COMPARISON OF FORMATION ALGORITHMS IMPLEMENTED ON MULTI-AGENT MOBILE ROBOTS

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1. INTRODUCTION

According to the many definitions a robot is an intelligent agent may be based on a mechanical structure or even in cooperates with a software structure, which is in other words a total virtual agent. The nominal robot is a electro-mechanical machine which consists of several components for manipulation. The main parts consist of a computer or a micro controller unit, a program and some electronic gadgets including sensors, actuators and power regulators, etc.

There are many different types of robots. The classification can be autonomous or semi-autonomous or even those which are used for research into human-like agents, such as ASIMO and TOPIO, as well as those with more defined and specific roles, such as Nano robots and Swarm robots and helper robots which are used to make or move things or perform menial or dangerous tasks, such as Industrial robots or mobile or serving robots. Another common characteristic is that, by its appearance or movements, a robot often conveys a sense that it has intent or agency of its own.
The navigation of robot is a very common problem because it demands a lot of money, programming and computing as well as analytical thinking of the designer. The results of our research discusses about analytical aspects of several navigational algorithms deployed to a prototype mobile robot system consisting a leader and a follower. The deployed algorithms are expected to behave under non-holonomic constraints. The algorithms are based on P, PID, and an algorithm based on velocity and direction and distance are amongst the test conditions.

The results justified the expected accuracy of each algorithm and revealed the importance of each algorithm considering financial constraints.

2. METHODOLOGY

The mobile robot platform consists of two mobile agents. One is considered as a “Leader” and obviously the other is a “Follower” [3]. The leader robot always behaves independently and based on leaders action the follower is capable of mimic the leader’s behavior [1], [2], [3] and [4]. This particular aspect seen in nature is adopted for multi-agent navigation.

To develop the two mobile robots the Arduino open source hardware and software platform is used. The Arduino single board computer development environment consists of two basic components.

1. IDE (Integrated Development Environment)
2. The computing platform based on Atmega 1280 MCU (Micro Controller Unit)

Since this is an open source platform the IDE is distributed free of charge. The computing hardware platform has to be paid for. There are two algorithms.

1. Based on Proportional error of the leader’s trajectory to the follower’s trajectory
2. Based on PID (Proportional Integrative and Derivative) error of the leader’s trajectory to the follower’s trajectory
3. Based on non holonomic constraints with velocity

The each of the algorithms developed by using Arduino platform and it’s incorporated development language “Arduino”, which is a closer relative to the higher level language class of java, c++…etc. The leader robot is capable of line following. The leader’s trajectory is given as a white line in a black surface such that the leader traces the white line and keeps tracking the line. Then the leader passes the direction and speed to the follower by using RF communication link.

The first algorithm is based on the leader’s error trajectory. The error is then multiplied by the proportion gain. The proportional gain is found by fine tuning a rough proportional gain found by the trial and error method. Then the proportional error is transferred to the follower robot and it then does the change it course to meet the leader's trajectory

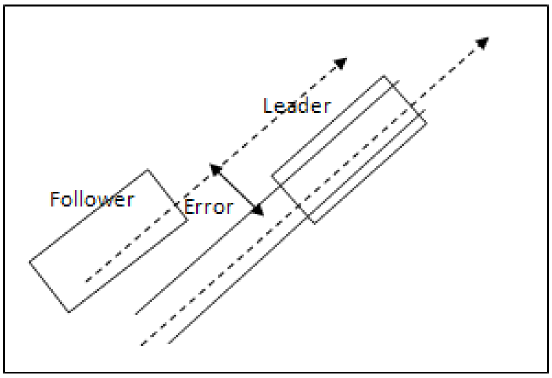

Figure 01: Error formation of Leader Follower

The second algorithm is as same as the first one and the only difference is that it includes not only proportional error factor but also integral error component and derivative error component, which predicts the future error by considering the past error situations. The error amount is used for the instantaneous motor speed calculation of the follower.

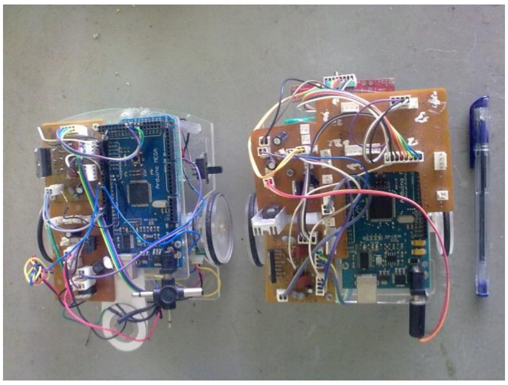

Figure 2: Leader and Follower Robots

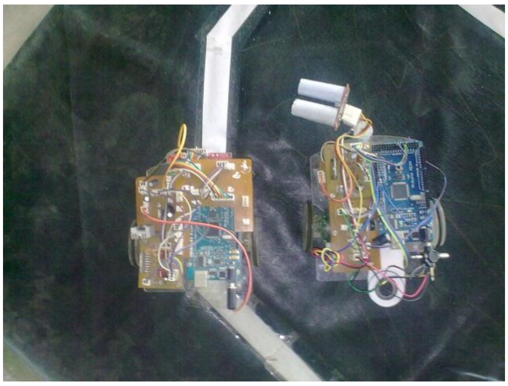

Figure 3: Leader and Follower Robot in operation on Symmetric track

3. RESULTS & DISCUSSION

The algorithms are tested for three different trajectories. They are as follows:

Table 1: Trajectory formation

Trajectory no	Shape of the trajectory	Description
1		Straight Line
2		Symmetric track
3		Curve and asymmetric

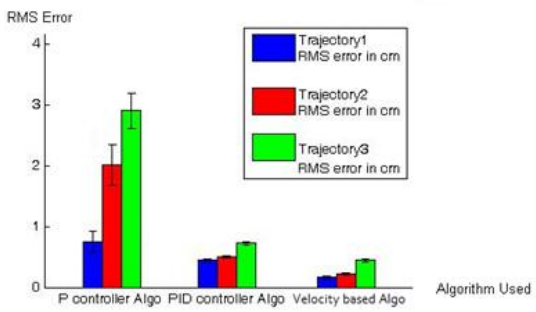

Figure 4: RMS error plotted with MATLAB for three trajectories

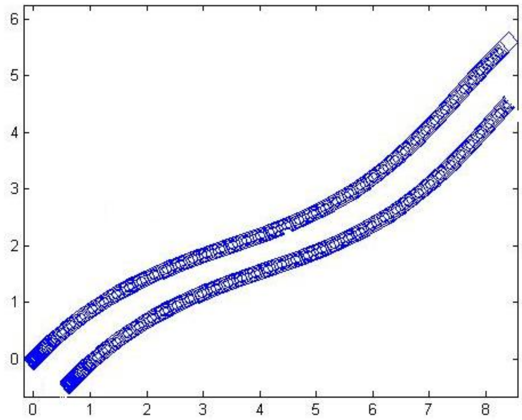

Figure 5: The simulation of a constant formation keeping Leader follower modal for a curved path following

The third one is based on non holonomic constraints and hence gives us the real control aspects for broader terms of mobile robot navigation.

When the two algorithms implemented on same two robot platform each time and the results show a visible improvement as the PID algorithm is used compared to P algorithm and it has been a much stable plot and more accurate one is found for the velocity based algorithm is implemented.

The PID algorithm is capable of not only analyzing the error but also it analyzes the rate of change of error and integral error data as well.

With additional control data exists with non holonomic constraints the accuracy is higher for all trajectories and the variation of error is found very low. These properties are the real parameters which will give us the stability and better control of the agents.

The cost of the sensors, the complexity of algorithm and the limited memory and computing power play a critical role and according to the fig. 3 RMS error plot for three trajectories when robots are uploaded with each algorithm respectively PID controller algorithm gives better results. But when it really matter the above mentioned factors the "P' controller can be implemented for straight paths for "Leader Follower" multi-agent mobile robot systems.

4. CONCLUSION

The algorithms tested are open loop controllers yet they play a good role with limited resources. The next phase would be to integrate a radar system to locate the leader and have a feedback control loop running and see the difference.

The feedback control loop would minimize the error and would be implemented with actual products like AGVs (Automated guided Vehicles).

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