CONTROL SYSTEM FOR BACKING UP A TRUCK AND TRAILER

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Introduction

This paper represents a computer control system developed to control the backing up motion of a simulated truck and trailer vehicle into a loading dock. The process is carried out using two different approaches. In the first approach the fuzzy logic theory is used to generate the steering angle to control the backing up motion of the vehicle. For the second approach an artificial neural network is trained to get the same output. A simulation model is used to demonstrate the performance of the systems. The results are compared using graphical representations. In this project the control system designed using the fuzzy logic is capable of controlling the vehicle within a larger area than that of the neural network control system.

Many computer control systems have been proposed to Control the Backing up motion of a Truck and Trailer. But most of those approaches were developed assuming that there is enough clearance between the rear end point of the truck and the position of the dock so that the vehicle can be backed up into the desired position (*Kong and Kosko (1992); Freeman (1994); Nguyen and Widrow, 1990).*

In the approach described in this paper the assumption is discarded by considering the actual values for the distances in both X and Y directions.

Methodology

First the inputs for the control systems are decided considering the position and orientation of the truck and trailer as shown in the Figure 1.

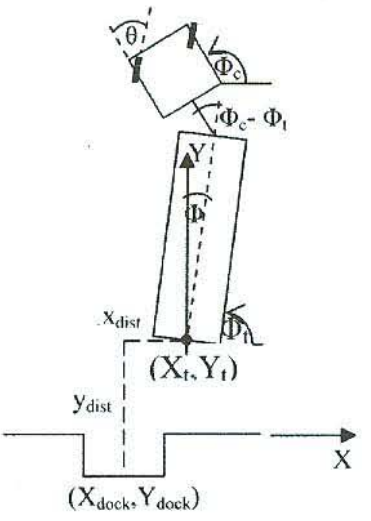

Figure 1. Variables considered for control systems

Fuzzy logic control system

According to the Figure 1 the distance to the rear end point of the trailer along the positive X direction (X_{dist}) and along the positive Y direction (Y_{dist}) from the position of the dock, orientation of the trailer with respect to the positive X direction (Φ_t) and the relative angle between truck and trailer (Φ_c- Φ_t) are the inputs to the system to produce the steering angle of the truck as the output. The System is designed in two separate fuzzy logic systems as shown in Figure 2 where the first system generates the required value for the relative angle between the truck and the trailer and the second system compares the required value and the current value of that angle to generate the steering angle of the truck. The system is implemented using the MATLAB Fuzzy Logic Tool Box.

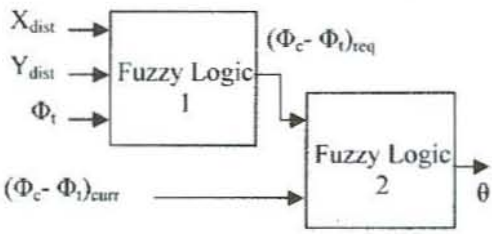

Figure 2. Fuzzy logic control system

Table 1. Variables of fuzzy logic system

Variable	Type	Range	Units
X_{dist}	Input	-50 to +50	Meter
Y_{dist}	Input	0 to +100	Meter
Φ_t	Input	-180 to +180	Degree
$(\Phi_c- \Phi_t)_{curr}$	Input	-90 to +90	Degree
Θ	Output	-60 to +60	Degree

In the second approach a two layer feed forward back propagation neural network is trained to obtain the required steering angle to move the trailer into the loading dock. As shown in Figure 3 the neural network takes four inputs which are the current position of the rear end point of the trailer (Xt,Yt), the orientation of the truck (Φ_c) and the orientation of the trailer (Φ_t). The neural network is implemented with 25 nodes in the hidden layer and a single node in the output layer. The simulation model is used to generate the training data set for the neural network by manually controlling the backing up motion of the vehicle. The Implementation and the training of the neural network are done using the MATLAB Neural Network Tool Box.

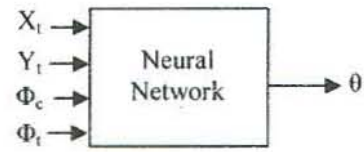

Figure 3. Neural network control system

Table 2. Variables of neural network system

variable	type	Range	units
X_t	Input	-10 to +10	meter
Y_t	Input	0 to +20	meter
Φ_t	Input	0 to 360	degree
Φ_c	Input	0 to 360	degree
θ	Output	-60 to +60	degree

The simulation model is created using Mathlab graphical user interface. It is capable of generating the next position of the vehicle when the current steering angle and the current position of the vehicle are given as the inputs. The simulation stops when the rear end point of the vehicle reaches the position of the dock.

Results

Both control systems are tested for different initial positions and orientations. It is observed that when the initial distance between the rear end point of the trailer and the position along the Y direction is large, the control systems are capable of controlling the motion of the truck and trailer vehicle into the loading dock more accurately than that of having a small clearance along Y direction. Here the neural network control system is only capable to control the vehicle within a smaller square area than that of the fuzzy logic control system. Therefore the comparisons of the performance of the two control systems are done only within the range where the neural network can control the vehicle. As shown in the Figure 4 the variations of the values of the variables, straight line distance from the dock, distance along the positive X direction and the orientation of the trailer are plotted against the time to make the comparisons of the two systems.

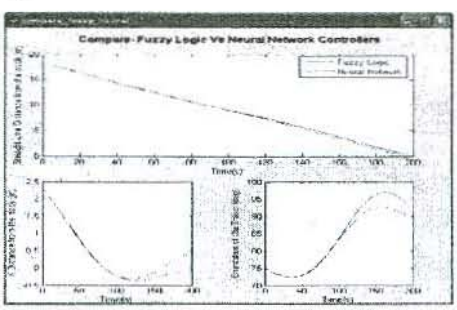

Figure 4. Comparison of the two control systems

It is observed that with the neural network control system the trailer reaches the desired final position taking less time than when it is controlled by the fuzzy logic.

Conclusion

The fuzzy logic control system to control the backing up motion of the truck and trailer vehicle is developed in a short period of time than that of the neural network control system. The main reason for this is that there is no proper method to find the number of nodes for the hidden layer of the neural network used in this process. Also when the range of the inputs is considered to be large the performance of the training phase of the neural network decreases reducing the area where the control system is capable to control the motion of the vehicle. Also this control system can be further developed by including the ability to control the switching between forward and backward motion of the vehicle and some obstacle detection mechanisms.

References

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