sensor is 44.5mm,13mm and 21.5mm. the weight of the sensor is 5gm.

4 Experimental Study

4.1 Detection of object and finding the distance

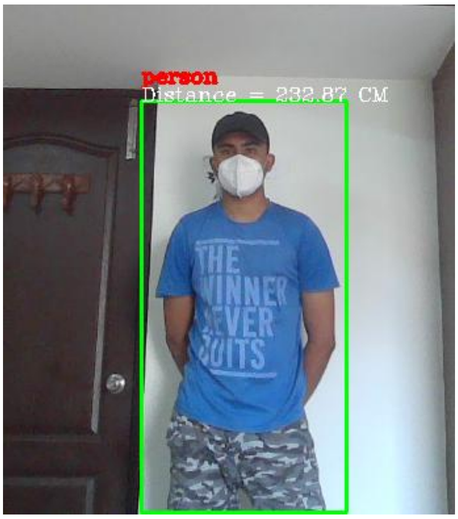

Fig 4 – Object detection and distance estimation

The sensor has detected the object as a person and estimated the distance as 232cm. the actual distance between the detected object and sensor is shown in fig 8.

Fig 4.1 – Actual distance from camera to the object

Fig 4.2 – Different object detection and distance estimation

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4.2 Distance estimation using proximity sensor:

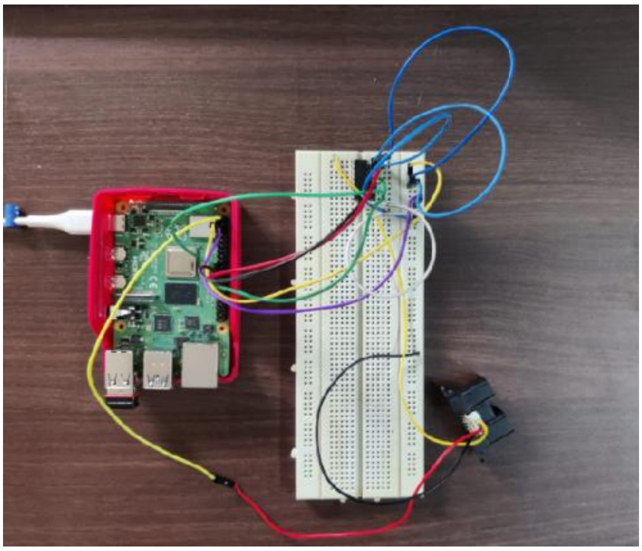

Fig 5 - experimental setup of proximity sensor

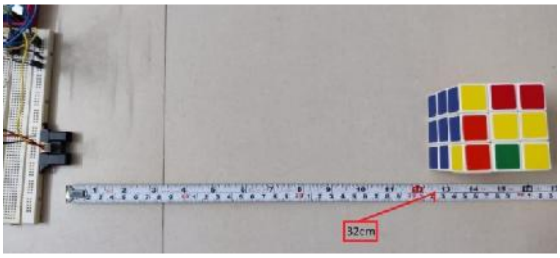

Fig 6 – Distance between the sensor and the

```
>>> %Run dist.py
  Distanz: 32.32 cm
  Distanz: 32.32 cm
  Distanz: 32.32 cm
  Distanz: 32.32 cm
  Distanz: 111.54 cm
```

Fig 6.1 – Distance received from sensor

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Fig 6.2 – Distance between the sensor and the object

Fig 6.3 – Distance between the sensor and the object

Conclusion:

The sensors measure distance, however the camera sensor requires references (width of the item, known distance, and reference picture) for object identification, and the distance is determined using object detection. With object detection and distance estimation from the camera sensor or the proximity sensor(depends on which sensor is mounted on the MAV) the MAV can be navigated safely.

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