AUTONOMOUS POSITION TRACKING AND ALIGNMENT ROBOT WITH IMPROVED DATA ACQUISITION ALGORITHM

Siddhesh Gotad[1], Vikrant Fernandes[2], Harsh Jain[3], Omkar Chavan[4]
[1, 3& 4]Department of Electronics and Telecommunication Engineering,
Mumbai University, Mumbai, India.
siddheshgo@gmail.com
[2]Department of Computer Engineering, Mumbai University, Mumbai, India.
vikrant.ferns@gmail.com

ABSTRACT

In this paper we present a system for mapping the position of a robot and autonomously manoeuvre it to a desired location in a given two dimensional space. The process includes a data acquisition algorithm having high stability and low complexity and also a PID controller for error elimination during alignment process. The coordinates of the position are extracted from a transmitter and receiver type SHARP infra-red sensor. This system is highly accurate and has a wide range of application in industrial as well domestic robotics applications.

KEYWORDS: *SHARP sensor, Data acquisition, PID error correction, algorithm, Merge sort, Robotics.*

I. INTRODUCTION

In today's world the desire for automating things has increased like never before. At present, remarkable improvements have been achieved in position alignment techniques however, the accuracy of such systems have always been an issue. The need for a highly accurate alignment system is of highest priority in industries where precision is paramount. Data acquisition systems play an important role in the precise determination of coordinates of the position as the traditional methods introduce large proportions of noise. Therefore, development of an error-free data acquisition system is a must.

Systems with artificial intelligence are becoming the important aspects of modern research and development. Precision and accuracy have been key aspects for a future scope in artificial intelligence to a new level. For this purpose to be achieved, a robot following PID error elimination algorithm embedded with distance sensors to feed real-time data to the system is implemented. This will enable the robot to know its surrounding environment and locate its coordinates on a map, already available with the robot. Later, using this data, it can realign itself at user-defined or code-defined desired location. Extending its application in the real world, it could be utilized in automated driving, pathfinding, topology construction, and so on.

II. METHODOLOGY

The setup involves a robot that locates itself on a given map using the SHARP GP2Y0A21YK Infra-red distance sensor mounted on the robot. This point on the map is then be marked as the current position. The final position is either transmitted to the Robot by the operator or it can be pre-coded. A closed loop now checks if the Robot is at the final position. If the Robot is at any position other than the final position, the PID error correction algorithm determines the error in its position and transmits the required correction to the motors to realign the Robot as shown in Figure 1. All the algorithms have implemented on Arduino Mega 2560 micro-controller platform. The entire process includes two important phases which are as follows:

i. Data Acquisition algorithm
ii. PID error correction algorithm

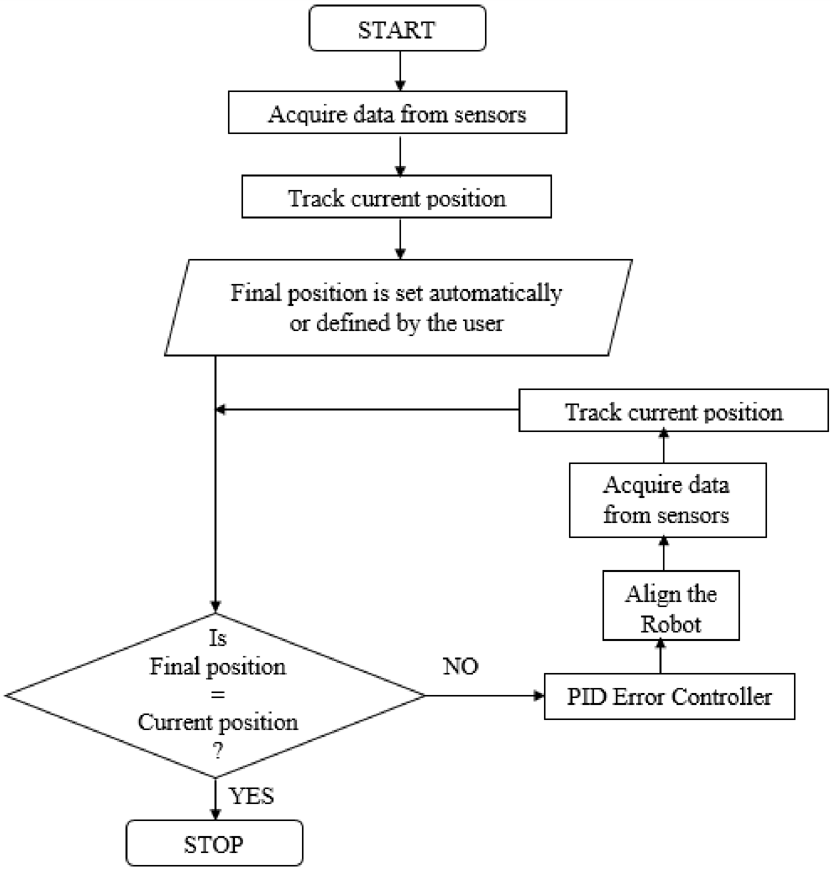

Figure 1. Methodology

III. DATA ACQUISITION

Sensor noise is a very common issue which can lead to huge miscalculations in precision robotics. In order to undermine this problem, a novel data acquisition algorithm was developed.

3.1. Concept

Readings from sensors are often affected by noise and keep fluctuating within certain limits. These fluctuations are often observed in the form of crests and troughs. The algorithm proposed in this paper selectively eliminates the crests and troughs from the set of readings obtained from the distance sensor used in the system. The remaining readings are then levelled out by calculating the average. The refined reading is then converted to centimetres using a formula.

Merge sorting technique used in the data acquisition algorithm is a fast sorting technique and has low time complexity. It uses a divide-conquer-combine approach which can be explained as follows [1]:

1. Divide: Partition the n-element sequence to be sorted into two sub-sequences of n/2 elements each
2. Conquer: Sort the two sub-sequences recursively using the merge sort.
3. Combine: Merge the two sorted sub-sequences of size n/2 each to produce the sorted sequence consisting of n elements.

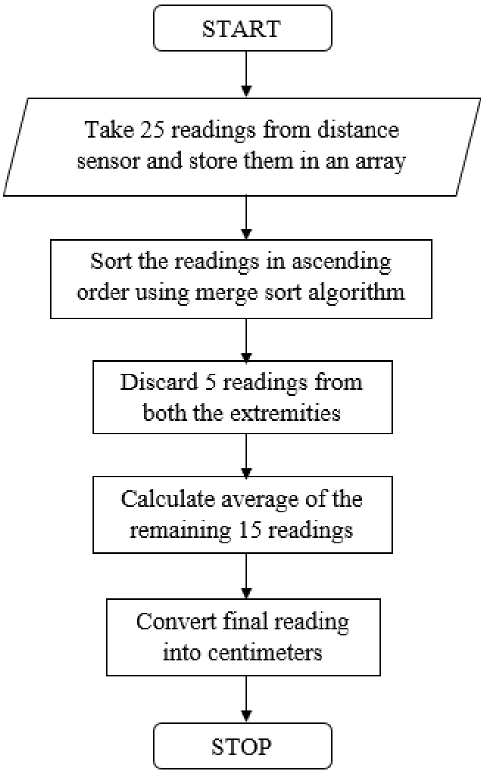

Figure 2. Flowchart for Data Acquisition technique

3.2. Observations

An R-C filter was implemented to electronically reduce the sensor noise but problem of sensor noise still persisted. The data acquisition algorithm was thus implemented, and the stability of the readings can be verified from Figure 3 and 4. Figure 3 shows the sensor readings when the robot is stationary. Figure 4 shows the sensor reading when the bot is moving. From Figure 4, it can be inferred that the data acquisition algorithm gives extremely stable readings required for precision robotics.

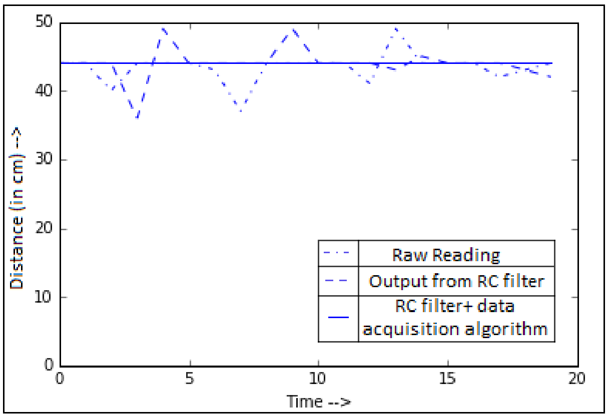

Figure 3. Sensor readings when bot is stationary

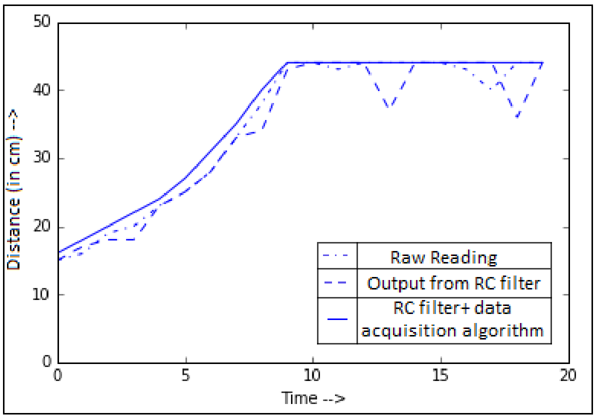

Figure 4. Sensor readings when bot is moving

In order to sort the 25 readings obtained from the sensor, bubble sorting technique was used. However, during testing it was observed that bubble sorting technique requires considerable amount of time for processing which is not acceptable for fast moving Robots. Therefore, merge sorting technique was used to speed up the processing. Table 1 shows comparative analysis of time complexity for bubble sort and merge sort.

Table 1. Time Complexity of sorting techniques

Sorting Technique	Bubble Sort	Merge Sort
Time Complexity for n	$O(n^2)$	O(n log(n))
Time Complexity for 25	O(625)	O(25log(25)) = O(35)

IV. PID ERROR CORRECTION

It is necessary for a robot to have minimum amount of error. A Proportional–Integral–Derivative controller (PID controller) is a control loop feedback mechanism used for error correction. The 3 types of errors are as follows [2]:

- Proportional (P): It accounts for present values of the error. For example, if the error is large and positive, the control output will also be large and positive.
- Integral (I): It accounts for past values of the error. For example, if the current output is not sufficiently strong, error accumulates over time, and the controller will respond by applying a stronger action.
- Derivative (D): accounts for possible future values of the error, based on its current rate of change.

Implementation of the PID error correction algorithm is shown in Figure 5. Kp, Ki and Kd are experimentally determined constants and vary from system to system.

```
error= final position – current position
P=error
I=I + error
D=error – past error
PID correction= Kp*P + Ki*I + Kd*D
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Figure 5. Code snippet of PID controller

V. IMPLEMENTATION

The entire hardware and algorithm implementation has been done on Arduino Mega 2560 micro-controller platform. LCD panel and HEX keypad make the system user friendly and easy to operate. Block diagram of the hardware is demonstrated in Figure X. Figure X shows the Robot with SHARP distance sensors mounted on it.

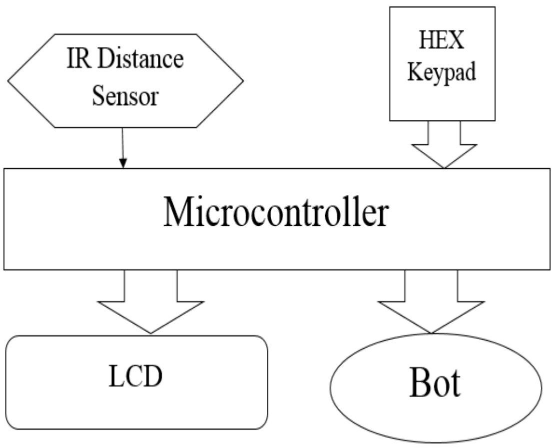

Figure 6. Hardware block diagram

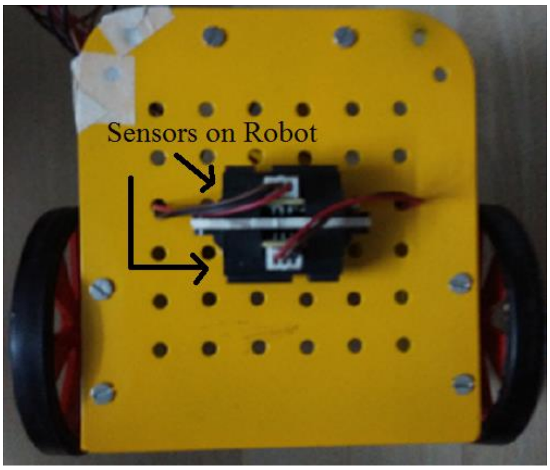

Figure 7. Robot with SHARP distance sensors

Proteus 8 software was used for PCB implementation of the circuit as shown in Figure 8. Figure 9 shows PCB with completely assembled circuit board with hardware interface.

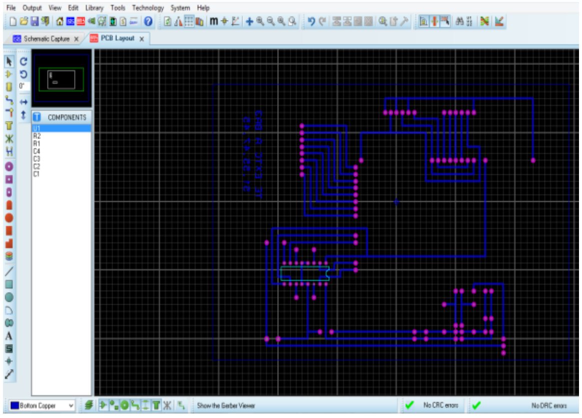

Figure 8. PCB layout

Figure 9. Assembled circuit board

VI. CONCLUSIONS

Thus, a system built for tracking the current position of the Robot in a given surrounding and autonomously aligning it to a position set by the user or the code itself. This system works on real-time input from the sensors and on algorithms that have been developed specifically to fortify accuracy and eliminate any possibility of errors. The advantage of this system over other systems is its mobility and compactness. A setup built for laser cutting and etching using this system is an effective and efficient use of the concept owing to its high accuracy.

A sample of this prototype can be used in robotics based applications such as:

1. Seed Sowing Robot
2. Smart Automatic Car Parking
3. SLAM based Terrain Marking Robot
4. Mars Rover Robot
5. Smart Wheel Chair

Algorithms developed for the system can also be implemented for applications such as:

1. Laser Cutting/Etching
2. 3D printing

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AUTHORS

Siddhesh Gotad received B.E. in Electronics and Telecommunication Engineering from St. Francis Institute of Technology, Mumbai, India and is currently working as a Research Assistant at St. Francis Institute of Technology.

Vikrant Fernandes received B.E. in Computer Engineering from St. Francis Institute of Technology, Mumbai, India and is currently working as a Research Assistant at St. Francis Institute of Technology.

Harsh Jain received B.E. in Electronics and Telecommunication Engineering from St. Francis Institute of Technology, Mumbai, India and is currently working Graduate Engineer Trainee at L&T Infotech.

Omkar Chavan received B.E. in Electronics and Telecommunication Engineering from St. Francis Institute of Technology, Mumbai, India and is currently pursuing M.S. in embedded systems from SUNY Buffalo, United States of America.