Fuzzy Logic Control for Autonomous Mobile Robots in Static and Dynamic Environments

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Abstract

Autonomous mobile robots have been widely used in many researches and applications. In this work, we develop collision avoidance and line following techniques for mobile robot navigation in static and dynamic environments with the integration of fuzzy logic fusion. Eight proximity sensors are used to detect different obstacles whereas three ground sensors are used to detect the line underneath the robot. The proposed method has been successfully tested in Webots Pro simulator and in in real time experiment.

Introduction

Mobile robots can be programmed to do specific tasks such as collision avoidance and trajectory planning. Various types of sensors and actuators are mounted on these robots for sensing the surrounding environment and making decisions accordingly. However, these sensors are in different types and thus have different accuracies and features. Some of them might be robust against external environmental factors such as high temperature and pressure while others might be affected which result in reducing the efficiency and reliability of these sensors. Consequently, multiple homogeneous or heterogeneous sensors are needed in designing an efficient autonomous mobile robotic system. Data fusion is the process of combining and aggregating different types of sources and sensors to get an improved result that is more significant and more reliable [1].

E-puck Mobile Robot

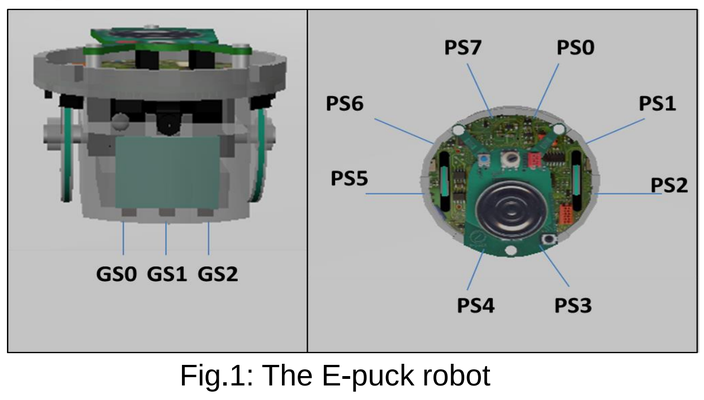

Fig.1: The E-puck robot

Webots Simulator

It is used to model, design, and program environments and mobile robots. It is composed of four main windows: the scene tree, the 3D window, the console, and the controller [2].

Proposed Method

A. Fuzzy Logic Controller Design for Line Following Mechanism

First, the difference (Δ) between the right and left ground sensors is calculated. The delta value (Δ) is an input to the fuzzy logic controller. Two outputs are generated which are LS and RS which adjust the robot speed to follow the line.

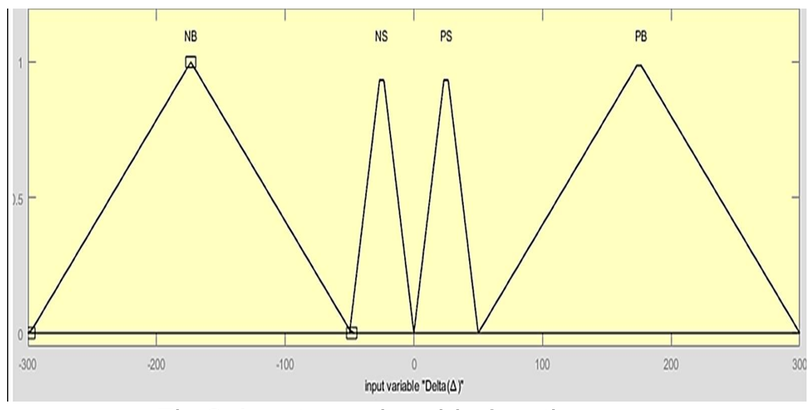

Fig.2: Input membership functions

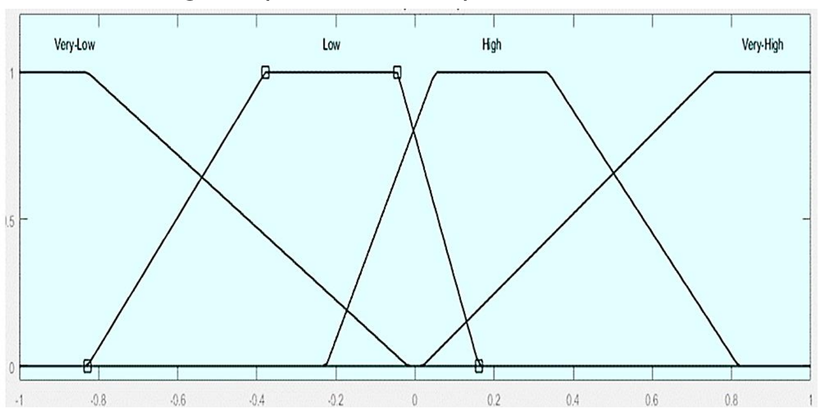

Fig. 3: Output membership functions

B. Collision Avoidance Mechanism

Eight proximity sensors are used for obstacle detection. These sensors have a range from 0 to 2000 whereas 1000 or more means there is a close obstacle and the robot needs to adjust its speed to spin around the obstacle.

Simulation and Real Time Experimental Setup

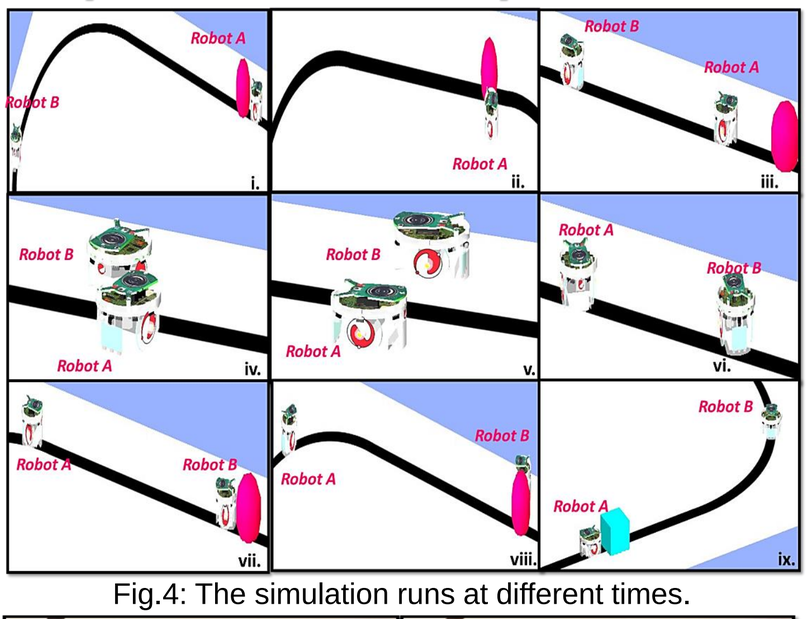

Fig.4: The simulation runs at different times.

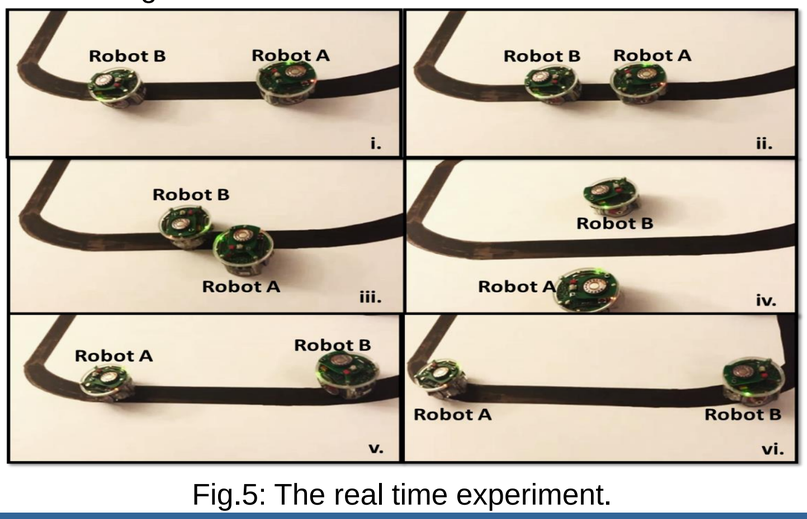

Fig.5: The real time experiment.

Performance Evaluation Results and Discussion

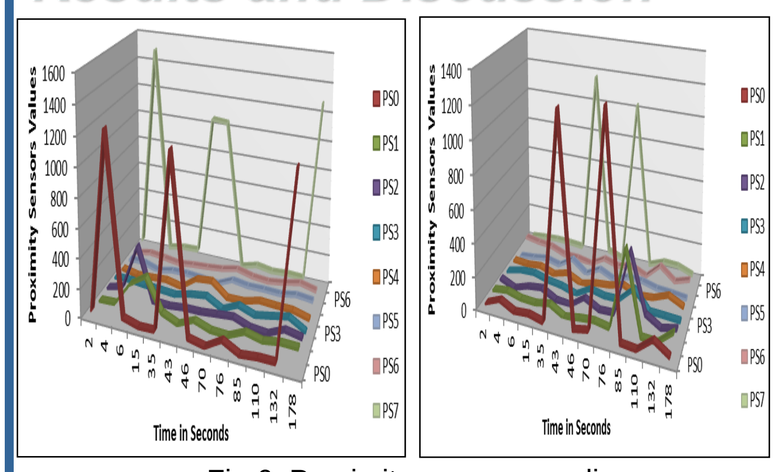

Fig.6. Proximity sensors readings

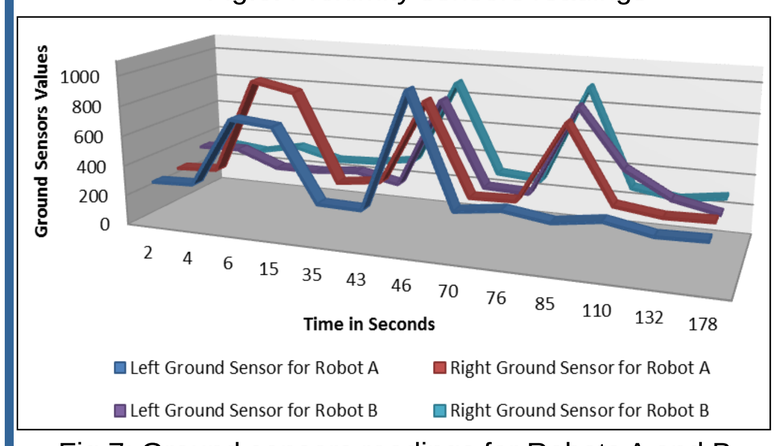

Fig.7: Ground sensors readings for Robots A and B

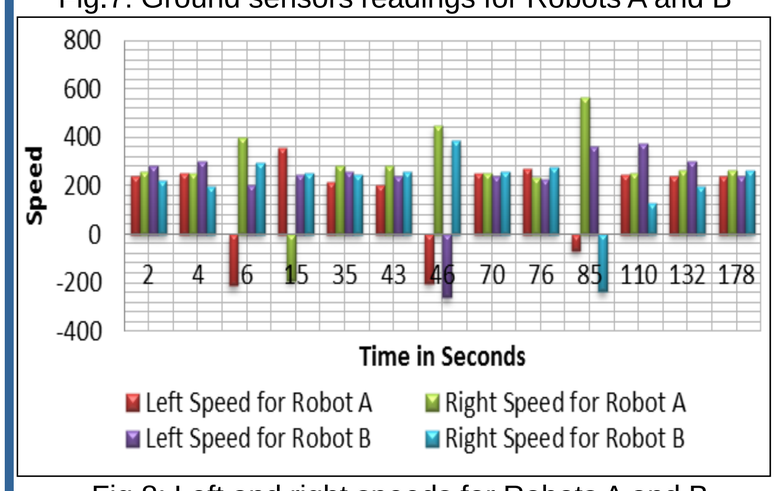

Fig.8: Left and right speeds for Robots A and B.

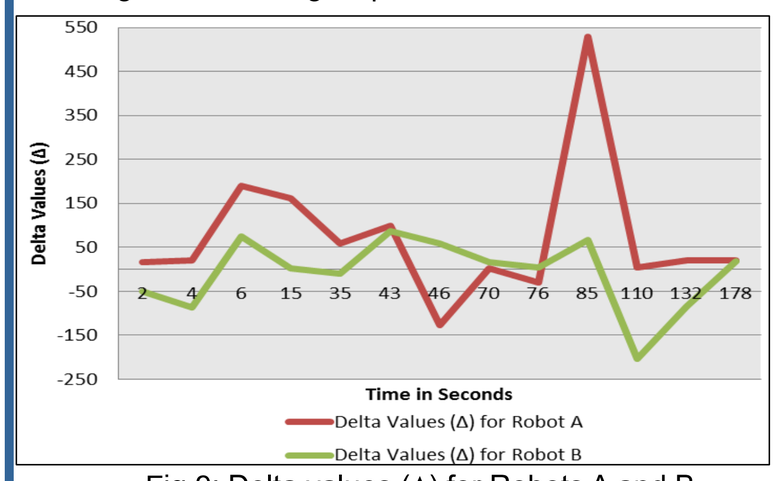

Fig.9: Delta values (Δ) for Robots A and B

Conclusion

A fuzzy logic controller was designed with one input and two outputs. Membership functions and fuzzy rules are developed. The simulation and real time experiments validate the effectiveness and the robustness of the proposed method in static and dynamic environments.

References

[1] F. Castanedo, "A Review of Data Fusion Techniques", The *Scientific World Journal*, vol. 2013, pp. 1-19, 2013.

[2] Cyberbotics.com, "Webots: robot simulator", 2016. [Online]. Available: https://www.cyberbotics.com/. [Accessed: 15- Feb- 2016].