



Distance Estimation Using Multisensor Data Fusion Technique with FPGA

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ABSTRACT: In today's smart world, the data fusion is an important part, the smart devices require reliable and different types of sensory data regarding their objectives for getting better information. Different types of sensors are often fused to obtain information which cannot be acquired by a solitary sensor alone. For mobile robots sensor fusion is particularly used for object detection and navigation. The proposed framework, aims to estimate the distance by multisensor data fusion technique using Infrared and Ultrasonic sensors. This distance estimation system is implemented by using two sensors (IR and US) and the FPGA (Altera Cyclone IV) as a controller. The data fusion method is applied to the data received from two sensors (IR and US). The FPGA is used to estimate the distance of obstacle with the help of Mean, Variance, Standard deviation and Coefficient of Variance which is collected from the two sensors (IR and US). The robot application is implemented which move in forward direction and stop when obstacle is detected within particular distance range. The FPGA feeds the fusion data (estimated distance) to the robot application and according to sensor characteristic only positive part is taken and neglected the negative, so as to increase the accuracy of system. This approach is beneficial than the other techniques both in terms of economic and computation

KEYWORDS: Ultrasonic sensor, Infrared sensor, Coefficient of variance, Multisensor data fusion technique

I. INTRODUCTION

In recent years, multisensor data fusion has received significant attention for both military and non-military applications. Data fusion techniques combine data from multiple sensors and related information from their database used to achieve improved accuracies, and then more specific inferences could be achieved by the use of a single sensor alone. The integration of data and knowledge from several sources is known as data fusion. Sensor fusion roughly means integration of information from different types of sensor into a unified interpretation. When we work with several sensors, it involves several uncertainties & represents several problems, to overcome these problems, data fusion technique is used. Suppose for the distance estimation of obstacle two sensors like IR sensor & ultrasonic sensor are used. In this case IR sensor offers simple, user friendly, lower cost than ultrasonic sensor and fast obstacle detection. However it has some serious limitations like detecting mirror or glass based object due to reflectance property. It will not give accurate reading in sun light.

On the other hand ultrasonic sensor depends on sound propagation so it will unaffected by above situation. It requires wide beam & high cost. It can be used in sunlight application. So combination of these sensors gave advantages of two sensors. These two sensors are used as complementary way such as the advantages of one compensate for disadvantage of the other [1].

II. RELATED WORK

WANG Yunsong CHU et.al [2] used decision-level fusion method to diagnosis fault of automotive engine. This technique does not require appropriate sensor data and has robust operational performance but it has low fusion accuracy and high data pre-processing cost. MarinkaZitnik and Blaz [3] used data fusion approach by matrix trifactorization consist of data matrices to get the result. It required the no. of iterations to optimize algorithm converge when producing gain function. This algorithm is very complex one. Manish Kumar, Devendra P. Garg, and Randy A. Zachery [4] used a unified sensor fusion strategy based on a modified Bayesian approach that can automatically

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identify the inconsistency in sensor measurements so that the spurious measurements can be eliminated from the data fusion process. This formulation was an estimate of probability that the data is not spurious according to measured data and unknown value of true states. Lijun Xu [5] used wavelet transform-based data fusion algorithm for multisensor systems. He used Minimum Mean Square Error estimator for time-invariant and time-varying processes. But in this technique wavelet should be carefully selected to estimate the variance of fast time varying system. Huadong Wu et al. [6] used sensor fusion technique for context aware computing. He used Dempstershafer theory of evidence and the classical Bayesian method and compare it with the weighted sum of probabilities method. David et al. [7] gives the introduction of different sensor fusion method for department of defence (DOD). He introduced data fusion application, process models and identification of applicable techniques. Tapan Kumar Nayak, Sanjit Kumar Dash, Himansu Sekhar Sasmal and Srikanta Patanaik [8] used data fusion technique for the object detection in robotics. Wireless sensor network was used for remote monitoring objects and environment. To handle uncertain, incomplete and vague information, data fusion technique is applied to a measuring system to reduce effectively overall uncertainty and increase the accuracy. In data fusion Dempster-Shafer evidence theory is used. Shrabani Bhattacharya and Rappavu Raj [9] used performance evaluation of multi-sensor data fusion technique for test range application. Data fusion technique consists of state vector analysis for range selection application. In this multiple sensors track data to provide complete and precise trajectory information about the flight vehicle under test, for the purpose of flight safety monitoring and decision making at test range. Tarek et al. [10] used phong illumination model to determine reflectance property of IR sensor so that it gives accurate readings. He used fusion of IR and US sensors for distance measurements.

III. PROPOSED SYSTEM

A. Block Diagram:

The Fig.1 shows the block diagram of system which consists of two sensors (IR and US) with FPGA for the measurement of distance.

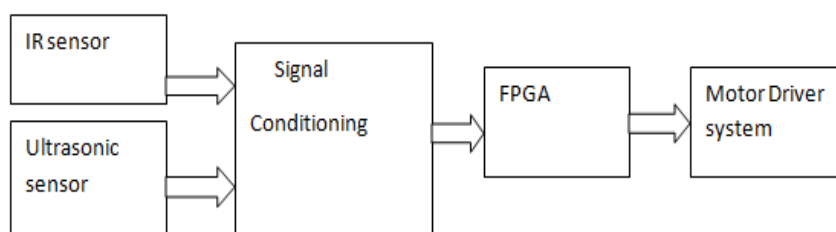


Figure.1. Block Diagram of System

The system consists of DEO-Nano board which includes Altera Cyclone® IV EP4CE22F17C6N FPGA with a built-in USB Blaster for FPGA programming [11]. The DE0-Nano board contains a Cyclone IV FPGA which allows users to configure the FPGA with a specified design using Quartus II software. The sharp Infrared sensor GP2Y0A02YK having range of 10 cm to 80 cm and ultrasonic sensor HC-SR04 are used [12]. The data has collected from the Infrared sensor & Ultrasonic sensor feed to I2C externally available on FPGA board and then this data is configured to FPGA to estimate the distance. The application for this system is shown in Fig.2.

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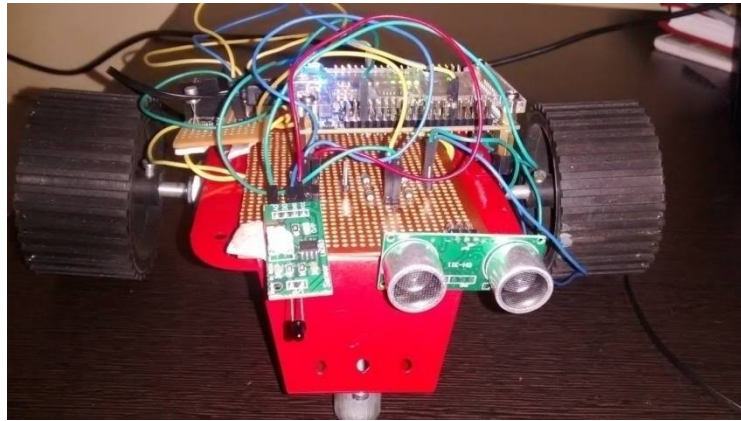


Figure 2. Photograph of the actual system

B. System Implementation:

Proposed system is implemented by using two different sensors Infrared sensor (IR) and ultrasonic sensor (US). The following parameters are considered in the estimation of distance. Let S_1 and S_2 are two values of distances obtaining from the sensors. The Mean (M) value of sensors is obtained by equation (1)

$$\text{Mean (M)} = \frac{S_1 + S_2}{2} \dots\dots\dots (1)$$

This formula is implemented using VHDL coding. σ_1 & σ_2 are the variances of two sensor value respectively and is calculated by equation (2)

$$\text{Variance} = \frac{[(\text{Mean} - S_1)^2 + (\text{Mean} - S_2)^2]}{2} \dots\dots\dots (2)$$

Standard deviation (SD) is calculated by equation (3)

$$\text{SD} = \sqrt{\text{Variance}} \dots\dots\dots (3)$$

Coefficient of variance (C.V) is calculated by equation (4)

$$\text{C.V.} = \frac{\text{Mean(M)}}{(\text{SD})} \dots\dots\dots (4)$$

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C. Distance Estimation Flow Chart

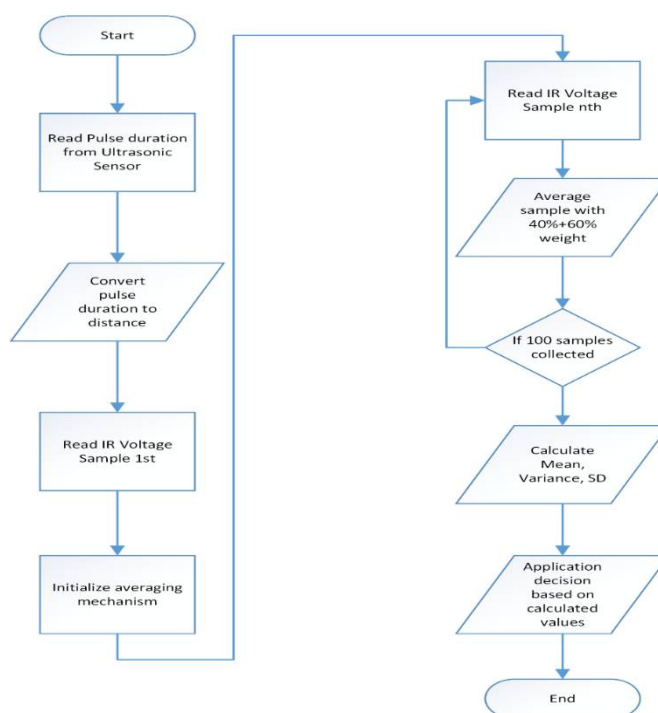


Figure.3. Distance Estimation Flow Chart

This chart of Distance estimation flow is shown in Fig.3 .The following are the procedure used for distance estimation using FPGA with two sensors (IR and US).

- When the obstacle detects, pulse from ultrasonic sensor is read first
- Convert the pulse duration into the distance.
- Read the Infrared sensor voltages.
- Initialize the averaging mechanism.
- Convert the IR voltages value into n^{th} samples
- By using least square weighted mechanism IR voltages converted into distance.
- Calculate the Mean, Variance, Standard Deviation and Coefficient of Variance.
- Display the results.

In this system by observing characteristic of both sensor, it can be observed that for small distance IR gives some variations and US gives the approximate reading. Thus for small distance up to 6cm reading of US is considered as fusion data and after that range, the Mean of both the sensors are taken and display the value as a fusion data. Coefficient of variance shows dispersion of reading.

IV. SIMULATION RESULTS

From the collected data and simulations the following are the results obtained.

The Fig. 4 shows the graph between Infrared sensor reading and actual distance, which shows the IR sensor gives variation up to 6 cm distance and afterward it gives the linearity.

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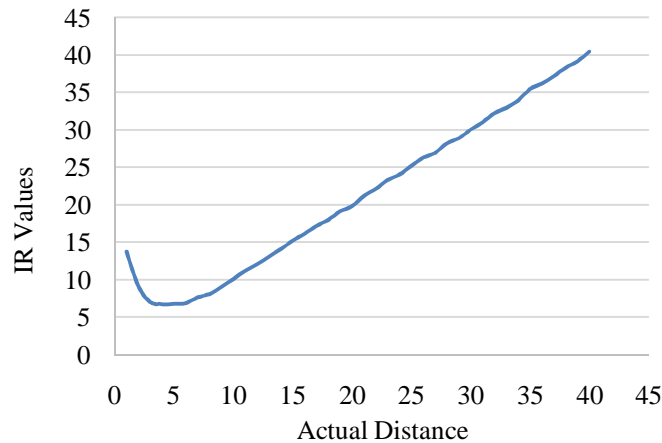


Fig.4.Relation between IR and actual distance

The Fig.5 shows the relation between actual reading and distance measured by ultrasonic sensor. In this the variation at small distance is not observed. So the actual distance is estimated in such a way that fusion data take the reading of ultrasonic sensor only because there is large variations in the IR sensor reading. After the 6cm distance, the Mean of both the sensors will be considered as estimated distance called fusion data. This fusion data is given to the motor driver system, so that it can accurately judge the distance of the obstacle and take further decision.

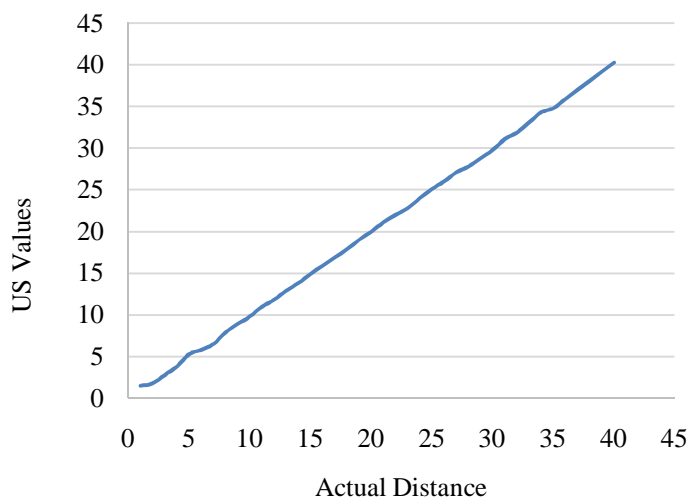


Fig.5. Relation between US Distance and actual distance

The Fig. 6 shows the relation of actual distance and fusion data and shows the linear relationship. This characteristics shows that instead of the single sensor if two or more sensors are used then it will gives better results than single sensor.

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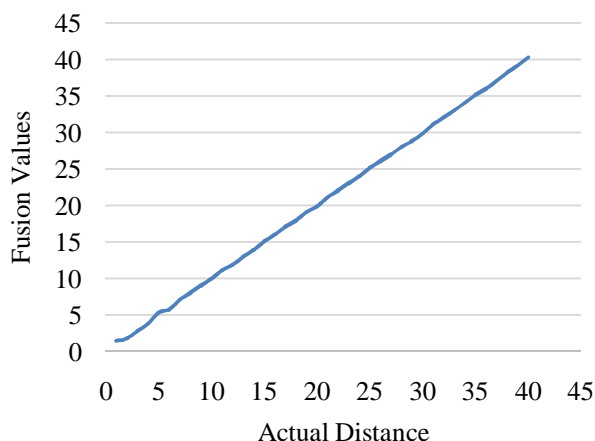


Fig. 6. Relation between Fusion Data and actual distances

The relation between coefficient of variance and fusion data is shown in Fig.7, from this the Coefficient of Variance gives maximum dispersion from its actual value. Coefficient of variance is very useful to give deflection of each distance value from its actual distance. According to the value of coefficient of variance, uncertainties at particular point will be predicted. If any sensor not working properly it can also be identified by coefficient of variance. This system used 39% logic element which consist of 31% combinational logic functions and 26% dedicated logic registers. It required 37264 memory bits and 25% PLL's. It consumed 305.74mW power.

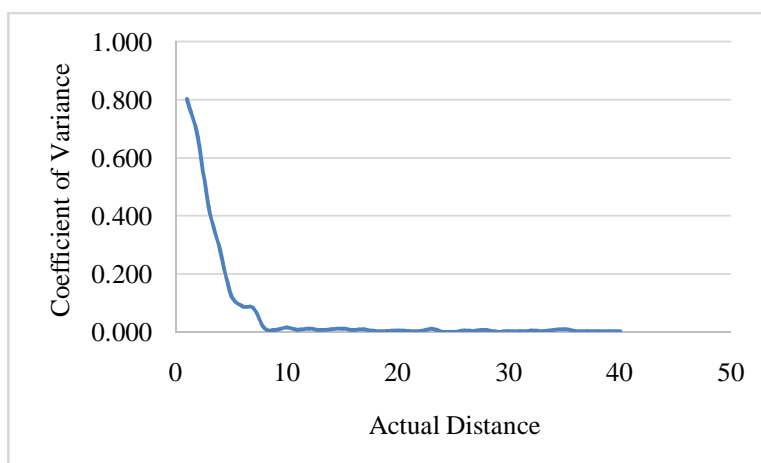


Fig 7. Relation between coefficient of variance and actual distance

V. CONCLUSION AND FUTURE WORK

A novel Data fusion technique based on mean & variance is presented. The proposed work is FPGA based implementation of data fusion architecture for Ultrasonic and Infrared sensors to find out the distance of an obstacle. The approach is less costly than the other existing techniques both in terms of economic feasibility and in terms of computation. Its low computational complexity leads to less hardware resource requirements without compromising the speed of operations. The proposed system require time for achieving result is less and total thermal power dissipation is 502.26mw. This system achieve accuracy near about 96%. These would be probably most useful advantages in the field of applications such as robotics and we are aiming its implementation in a cost effective manner. This system can be implemented by fuzzy logic.



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BIOGRAPHY

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