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RESEARCH ARTICLE

Development of a non-holonomic multi-agent robot navigation system with adaptive formation control

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Abstract: The service of mobile robots is found in many ways in present activities when the accuracy, mobility and the safety cannot be assured by the human intervention. The biggest challenge we face is that the collaborative navigation of the multi-agent systems, which is very difficult to achieve in real world. Major reasons for this are the dynamical nature of mobile robots, the cooperated tracking and navigation, and the requirement of very accurate and reliable hardware, causing very high investment in developing stage (Fukunaga, Y. U. Cao, A. and Meng, 1995). On the other hand, the use of low cost hardware does not usually guarantee the expected results

Keywords: *robot navigation system, mobile robots, multi-agent systems*

Introduction

The concept of 'formation' is used with the natural leader follower concept, where the leader knows where it is heading but the followers may not aware of what happens out there. This phenomenon can be seen when a group of birds flying from one continent to another. The proposed algorithms for the multi-agent system here is global. It can be used for any system from domestic robots to resource locating exploration and mapping, search and rescue, surveillance, cooperative manipulation, automated highways and network centric warfare.

The navigation is combined with the formation control, which drives the multi agents into a pre-assigned task. Our objective was to develop the algorithms and simulate and test them with appropriate hardware. The algorithms were developed using the 'C' computer language and the simulation works were implemented with the help of MATLAB software.

The developed multi agent system consists of two mobile robots. Typically

1. The Leader Robot
2. The Follower Robot

Each robot consists of two major units

1. Sensing unit
2. Control unit

The purpose of the sensing unit of the Leader is to identify the path (the white line in black background) and the steering angle corresponds to its trajectory. To perform this the Leader has a line sensor which is capable of differentiating the black and white colours and a digital compass which outputs the steering angle as an 8-bit (or a single byte) data. Also, it has a full duplex Wi-Fi transceiver in order to communicate and to send the information such as steering angles to its follower. The follower is also consisting of a digital compass, a full duplex Wi-Fi transceiver, IR range finder sensor and a servo motor in order to find the distance to the leader and the direction where it is heading.

The control unit of both the leader and the follower performs the encryption process of the data received from the Wi-Fi transceiver, which encrypts the range signal to distance, manoeuvring the motors to the desirable directions, identifying the white coloured path and finally the leader follower communication.

Methodology

The methodology consists of several phases. They are,

1. The “Virtual Leader” detects the desired path.
2. The “Virtual Leader” follows the path given.
3. The “Virtual Leader” generates the signals to be transferred to the “Followers”.
4. The “Followers” process the signal.
5. Then the followers follow the “Virtual Leader”.

The included steps are followed in order to preserve the clarity hence the development and programming was well defined. The “Virtual Leader” (Priyanka, Maithripala and Pushpakumara, no date) detects the desired path using its LDR’s (Light Dependent Resistor) which were used in a voltage divider circuit. The voltage drop due to colour change is measured by using the LDR sensor arrays and the “Virtual Leader” is driven in a pre- drawn path. The steering angle is measured and transferred using the radio signal to the “Followers”. The “Followers” can detect the distance between their respective positions and the Virtual Leader’s position by using (Infra Red) IR sensors. Those data obtained by the IR sensors the Follower manures its motors appropriately in order to follow their trajectory ; Betts, 1998). The geometric representation shown in figure 2.1 depicts that steering angle θ_i and the distance PE_i or the coordinates [x, y] and [x_i, y_i] is found the trajectory of the leader is tracked.

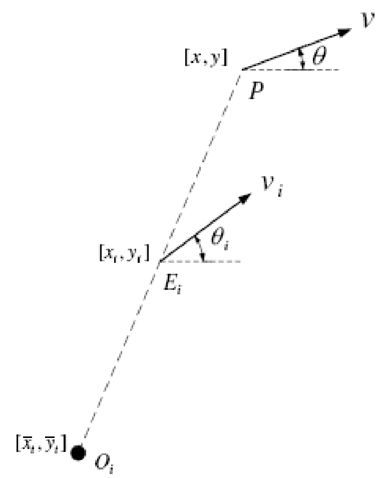

Figure 2.1 The Geometric representation of Leader Follower concept

Results

The results assured the following objectives. The multi- agent robot system is capable of following

1. A straight line.
2. A curved line.

The following results were obtained from the digital compass module when the steering angle was changed from 0 degrees to 360 degrees. The corresponding results are tabulated in Table 3.1. A proportional controller is used for developing the algorithm for reading corresponding steering angle θ.

Table 3.1 The variation of output data Vs steering angle θ from the digital compass.

Steering Angle (Degrees)	Data Value from compass (Read by 8 bit value)
0	0
45	3
90	63
135	95
180	127
225	159
270	191
315	223
360	255

The MATLAB simulation was also predicted the behavior of results of the developed algorithm. The simulation is shown on the figure 3.1. It reflects the complete behavior of the fully developed system.

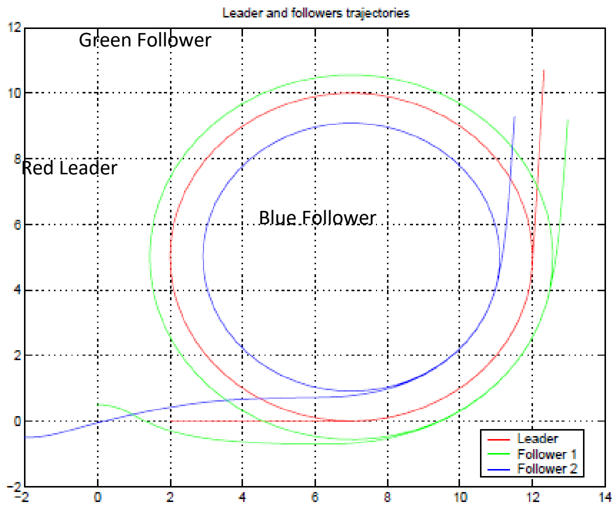

Figure 3.1 Results of the MATLAB Simulation.

Conclusion

The multi agent system is appreciably working to the limits it was given. The next stage of development of this research is to develop a navigation system by using GPS. This final assessment would benefit on many areas like military, aero traffic and navigation controlling, highway traffic controlling and cluster satellite controls and other aero space applications.

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