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Methodology for Distance Measurement: A Comparative Study

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ABSTRACT: *Distance measuring sensor provides information on an absolute position of target and deals with transmitter and receiver, which define the dimensions of an object. Depending on the equipment, light condition, angle of reflection from the surface and reflective properties on the measuring surface. In this review paper 3 various reflection measurements namely Time of Flight sensor, Ultrasonic sensor and Monovision camera are used for distance measurement. Because of different reflective capabilities of various objects, comparison of different survey equipment is made inorder to uplift the coconut climbing unit vertically to measure the endpoint and also to place the entire climbing unit 2meters beneath the crown of the tree to make ready for the next chopping action.*

Keywords: Time of Flight sensor, Ultrasonic sensor, Monovision camera.

1. INTRODUCTION

The state has 25,000 hectares under coconut plantations and an acute shortage of pluckers. It is a challenging time. Due to shortage of pluckers, farmers are increasingly hesitant to grow new crop. Coconut harvesting is traditionally carried out by men who belong to the economically lower class of society. As the number of literacy rate increases and awareness about the high paid job opportunities, the number of men climbing coconut trees for harvesting coconut has decreased increasingly. As these men usually do not have any insurance coverage, any accidents while climbing the trees would affect the entire family. Hence end-to-end autonomous coconut harvesting robot system starting from mechanical climbing and harvesting designs to vision-based coconut detection and harvesting is introduced.

In industrial applications, distance in air is often measured by using ultrasonic sensors. Then the main measuring principle is based on the Time-of-Flight (ToF) estimation, that is the time needed for an ultrasonic wave to travel from the transmitter to a target and then, after reflection, back to the receiver located near the transmitter. In conventional distance sensing techniques like laser, scanners or image based stereo-vision now-a-days Time-of-Flight (ToF) sensors have become a considerable alternative. To provide full-range distance information at high frame-rates, ToF sensors achieve a significant impact onto current research areas like online object recognition, collision prevention or scene and object reconstruction [1].

To measure distance, position changes, level measurement, such as presence detectors or in special applications Ultrasonic sensors are often used for automation tasks [4]. Ultrasonic sensor is based on the principle of measuring the propagation time of ultrasonic waves. This principle ensures reliable detection is independent of the color rendering of the object and the type of its surface. Materials such as liquids, bulk materials, transparent objects, glass etc are reliably detected.

Mono vision on the other hand is comparatively less expensive as it requires only one camera. Object depth is computed based on the amount of image resizing in proportion to the camera movement [6]. The mono vision based approach in Ref. 8 includes two steps: (i) It calculates an interpolation function based on the height and the horizontal angle of the camera, and (ii) It then uses this function to calculate the distance of the object from the camera. The limitation of this method is the dependency on primitive height and horizontal angle [7].

In this paper, comparative study of advanced sensors and Monovision based cameras are referred to implement endposition distance value to make use of coconut harvesting.

1.1. Time Of Flight Sensor

Time of flight describes a various method and measures the time, taken for an object, particle, (or) acoustic, electromagnetic (or) other wave to travel a distance through a medium. In simple it is a “Measure of time”.

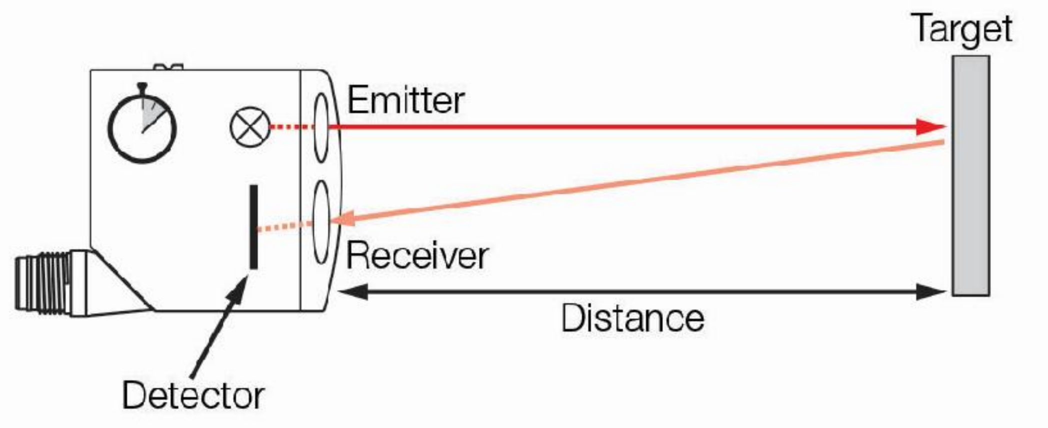

Fig1.1: Time of flight sensor

A new innovation, Time of Flight (ToF) signal processing IC by Intersil Corporation, that provides a complete object detection and distance measurement solution when combined with an external emitter (LED or Laser) and photodiode. The ISL29501 ToF device offers one-of-a-kind functionality, including Ultra-small size, low-power consumption and superior performance ideal for connected devices that make up the IoT (Internet of Things).

1.1.1. Time of Flight principle:

The time taken to Measure the distance between a sensor and an object, is the Time-of-Flight principle (ToF), based on the time difference between the emission of a signal from the emitting end and the return wave from the object is received after due to its reflection and received by photodiode. Various types of signals or carriers can be used with ToF. TeraRanger sensors use light as their carrier, because it is uniquely able to combine speed, range, low weight and eye-safety. By using infrared light we can ensure less signal disturbance and easier distinction from natural ambient light, resulting in the highest performing sensors for their given size and weight.

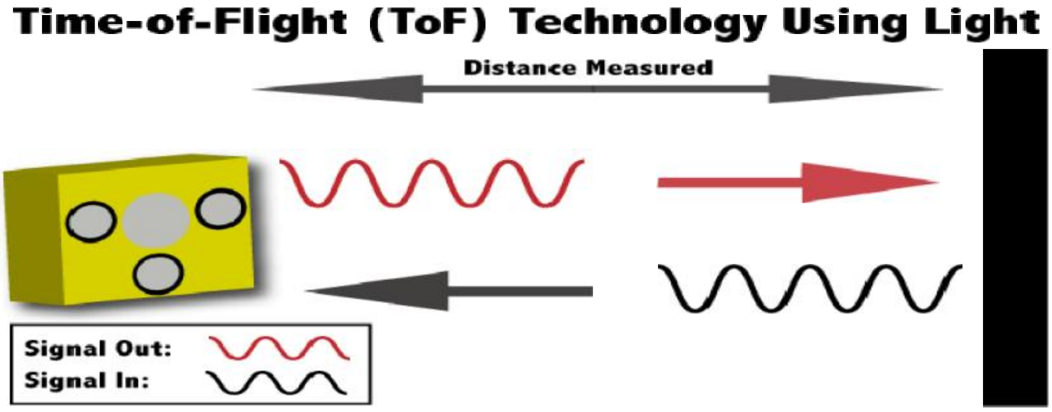

Fig1.1.1: Time of flight sensor principle

The ISL29501 has a built-in current DAC circuit that drives an external LED or laser. The modulated light from the emitter is reflected off the target and is received by the photodiode. The photodiode then converts the returned signal into current, which is used by the ISL29501 for signal processing.

An on-chip Digital signal processor calculates the time of flight, which is proportional to the target distance. The ISL29501 is equipped with an I2c interface for configuration and control. Based on Time of Flight principle (ToF), ToF, used to estimate full-range distance information in real time by illuminating the scene with modulated infrared light and determining [1]. The phase shift between the reference signal and reflected light, due to several error sources. In this paper calibration task is very complex and time consuming in respect to the reference data acquisition [1]. To avoid such complexity ISL29501 Evaluation software user guide used for quick calibration. Steps to be followed are

1. Extract files from the archive file to a convenient location.
2. Plug the USB cable into the reference design.
3. Double click “ToF.exe” to start the GUI.
4. From the GUI does a File->Load profile->Filename (calibration).
5. Click “start” to begin distance measurement.

Besides the phase or time delay, two more parameters are unknown in the incoming signal, namely its amplitude and power of the background light of scene. This is the reason why at least three measurements in a cycle or pulse are needed to calculate a distance. Averaging by means of the accumulation of several periods of the signal for a single distance measurement to reduce shot noise[4].

1.2. Ultrasonic Sensor

Ultrasonic sensors also said as ultrasonic transducer, sends a sound pulse and then measure the distance to or the presence of a target object, toward the target and then measuring the time it takes the sound echo to return. Knowing the speed of sound, the sensor determines the distance of the target and sets its outputs accordingly.

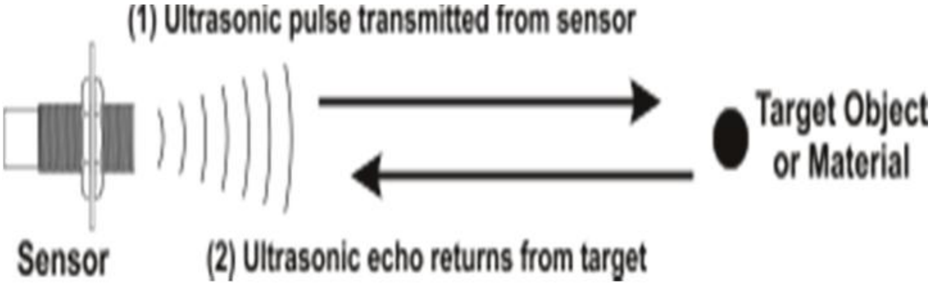

Fig1.2: Ultrasonic sensor operation

Sensor outputs are set based on the measured distance, or under override conditions, a lack of target detection or user-selected response algorithms. Outputs can be:
• an analog voltage or current signal proportional to the measured distance
• Switches or relay contact closures that open or close at specific distances
• distance data transmitted digitally as serial data communications.

This paper deals with the verification of the accuracy of measurement distance ultrasonic sensor in the current environment. As a measuring sensor was chosen SFR08 and the measurement interfaced with EEPROM in the form of i2c. Hence sensor array is simply created. The method to Control and visualization is made on PC based. As communication card was used NI USB 8451 [4]. The goal was to determine the actual sensor accuracy while measuring longer distances. The sensor accuracy was not included in temperature compensation of the measured data when evaluating [4].

Ultrasonic sensors HRLV-Max Sonar-Ezo proximity is based on the principle of measuring the propagation time of ultrasonic waves. This principle ensures to design and the type of its surface and detection is

independent of the color rendering of the object. Ultrasonic sensor can also detect even such materials as liquids, bulk materials, transparent objects, glass etc.

1.2.1. Ultrasonic principle:

Ultrasonic sensors emit short, high-frequency sound pulses at regular intervals. At the velocity of sound, the sound pulses propagate in the air. The sound of pulses strikes an object, and then they are reflected back as echo signals to the sensor, then the echo signal computes the distance to the target based on the time-span between emitting the signal and receiving the echo.

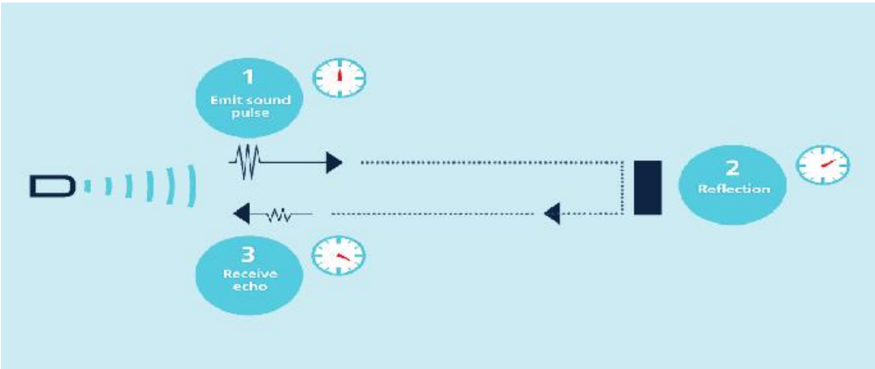

Fig1.2.1: Ultrasonic principle

By measuring the time, the distance to an object is determined and not by the intensity of the sound. Ultrasonic sensors are excellent at suppressing background interference.

The use of ultrasound can be classified into two main groups namely,

- Active ultrasound
- Passive ultrasound

Active ultrasound exhibits, physical or chemical effects when applied. Then reaches the highest values when generated. Speed of sound is dependent on the type of environment in which it moves, and the current temperature of the environment. The output of passive ultrasound output is generated only at lower values.

In this paper to measure the spring heights during the car movement, ultrasonic sensor has been mounted onto the back of a car and equipped with four potentiometer sensors. To record the ultrasonic sensor and the potentiometer outputs a portable digital recorder is used. Sensor tests asphalt and rough ground and the four potentiometer outputs have been used to compute a distance reference value to be compared with the ultrasonic measured distance. By adding the tire deformations to the spring heights measured by the potentiometers, end spring heights, have been estimated which in turn used to identify the plane of the vehicle body. The distance reference value that corresponds to the distance the ultrasonic sensor should produce has been determined by putting the measuring head coordinates into the identified plane equation [8].

For many applications ultrasonic plays a vital role not only for distance measurement but also around the world, indoors and outdoors in the harshest conditions, namely liquid level control, full detection, thread or wire break detection, robotic sensing, stacking height control and also for people detection for counting based upon proximity detection and range measurement.

If the detect point is independent of target size or material reflectivity proximity detection is used and change in movable distance is calculated by means of ranging measurement.

1.3. Monovision camera

Monovision camera and laser scanner is mainly used to detect the obstacles. At first laser scanner is used to detect the obstacles and then mono vision camera is used to confirmation of obstacles. By means of mono vision camera the user can detect the length and breadth of the obstacles and using laser scanner is used to detect the distance between their vehicle and obstacles.

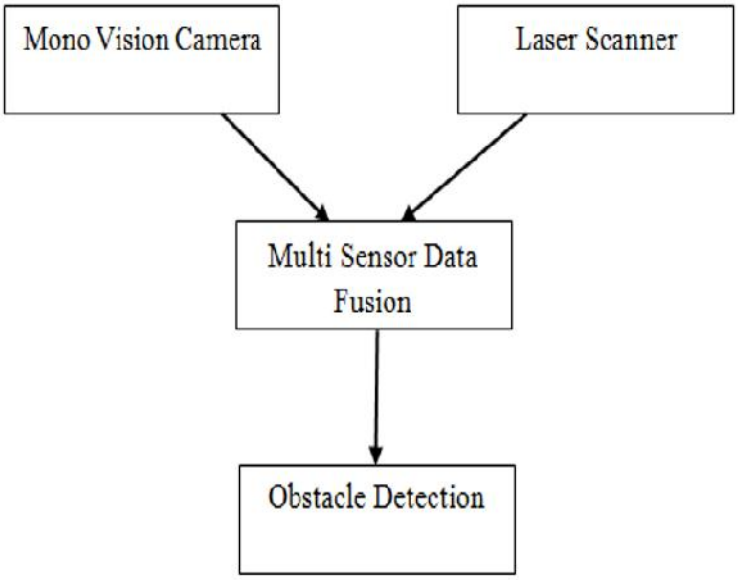

Fig1.3: Obstacle Detection by Monovision camera.

It is necessary to measure the distance of an object from a single image to have a frontal view and to know the true magnitude of the object. The dimensions of vehicles are different depending on the model, so they cannot be used as a reference. It must be approved and its shape and dimensions are fixed in each country. Localizing the front vehicle's number plate and having previously established a relationship between the number plate's size in the image and the distance to the camera, the vehicle's distance can be obtained directly.

The first step consists of establishing of a region of interest on the road corresponding to the safety area in front of our vehicle after capturing a grayscale frame. The vehicle detection step begins and a first distance estimation is performed based on the vehicle's bounding box location. Then the search of the vehicle's number plate is used for two purposes: to validate the vehicle's detection and to obtain the vehicle's distance [11]. The intension of this paper is to for on-road vehicle detection and computation of distance and relative speed in urban traffic by means of Monovision based system.

The main drawback of this camera, Single sensor is used to detect the obstacles but that sensor must have support of other sensor for confirmation of obstacles but multi sensor usage is more precise and accurate.

As no depth information is available to avoid obstacles, Monovision faces much more difficulties and the other problem of this paper is object detection in varied real time. Pixel density varies drastically when there is a transition between one pattern to other. Three main algorithms are used namely, the obstacle prediction, Obstacle detection, Multipath traversal to overcome the above listed problem [12]. By observing the relationship between the physical distance of an object and pixel height of an image, distance of a single image is calculated [13].Object detection, obstacle avoidance, and location finding are the major challenges observed.

Image accuracy taken by camera mounted on the robot, affect s development of vision based machine is Image accuracy. By using Laser beam pixel area (LBPA) based Image programming technique used by a hybrid system which is a combination of camera and laser pointer [7]. Mainly Vision Based Navigation for an Unmanned Aerial Vehicle implementation this paper is observed. A vision-based navigation method mainly used for indoor environment for an autonomous mobile robot, to avoid obstacles. With a model-based vision system Self-localization of the robot is done [14]. By using a retroactive position correction system, non-stop navigation is realized. With the help of single camera stationary obstacles are avoided and also with the help of single-camera vision, moving obstacles are detected.

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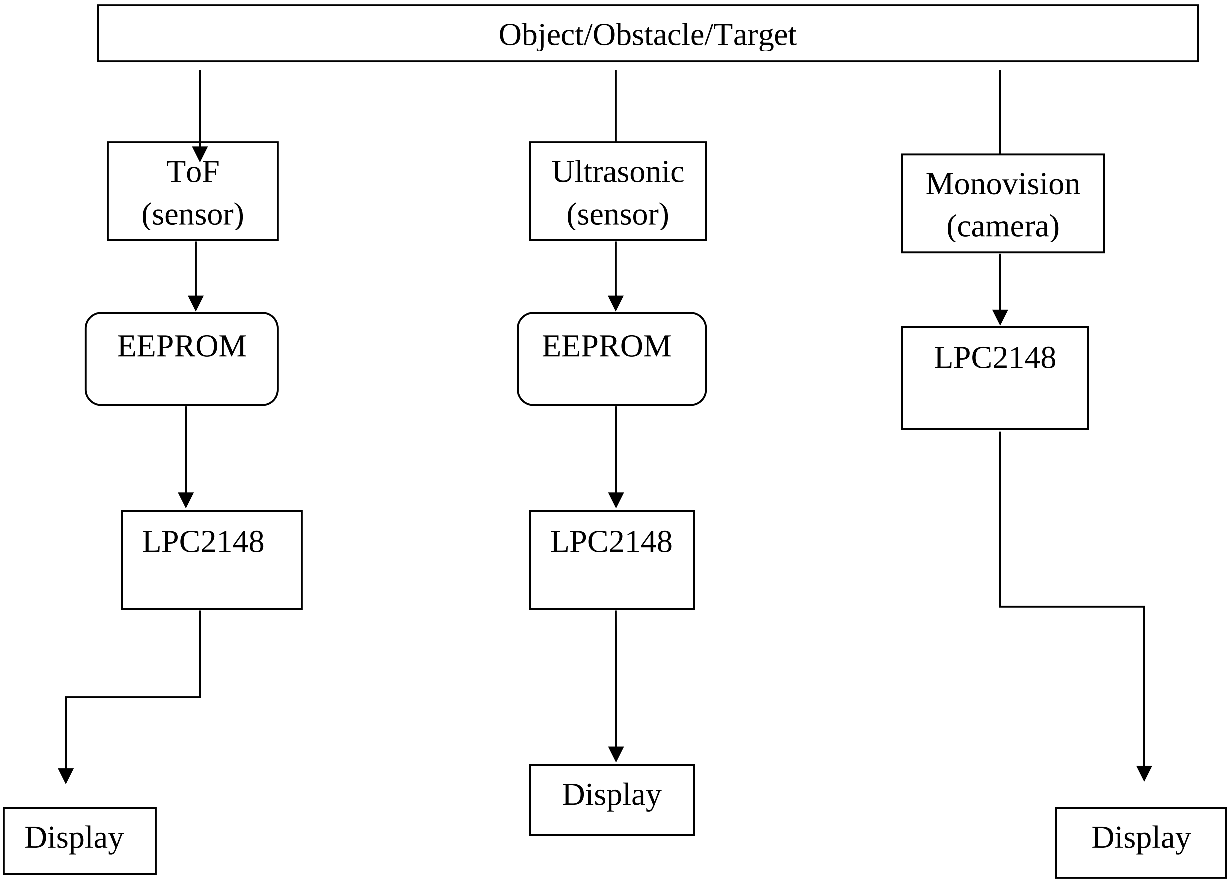

Fig1.1, 1.2, 1.3: Comparative block of Distance Measurement.

Implementing various methods of sensing technique and then the retrieved values of various distance measurement is interfaced with EEPROM chip. Now the result of EEPROM is interfaced with LPC2148 and then viewer views the result through display.

CONCLUSION

As a result of comparative study, ToF(Time of Flight) is much more standard and has optimum values, since has self contained measurement system and operates in continuous or single shot mode along with on-chip active ambient light rejection. And calibration work is made done with ISL29501. Though Ultrasonic sensor is direct with distance, sensor sort is indicated while detecting solid surface and requires a base target surface range on the other hand Monovision camera has a low visual acuity and depth perception along with contrast sensitivity.

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