The Proposed Neural Networks Navigation Approach

HACHOUR OUARDA
Department Of Electrical and Electronics Engineering
Faculty Of Engineering Sciences
Signal and System Laboratory
Boumerdes University
Boulevard de l'independence Boumerdes 35000
ALGERIA
E-mail: hachour_ouarda@yahoo.fr

Abstract: - in this present work we present a neural network navigation approach. To deal with cognitive asks such as learning and generalization; the use of Neural Networks (NN) is necessary to bring the behaviour of Intelligent Autonomous Systems (IAS**).** Indeed**,** NNs are well adapted in appropriate form when knowledge based systems are involved. Since the network is able to take into account and respond to new constraints and data related to the external environments, the adaptation here is largely related to the learning capacity. To build a system of "neurons" that makes new decisions, classification and forecasts just as human being, a neural network is relied on previously solved examples. Besides, Networks of neurons can achieve complex classification based on the elementary capability of each neuron to distinguish classes its activation function. In designing a Neural Networks navigation approach, the ability of learning must provide robots with capacities to successfully navigate in the environments like our proposed maze environment. Also, robots must learn during the navigation process, build a map representing the knowledge from sensors, update this one and use it for intelligently planning and controlling the navigation. The simulation results display the ability of the neural networks based approach providing autonomous mobile robots with capability to intelligently navigate in several environments.

Key-Words: - Intelligent autonomous mobile robots, Neural Networks (NN), Navigation, learning, behaviour**,** Decision**.**

1 Introduction

Research into high-level questions of cognition, localization, and navigation can be performed using standard research robot platforms that are tuned to the laboratory environment. This is one of the largest current markets for mobile robots. Various mobile robot platforms are available for programming, ranging in terms of size and terrain capability.

Although mobile robots have a broad set of applications and markets as summarized above, there is one fact that is true of virtually every successful mobile robot: its design involves the integration of many different bodies of knowledge. No mean feat, this makes mobile robotics as interdisciplinary a field as there can be. To solve locomotion problems, the mobile roboticist must understand mechanism and kinematics; dynamics and control theory. To create robust perceptual systems, the mobile roboticist must leverage the fields of signal analysis and specialized bodies of knowledge such as computer vision to properly employ a multitude of sensor technologies. Localization and navigation demand knowledge of computer algorithms, information theory, artificial intelligence, and probability Theory.

It is important that algorithms for navigation control in cluttered environments not be too computationally expensive as this would result in a sluggish response. It has been acknowledged that the traditional Plan-Sense-Model-Act approaches are not effective in such environments; instead, local navigation strategies that tightly couple the sensor information to the control actions must be used for the robot to successfully achieve its mission [1,2,3].

The robots are compelling not for reasons of mobility but because of their *autonomy*, and so their ability to maintain a sense of position and to navigate without human intervention is paramount. For example, AGV (autonomous guided vehicle) robots autonomously deliver parts between various assembly stations by following special electrical guide wires using a custom sensor. The Helpmate service robot transports food and medication throughout hospitals by tracking the position of ceiling lights, which are manually specified to the robot beforehand. Several companies have developed autonomous cleaning robots, mainly for large buildings. One such cleaning robot is in use at the Paris Metro. Other specialized cleaning robots take advantage of the regular geometric pattern of aisles in supermarkets to facilitate the localization and navigation tasks.

The environment complexity is a specific problem to solve since this environment can be imprecise, vast, dynamical and partially or not structured. Robots must then be able to understand the structure of this environment. To reach the goal without collisions, these robots must be endowed with perception, data processing, recognition, learning, reasoning, interpreting, decision-making, and actions capacities [4,5,6,7,8].

To take the best decision and to react intelligibly, neural networks are the wishes to understand principles leading in some manner to the comprehension of the human brain functions and to build machines that are able to perform complex tasks requiring massively parallel computation.

Neural Networks deal with cognitive tasks such as learning, adaptation generalization and they are well appropriate when knowledge based systems are involved. In general Neural Networks deal with cognitive tasks such as learning, adaptation generalization and they are well appropriate when knowledge based systems are involved.

To solve navigation problems, neural networks prove interesting to deal with the behaviour of autonomous mobile robots near the human being in reasoning. This paper deals with an algorithm for two dimensional (2D) path planning to a target for mobile robot in unknown environment. The objective is to find a collision free path from an unknown initial position to an unknown target point. A complete path planning algorithm should guarantee that the robot can reach the target if possible, or prove that the target can not be reached. A few path planning algorithms are described here followed by the aim work of research in detail.

The proposed algorithm is able to achieve these tasks: avoiding obstacles, taking a suitable decision, and attending the target which are the main factors to be realized of autonomy requirements. The algorithm returns the best response of any entering map parameters.

The simulation results illustrate the generalization and adaptation capabilities of neural networks. An interesting alternative for future work is the generalization of this approach by increasing the number of possible robot directions. In this paper we discuss clearly the proposed neural networks navigation for autonomous mobile robots.

2 The proposed Navigation approach based on the Neural Networks

2.1 The Navigation problem

One of the specific characteristics of mobile robots is the complexity of their environment. Therefore, one of the critical problems for the mobile robots is path planning, which is still an open one to be studying extensively. Accordingly, one of the key issues in the design on an autonomous robot is navigation [9,10].

Navigation is one of the most challenging competences required of a mobile robot. Success in navigation requires success at the four building blocks of navigation: *perception,* the robot must interpret its sensors to extract meaningful data; *localization,* the robot must determine its position in the environment ; *cognition,* the robot must decide how to act to achieve its goals; and *motion control*(see the figure 1)*,* the robot must modulate its motor outputs to achieve the desired trajectory. Of these four components, localization has received the greatest research attention in the past decade and, as a result, significant advances have been made on this front (see the figure 2).

The existing GPS network provides accuracy to within several meters, which is unacceptable for localizing human-scale mobile robots as well as miniature mobile robots such as desk robots and the body-navigating nanorobots of the future. Furthermore, GPS technologies cannot function indoors or in obstructed areas and are thus limited in their workspace.

Furthermore, during the *cognition* step a robot will select a strategy for achieving its goals. If it intends to reach a particular location, then localization may not be enough. The robot may need to acquire or build an environmental model, a *map* that aids it in planning a path to the goal. Once again, localization means more than simply determining an absolute pose in space; it means building a map, then identifying the robot's position relative to that map.

The problem of representing the environment in which the robot moves is a dual of the problem of representing of the robot's possible positions. Decisions made regarding the environmental representation can have impact on the choices available for robot position representation. Often the fidelity of the position representation is posed by the fidelity of map. Three relationships are posed here to understand how to choose particular map:

1. The precision of the map must appropriately match the precision with which the robot needs to achieve its goal.

2. The precision of the map and the types of features represented must match the precision and data types returned by robot's sensors.
3. The complexity of the map representation has direct impact on the computational complexity of reasoning about mapping, localisation, and navigation.

Using these informations, we can construct the *configuration space* of the robot, in terms of which the path planning problem is formulated generally.

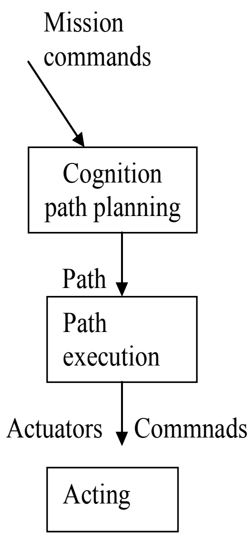

Fig. 1 Motion Control

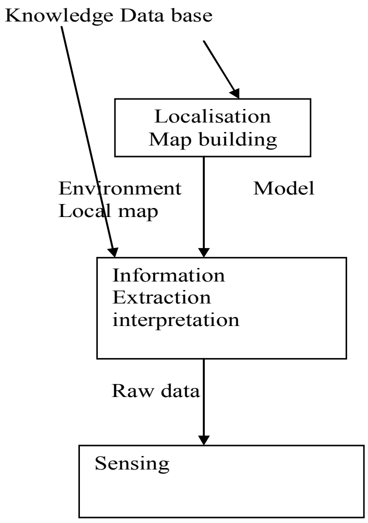

Fig. 2 Perception general view

2.2 The Proposed neural Networks Navigation Approach

The environment complexity is a specific problem to solve since this environment can be imprecise, vast, dynamical and partially or not structured. Robots must then be able to understand the structure of this environment.

To solve navigation problems, neural networks prove interesting to deal with the behaviour of autonomous mobile robots near the human being in reasoning. Neural Networks are the wish to understand principles leading in some manner to the comprehension of the human brain functions and to build machines that are able to perform complex tasks requiring massively parallel computation.

In general Neural Networks deal with cognitive tasks such as learning, adaptation generalization and they are well appropriate when knowledge based systems are involved. Thus, several approaches based on neural networks for autonomous mobile robots are oriented to design and achieve robots which simulate the human decision-making in similar way of acquiring some keys of intelligence. The key of intelligence is focused on the manner of: thinking, perceiving, and acting. Networks of neurons can achieve complex classification based on the elementary capability of each neuron to distinguish classes its activation function.

The adaptation is largely related to the learning capacity since the network is able to take into account and respond to new constraints and data related to the external environments. Just as human being, a neural network relies on previously solved examples to build a system of "neurons" that makes new decisions, classification and forecasts.

In designing a Neural Networks navigation approach, the ability of learning must provide robots with capacities to successfully navigate in the environments like our proposed maze environment. Also, robots must learn during the navigation process, build a map representing the knowledge from sensors, update this one and use it for intelligently planning and controlling the navigation.

The general structure of the proposed Neural Networks navigation is presented as follow :

Knowledge mapping: the model of the external environment plays an important role in the intelligent robot behavior. The human brain is able to create -simple maps of the external environment by compressing the huge amount of received sensory data, while preserving the relationships between important facts.
Action: the different map sensory informations are classified in several vectors where each component responds to a particular situation. These situations must be associated with the appropriate action taking advantage of the topology-preserving property of the network
Reinforcement learning: reinforcement learning allows associations between detected sensory situations and appropriate actions trough " trial and error" learning. This one uses only a priori knowledge such as "asked response" is executed. These associations are formed in unsupervised manner, i.e., with no " supervisor or teacher" required.

During the navigation, the robot must localize its target and recognize the environment. The movement of the robot are supposed possible only in four (04) directions and consequently four actions A=[A_F ,A_L, A_R, A_B] are defined as action to move Front, action to turn to the Left, action to turn to Right , and action to turn Back (see the figure 3). The situations of the static target localization are defined by T=[T_F T_L, T_R, T_B] while the static obstacle avoidance situations are defined by O=[O_1,O_2,O_3,…,O_i]. Three layers constitute the proposed Neural Network structure as shown in the figure 4.
Layer 1: this layer represents the input layer with four (04) input nodes receiving the components of the vector T=[T_F ,T_L, T_R, T_B]. This layer transmits the inputs to all nodes of the next layer.
Layer 2: this layer represents the hidden layer with i^{eme} nodes. The output of each node is obtained as follows:

$$\gamma_k = f(\sum_i X_i W_{1ki}) \quad (1)$$

Where f is the output sigmoid function, W_1 : the weights of the output layer and $W_1(t+1) = W_1(t) + \Delta W_1$. With $\Delta W_1 = \eta\delta y$ Whereas learning rate is : $0<\eta<1$ and Y : hidden output

Layer 3: this layer represents the output layer with (j^{eme}) output nodes which are obtained by :

$$T_j = f(\sum_k \gamma_k W2_{jk}) \quad (2)$$

In the proposed approach, the Neural Network is trained to capture the behaviour of a human expert while controlling the obstacle avoidance operation. The network must mimic the input/output mapping of this human expert. This set is trained in order to deduce at the end the best direction to be taken by the robot. The learning of the proposed networks are based on the supervise Gradient Back-Propagation .The training is performed in a learning environment where all situations of vector T and O are represented and only free-collision action is permitted in each situation.

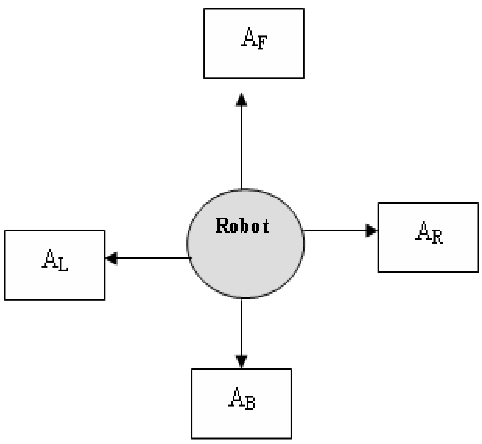

Fig. 3 robot and the four actions

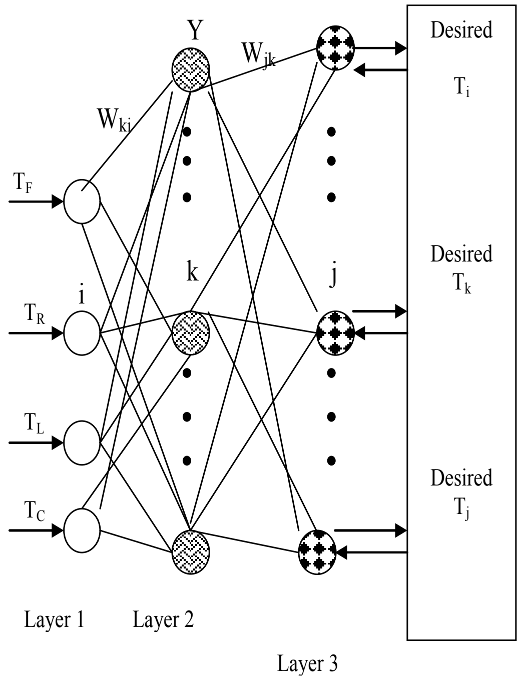

Fig. 4 Target Localization Neural Network

3 Simulation Results

The robot is simulated in different environments. To reflect the robot behavior acquired by learning in the explored environment and in new unvisited environments. The robot reacts in efficient and a satisfactory manner in these environments. As we can see the generalization and adaptation abilities of the system are achieved. The configuration of the environments changes by adding other shapes of static obstacles, in each situation the robot can navigate successfully.

The proposed approach is able to achieve the main task without collisions for every developed or proposed environment. Indeed, the networks grow to represent the problem as it sees fit. After learning, the target location situation is trained in the learning environments. From data obtained by computing distance and orientation of the robot-target, the robot is able to react, understand and achieve its mission perfectly.

The proposed approach can deal a wide number of environments and gives to our robot the autonomous decision of how to avoid obstacles and how to attend the target. More, the path planning procedure covers the environments structure and the propagate distances through free space from the source position. The results are very satisfactory to see the complexity of the principle and the extension versions of generation maps.

The figure 6 and the figure 7 clarify more the principle and show how the robot succeeds to reach the goal without collisions according to the configuration of the selected environments. Taking a suitable action and reacting at the appropriate way, the robot finds its safe way without collisions in efficient manner. If the algorithm does not converge, an error is returned .

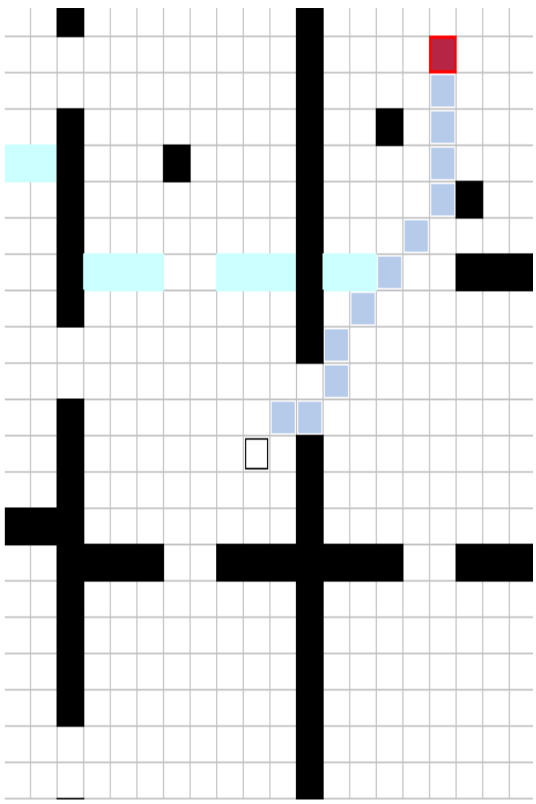

Fig. 6 Neural based navigation set-up1

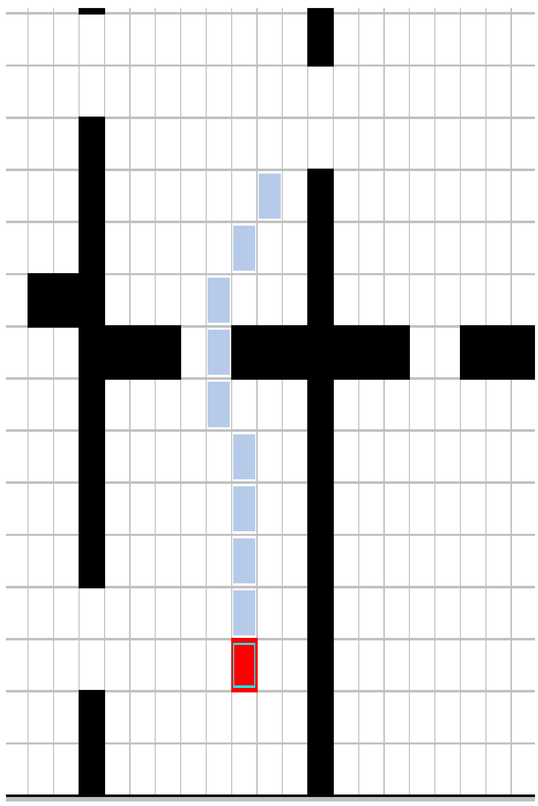

Fig. 7 Neural based navigation set-up2

4 Conclusion

In this paper we presented an approach for mobile robot positioning and navigation which is based on the principle of the neural networks. Starting out from a start location and orientation in the grid, the mobile robot can autonomously head for destination Cells. On the way it determines its location in the grid using the principle of the neural networks.

We demonstrated how we implemented the underlying algorithm in software. Target location situations are associated with favorable actions in an obstacle-free environment explained in detail in this paper.

We have run our simulation in several environments where the robot succeeds to reach its target in each situation and avoids the obstacles capturing the behaviour of intelligent expert system. The proposed approach can deal a wide number of environments. This navigation approach has an advantage of adaptivity such that the intelligent autonomous mobile robot approach works perfectly even if an environment is unknown.

This proposed approach has made the robot able to achieve these tasks: avoid obstacles, deciding, perception, and recognition and to attend the target which are the main factors to be realized of autonomy requirements. Hence; the results are promising for next future work of this domain. Besides, the proposed approach can deal a wide number of environments. This system constitutes the knowledge bases of our *approach* allowing recognizing situation of the target localization and obstacle avoidance, respectively. Also, the aim work has demonstrated the basic features of navigation of an autonomous mobile robot simulation. The intelligent behaviour necessary to the navigation, acquired by learning enable the robot to be more autonomous and intelligent

The simulation results illustrate the generalization and adaptation capabilities of neural networks. An interesting alternative for future work is the generalization of this approach by increasing the number of possible robot directions.

References:

[1] D. Estrin, D. Culler, K. Pister, PERVASIVE Computing IEEE, 2002,pp. 59-69.

[2] T. Willeke, C. Kunz, I. Nourbakhsh, The Personal Rover Project : The comprehensive Design Of a domestic personal robot, *Robotics and Autonomous,* Systems *(4*), Elsevier Science, 2003, pp.245-258X2.

[3] L. Moreno, E.A Puente, and M.A.Salichs, : World modeling and sensor data fusion in a non static environment : application to mobile robots, in *Proceeding International IFAC Conference Intelligent Components and Instruments for control Applications*, Malaga, Spain, 1992, pp.433-436.

[4] A.Howard, M.J MatariĆ and G.S.Sukhatme, An Incremental Self-Deployment Algorithm for mobile Sensor Networks, autonomous robots, *special Issue on Intelligent Embedded System*s, 13(2), September 202, pp. 113-126.

[5] O. Hachour and N. Mastorakis, IAV : A VHDL methodology for FPGA implementation, *WSEAS transaction on circuits and systems,* Issue5, Volume3,ISSN 1109-2734, pp.1091-1096.

[6] O. Hachour AND N. Mastorakis, Avoiding obstacles using FPGA –a new solution and application ,*5th WSEAS international conference on automation & information (ICAI 2004) , WSEAS transaction on systems ,* issue9 ,volume 3 , Venice , italy15-17 , November 2004 , ISSN 1109-2777, pp2827-2834 .

[7] O. Hachour AND N. Mastorakis Behaviour of intelligent autonomous ROBOTIC IAR", *IASME transaction*, issue1, volume 1 ISSN 1790-031x WSEAS January 2004,pp 76-86.

[8] O. Hachour AND N. Mastorakism Intelligent Control and planning of IAR, 3rd WSEAS International Multiconfrence on System Science and engineering, in Copacabana Rio De Janeiro, Brazil, October 12-15,2004.www.wseas.org.

[9] O.Hachour, The proposed Fuzzy Logic Navigation approach of Autonomous Mobile robots in unknown environments, *International journal of mathematical models and methods in applied sciences*, Issue 3, Volume 3, 2009 , pp 204-218.

[10] O.Hachour, the proposed hybrid intelligent system for path planning of Intelligent Autonomous Systems, *International journal of mathematics and computers in simulation*, Issue 3, Volume 3, 2009, Pages 133-145.