Evaluation of energy consumption of a self-guided vehicle in obstacle avoidance situation (Human vs the DWA method)

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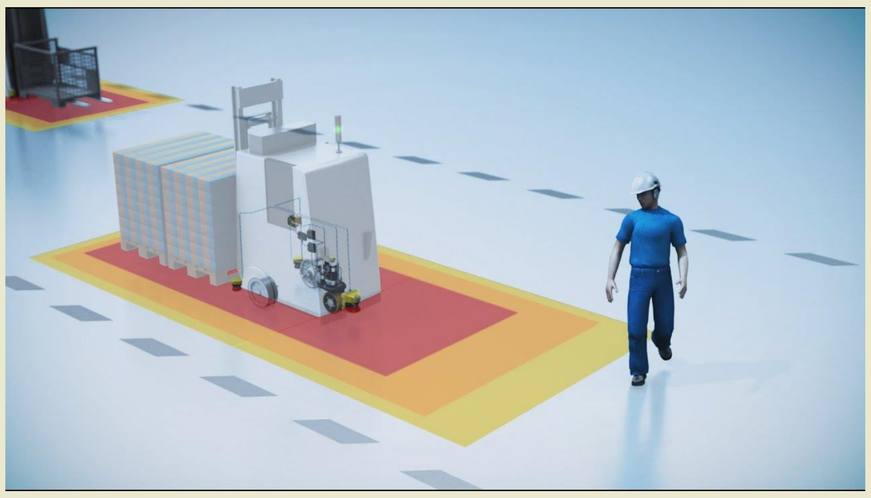
Introduction

Self-Guided Vehicles

Self-Guided Vehicles (SGVs) are important part of smart factories. The main task of SGVs is transportation of the production chain. However, they have some restrictions:

1) Their only energy sources are battery packs that are carried by them
2) Limited time of energy for long time missions
3) Charging or changing their sources while doing tasks are time-wasting

Obstacle Avoidance



Obstacle avoidance is another problem for SGV. It must consider changes in environment to avoid unforeseen obstacles such as human and robot. Since static and dynamic obstacles can populate the navigation environment, the selection of an appropriate obstacle avoidance function is essential in motion planning.

Methodology

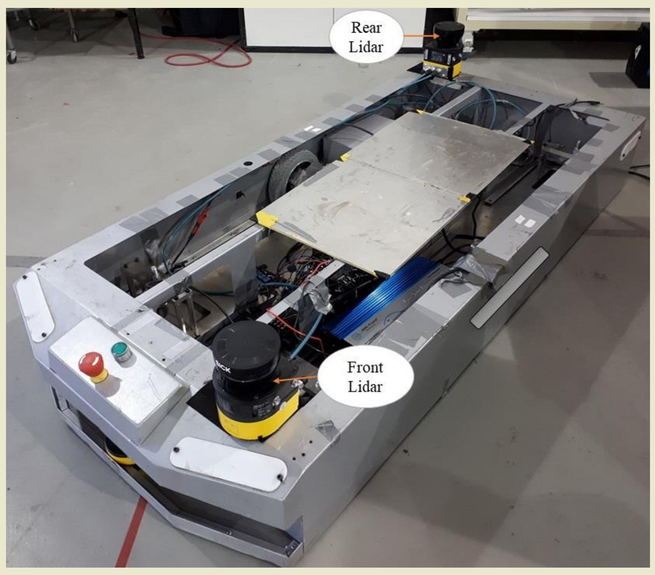
Two used methods to show the effect of obstacle avoidance problem on energy consumption of SGV:

- Dynamic Window Approach (DWA)
- Manual controller

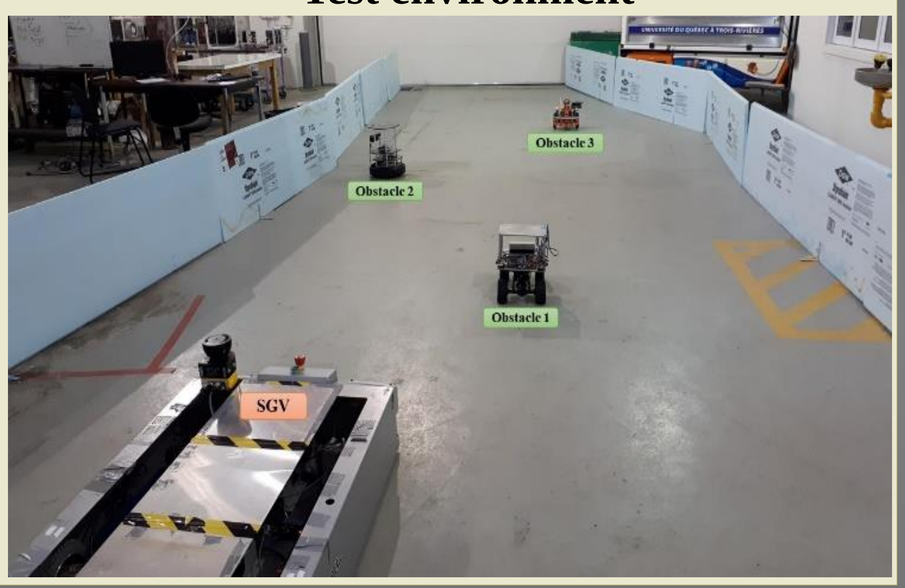
3 Scenarios:

i. 3 unforeseen static obstacles
ii. 2 unforeseen dynamic obstacles
iii. 2 unforeseen static obstacles and 1 unforeseen dynamic obstacle

SGV

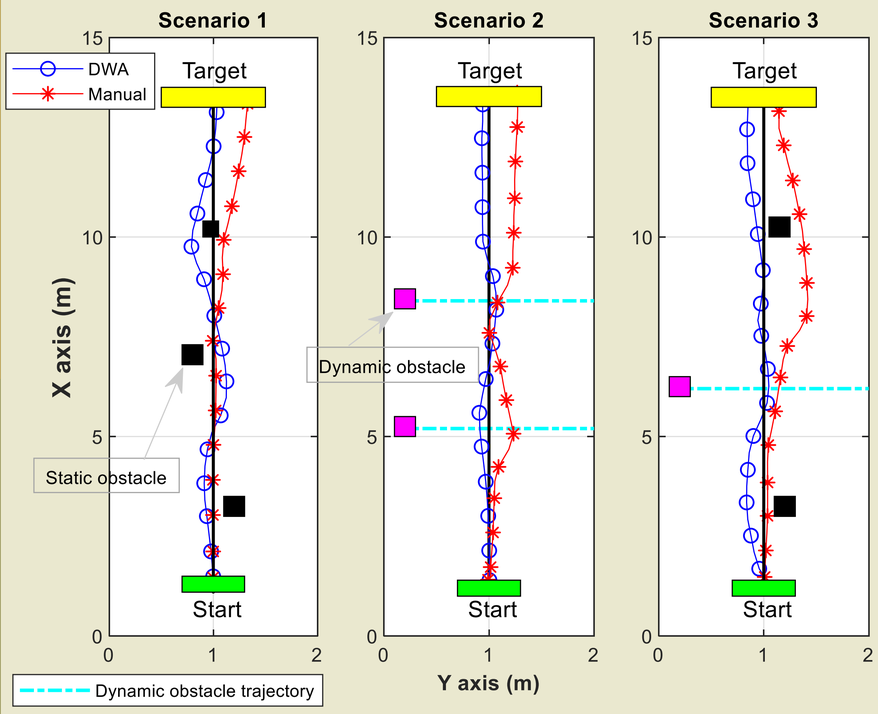


Test environment

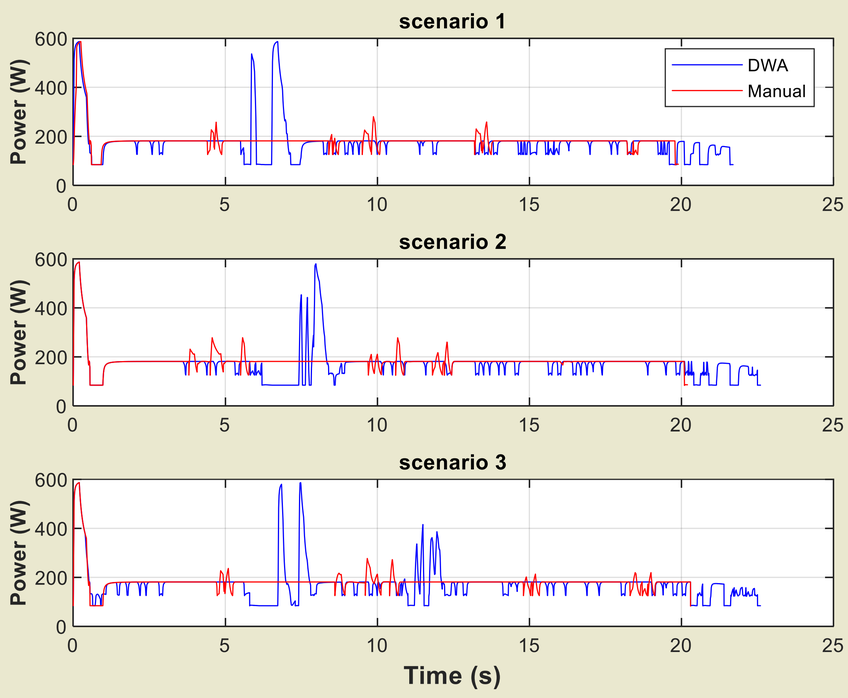


Experiment Results

SGV trajectories in 3 scenarios



SGV power consumption in 3 scenarios



Results of experimental tests

Scenario Number	Local Path Planning Method	Maximum Linear Speed (m/s)	Maximum Angular Speed (rad/s)	Time (s)	Total Energy consumption (J)	Energy Consumption Difference between DWA and Manual (%)
1	DWA	0.6	0.5	21.6	3816	- 4.9%
	Manual	0.6	0.5	19.9	3636	
2	DWA	0.6	0.5	22.6	3888	- 8%
	Manual	0.6	0.5	20.2	3600	
3	DWA	0.6	0.5	22.6	3960	- 5.7%
	Manual	0.6	0.5	20.3	3744	

Conclusion and perspective

- According to figure of power consumption profiles, there are more frequent changes in DWA method. They have been executed because of the sudden reaction of the SGV in response to unforeseen obstacles.
- Although the time of each test has taken less than 22 seconds, the energy consumptions of human controls are less than DWA.
- Results prove that the type of SGV reaction can affect energy consumption enormously and the energy constraint must be considered.
- In the following, the energy model of SGV will be added to motion planning algorithm as a new constraint to achieve an energy-efficient obstacle avoidance method.

Acknowledgment

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References

Patle, B., et al., A review: On path planning strategies for navigation of mobile robot. Defence Technology, 2019.