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Robot Navigation with Speech Commands

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1. Introduction

The field of Robotics draws on a multitude of engineering disciplines. There are mechanical, electrical and software considerations but the interaction among these and other disciplines is quite complex. Today's robots are equipped with wheels, wings, legs and also camera and laser/sonar range finders to perceive its neighborhood world. Vision-based robots are obviously smarter, but a mobile robot needs an online facility for scene analysis, which is a formidable task. AI tools may be used to model its neighborhood world using visual input and range information. Such model of perception enhances the robot's capability in coordinating complex actions pertaining to motion, visual tracking and avoidance of obstacle (Corke Peter, 2005; Corke Peter, 2003; Ragavan S. Veera & Ganapathy V, 2007). The field of neural networks can be thought of as being related to AI, machine learning, parallel processing, statistics, and other fields. The attraction of neural networks is that they are best suited to solving the problems that are the most difficult to solve by traditional computational methods (Rich, E. and Knight, K, 1991). ANNs were inspired by models of biological neural networks since much of the motivation came from the desire to produce artificial systems capable of sophisticated, perhaps "intelligent", computations similar to those that the human. The network presented here learns with the Back Propagation (BP) algorithm (Basheer, I.A & Hajmeer, M, 2000; E. D. Karnin, 1990; R. Hecht–Nielsen, 1989; Yegnanarayana, B, 2004).

This chapter deals with robot navigation avoiding static and dynamic obstacles in the path of the mobile robot, planning the future path of the mobile robot with the help of Artificial Neural Networks (ANNs) and also accepting the speech commands to traverse the directed path and accordingly to reach the destination.

Three ANN models has been discussed one each for speech signal inputs (ANN-1), static and dynamic input (ANN-2)and decision making (ANN-3). The robot can move left, right, forward left ,forward and forward right along with start and stop commands based on speech signals. The speed of the robot is constant but it can be varied to have the advantage of providing the acceleration at the start and de-acceleration to avoid any damage to robot or obstacle.The direction of movement can be controlled speech commands.

The uttuances of 50 speakers were recorded for seven words namely start, stop, TL, TR, FL, FW and FR are recorded and sampling is done at 16 kHz. The speech data bank is developed by cutting the word and storing in the seperate files. The signal processing tool box in MATLAB is usede to extact the speech feature namely,formant frequency,Peak power spectral density, cepstrul magnitude and number of zero crossing. The mean values for all the words are calculated to get speech feature for command control of the Robot. The ANN Model is trained for the command signals and use to drive the robot.

2. Methodology of Robot Navigation

The methodology of navigation of mobile robot using ANN with speech commands is represented in the figure No-1. After reading the positions of source, destination and obstacles (static and dynamic), the mobile robot makes decision for two aspects mainly; the avoidance of collisions with obstacles and secondly reaching the destination through optimized path in minimum time. The decision making is accomplished by ANN technique. In the mean time if the robot gets the speech command, it pause from whatever is doing and takes the new instructions for further movements and decision making.
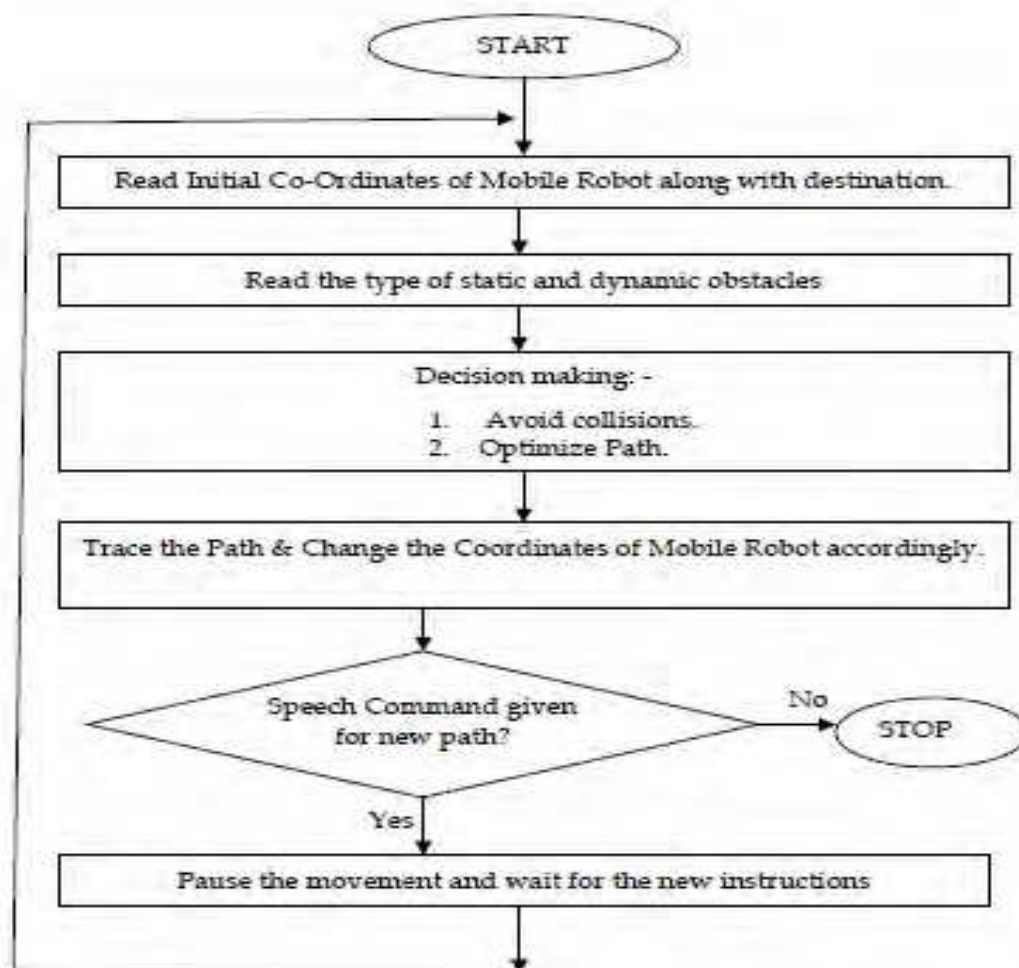

Fig. 1. Flow diagram for robot path planning using speech command

2.1 The Neural Network Based Local Guidance Scheme

The navigation of the mobile robot is based on the steering decision based on a local grid. The local grid is used to collect the local information. The speech command is issued to direct the robot to avoid the obstacles and move towards the current sub-goal. The ANN consist of 3-layers structure (Figure 2) with two hidden layers of 10 neurons each and the network is trained by the Back-propagation algorithm.

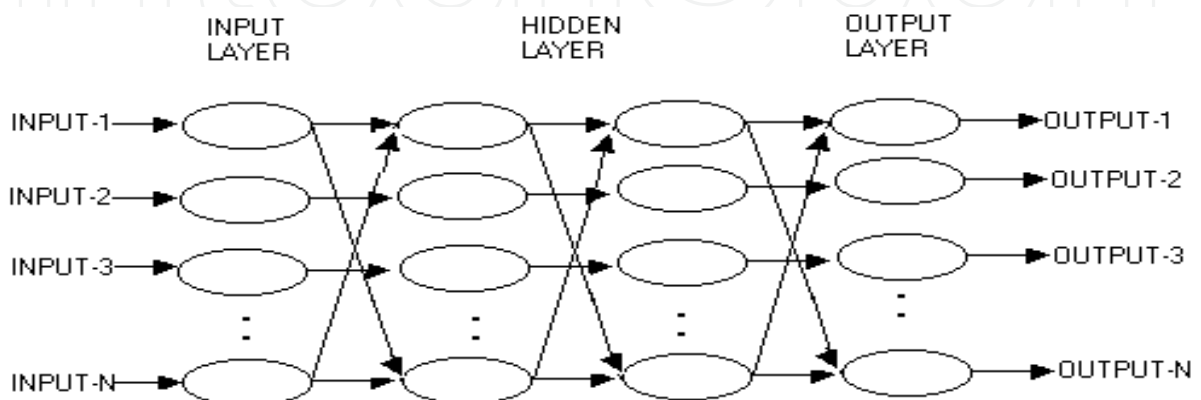The learning rate is 0.01 and momentum is 0.9.The NN is traned and tested on the ANN Toolbox in MATLAB 7.0.1.

Fig. 2. Multi-Layer Neural Network

2.2. Local Grid

The local information is represented as 15 equal squares (Figure 3), which are used to indicate the occupation state of the immediate neighborhood of the robot. A binary value is assigned to each square. The value '1' implies that the square is full (presence of obstacles), '0' means that the square is empty (absence of obstacles) and for speech commands binary value '0' means no speech command is given during the motion and binary value '1' means speech command STOP is given and so mobile robot shall stop at that very moment to get the new instructions. After getting the new destination the robot again plans the path and reaches the new destination avoiding the obstacles. MR represents the Mobile Robot. There are five steering commands, which define the following moving action:

FW = Forward (MR to12),
FL = Forward left (MR to11),
FR = Forward right (MR to13),
TL = Turn left (MR to10),
TR = Turn right (MR to14) &
STOP = Pause the motion.
START=to start the Robot

3	4	5	6	7
2	11	12	13	8
1	10	MR	14	9

Fig. 3. Local Grid

2.3 Observations & Results

The sample training patterns for the static and dynamic and Path planning nets are presented in tabular form in Table No. 1, 2 and 3 respectively. The entries under inputs, denotes the cell numbers surrounding the Robot.

Inputs are position of obstacles at respective cells of the grid (1 = presence and 0 = absence of obstacle) and the speech command SP (0= no speech command and 1 = speech command STOP). Outputs are five action commands (L = Left; FL = Forward Left; F = Forward; FR = Forward Right; R= Right) and two-direction indicator (TR = Turn Right and TL = Turn Left).

Outputs of Table No. 1 and 2 are AND ed and given as input to Table 3. The output of the DM net gives command to the robot i.e. YES to go and NO to stop. The user menu is made fully interactive and is equipped with the stunning graphic effects. The current location of the robot is indicated on the screen, whenever the robot moves. After giving the destination the work of the operator is over and robot starts moving towards the destination, recognizing the obstacles and also uses the past knowledge about obstacle to decide the appropriate path.

In case the operator wants to change the destination while the robot is traversing the path, the operator gives the speech command STOP and robot stops the motion it is traversing, and waits for the new instructions. After the operator gives the new instructions (i.e. new destination) the robot traverses the path accordingly avoiding the static and dynamic obstacles.

INPUTS (Square Values)										OUTPUTS						
1	2	7	8	9	10	11	12	13	14	L	TL	FL	F	FR	TR	R
1	1	0	1	1	0	0	0	0	1	1	1	1	1	1	1	0
1	1	0	1	0	0	1	0	0	0	1	1	0	1	1	1	1
.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1

Table 1. Training Pattern Samples of staticNetwork

INPUTS (Square Values)										OUTPUTS						
1	2	3	8	9	10	11	12	13	14	L	TL	FL	F	FR	TR	R
0	0	0	0	0	0	0	0	0	1	1	1	1	0	0	1	0
0	0	1	1	0	0	0	0	0	0	1	1	0	1	0	1	0
.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1

Table 2. Training Patterns Samples of Dynamic Networks.

INPUTS								OUTPUTS	
L	TL	FL	F	FR	TR	R	SP	Y	N
1	1	1	0	0	1	0	0	1	0
1	1	1	0	0	1	0	1	0	1
1	1	0	1	0	1	0	0	1	0
1	1	0	1	0	1	0	1	0	1
.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.
1	1	1	1	1	1	1	0	1	0
1	1	1	1	1	1	1	1	0	1

Table 3. Training Pattern Samples of Path planning Network.

3. Conclusions

The navigation planning and guidance of the mobile robot is successfully implemented using ANN in a planner workspace by finding the collision free path to lead the robot from the initial critical configuration to the goal among the set of obstacles, other wise every possible input is tried and there is no way to be certain for the precise output. The path planning algorithm may be expected to make several prediction regarding probable paths to destination by making linked queue and whenever it encounters obstacle it should follow the other nearest queue having the least possibility of the obstacles. The speed of the robot is constant but it can be varied to have the advantage of providing the acceleration at the start and de-acceleration when the obstacle is sensed for stopping the robot or slowing down to avoid any damage to robot or obstacle. This work can be extended to real time path planning and hence can be effectively applied for commercial purpose.

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