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Autonomous vehicle convoy using Lego Mindstorms

M.A. Abdullah[1,2,*], M.A. Azan[1], F.R. Ramli[1,2], M.K. Mohamed Nor[1]

[1)] Faculty of Mechanical Engineering, Universiti Teknikal Malaysia Melaka, Hang Tuah Jaya, 76100 Durian Tunggal, Melaka, Malaysia.
[2)] Centre for Advanced Research on Energy, Universiti Teknikal Malaysia Melaka, Hang Tuah Jaya, 76100 Durian Tunggal, Melaka, Malaysia.

*Corresponding e-mail: mohdazman@utem.edu.my

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ABSTRACT - Autonomous vehicle convoy is a future driving and technology system that have been researched and developed for decades to solve problems in our transportation system nowadays. The increasing of road traffic has contributed to traffic congestion and more severely causes accidents. The aims of this study are to develop convoy algorithm and demonstrate autonomous vehicle convoy system using the LEGO Mindstorms Education EV3 by performing convoy experiment using small scaled car. The convoy or platooning need to satisfy the range of constraints by keeping the control parameters. It consists of one leader and two followers which have to maintain speed and safe distance while moving at designated route.

1. INTRODUCTION

The development in vehicle platooning has been a research for many years and decades to get improvement and effective way of convoy system such as the communication between the vehicles, the safety distance, the control velocity and other control parameters to ensure the safety and passenger comfort. Many researches have been made to study the implementation of convoy driving in reducing the congested road or motorway, smooth the traffic flow and more [1]. Nowadays, autonomous vehicle convoy or platooning is also a driving system that has been researched and studied recently. A research from [2] about adaptive control of an automatic convoy of vehicle described that autonomous vehicle convoy is a group of automated vehicles move together like a virtual train that their movement been controlled automatically but supposedly the first or the lead vehicle plays an important role that professionally trained driver to drive and guide the convoy manually. The main problem in the convoy driving that have been focused from previous research on car following is to maintain the safe distance constantly [3]. The methods to counter the problem have been discussed that by using the guidance-based motion planning algorithm for time optimal autonomous rendezvous with moving vehicle convoys. In this research, 3 simple and identical scaled model cars are assembled using Lego Mindstorms. Using available sensors such as ultrasonic and colour sensor, the convoy mechanism is programmed in Lego Mindstorms Education EV3 software.

2. METHODOLOGY

The cars are assembled using Lego Mindstorms parts equipped with colour sensor (for leader) to follow certain route and ultrasonic sensor (for followers) to measure and maintain safe distance. Figure 1 shows the experiment setup for autonomous vehicle convoy.

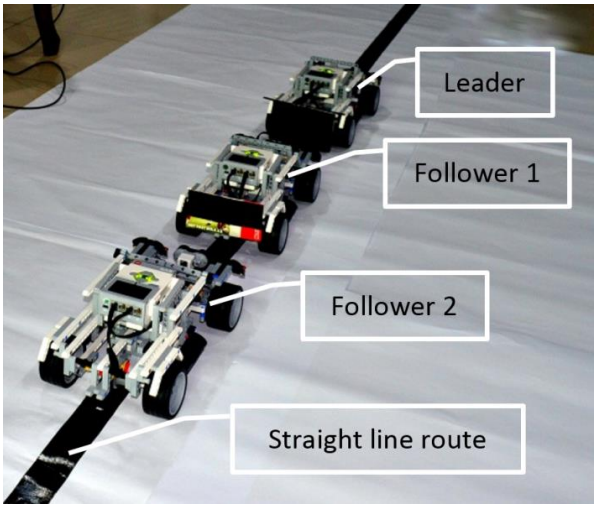

Figure 1 Autonomous convoy experimental setup

The experiment has two manipulated variables which are the speed rotation of the drive motor and the vehicle distance travel. The power speed rotation of the drive motor is setup at 40 %, 50 % and 60 %, where the vehicle distance travel setup for 100 and 200 centimeters. The responding variables need to be record are the time travel and the distance gap between the vehicles. The constant variables is the initial distance between the vehicles, 14.9 centimeters that been defined as the safe distance in this project. The safe following distance is actually greater than a car length and varies depending on speed travelling, road condition and type of vehicle. In this project, 15 centimeters length has been assume as the safe following distance because the scaled model car is made of from LEGO or bricks components that very light and low mass inertia. The algorithm for the autonomous vehicle convoy is shown by Figure 2.

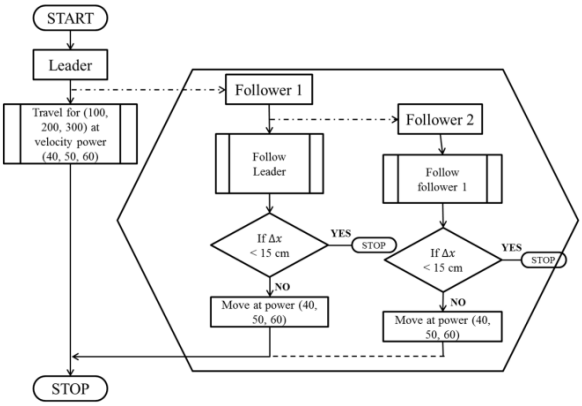

Figure 2: Algorithm flow

3. RESULTS AND DISCUSSION

Figure 3 and 4 present the gap distance against velocity power for distance travel 100 and 200 cm respectively. From the graphs, at 40 velocity powers, the gap distance between Leader and Follower 1 decrease by 1.9 cm, and decrease 3.1 cm between Follower 1 and Follower 2. At 50 velocity power, the gap distance between Leader and Follower 1 decrease by 3.5 cm, and decrease 3.18 cm between Follower 1 and Follower 2. At 60 velocity power, the gap distance between Leader and Follower 1 decrease by 4.6 cm, and same goes between Follower 1 and Follower 2. Thus, it shows that the higher velocity power (speed) travel, the shorter distance gap between the vehicles. The higher speed produces large momentum, thus taking more time to brake or stopping the vehicles.

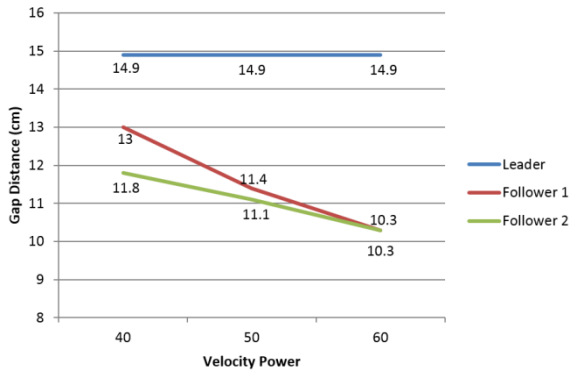

Figure 3 Gap distance for 100 cm test

For 200 cm test, at 50 velocity power, the gap distance between Leader and Follower 1 decrease by 3.1 cm, and decrease 3.5 cm between Follower 1 and Follower 2. The higher gap 11.8 cm for Follower 1 compared to 11.8 cm for Follower 2 is perhaps due to late response of Follower 2.

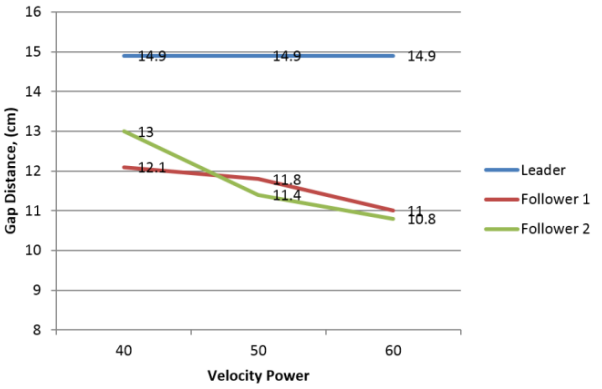

Figure 4: Gap distance for 200 cm test

4. CONCLUSIONS

In this research, an autonomous convoy system has been implemented and successfully tested using Lego Mindstorms scaled model cars. The followers have followed the leader and maintain safe distance between them. Using available parts, the system can be implemented on actual passenger vehicles for autonomous convoy driving and giving comfort for drivers to follow vehicles in convoy.

5. ACKNOWLEDGEMENT

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