Intelligent autonomous vehicle navigated by using artificial neural network

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Intelligent Autonomous Vehicle Navigated by using Artificial Neural Network

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***Abstract*— This paper illustrates on such an intelligent autonomous vehicle (mobile robot) that can be navigated by using visual identification of road direction which utilizes artificial neural network. As a sensor to retrieve the information of surroundings, a camera is mounted on the top of the vehicle. An artificial neural network, Kohonen-type Concurrent Self-Organizing Map (CSOM) is then used to make correct identification of road direction by accessing the sensor's information. The road directions can be classified into three classes- left, straight & right, for each of which individual SOM module is used. The camera's readings are fed to all three SOM modules and the winning neuron is selected as output which is then accounted as the classifier's decision. The decision is then used to navigate the vehicle accordingly.**

***Index Terms*— autonomous vehicle, artificial neural network, visual road detection, concurrent self-organizing map, edge detection.**

I. Introduction

It's a great challenge for the researchers to build a robust autonomous vehicle system still now, although intensive research is going on to make this system more dynamic and more robust. Precise automation of a system lies in two practical principle tasks- sensing and reasoning. Sensors make a system running more precisely by gathering information about the robot with respect to the surroundings. While the reasoning makes decisions in order to control the robot by applying appropriate algorithms on the information.

Precise controlling in real world environment is the main criterion to make a vehicle being driven autonomously. Because automation of vehicle based on traditional vision based pattern recognition system may perform well but won't be precise, since path detection in autonomous vehicle system in real time is the main aspect of this system, which is a difficult task. It's because of noise and incessant change in surrounding circumstances in real world scenario.

Thus immaculate decision making is required to achieve precise controlling. A perfect artificial neural network classifier can do so intelligently by making correct decision.

Let us accentuate on the artificial neural network. Artificial Neural Network, a vital part of artificial intelligence which was invented and modelled by being inspired from human brain functionality. As human brain can processes various information to make decision in many variant and uncertain conditions, this specialty of human brain influenced the design and functionality of artificial neural network. Thus an artificial neural network can learn from its given information and adapts to the situation using previous experience.

Artificial Neural Networks are relatively crude electronic models based on the neural structure of the brain. The brain basically learns from experience. It is natural proof that some problems that are beyond the scope of current computers are indeed solvable by small energy efficient packages. This brain modeling also promises a less technical way to develop machine solutions. This new approach to computing also provides a more graceful degradation during system overload than its more traditional counterparts [5].

Artificial neural network proved itself much more promising in doing jobs like pattern recognition, image processing, etc. Artificial neural network has done these dynamic tasks with a higher success rate. Self-organizing map, an unsupervised neural network widely used for exploratory data analysis, visualization of multidimensional data, segmentation of complex data etc. Self-organizing map is thus used in dynamic pattern recognition in different applications.

In this paper we presented an approach to identify visually the road direction of an autonomous vehicle system using self-organizing map classifier [11] and to control the autonomous system (mobile robot in our case) accordingly. It is based on the neural network model of Concurrent Self-Organizing Maps (CSOM) [11], representing a winner-takes-all collection of neural modules. Each module is an artificial neural network called Self-Organizing Map (SOM) [11] trained to recognize a specific class of road images. We used three classes (left, right, and straight) as a train data to detect left, right and straight of the road. Our system (car toy) will take images of the road automatically and decide which path (left, right, or straight) will choose.

II. Approach

The main tasks' sequence of this visual based autonomous vehicle system is-

i. Image acquisition
ii. Reasoning
   a. Feature selection.
   b. Classification.
iii. Feed the output to the vehicle.

III. For Automated Vehicle System Using ANN

A. *Image Acquisition*

As this autonomous vehicle identifies road direction visually, it uses camera to take the surrounding images. After taking the surrounding images need to extract road images these images. We only concern the road images of our work. This autonomous vehicle only uses the road images to

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perform path detection and selection. To do so the images are fed to the processing portion as a vector matrix to make decisions.

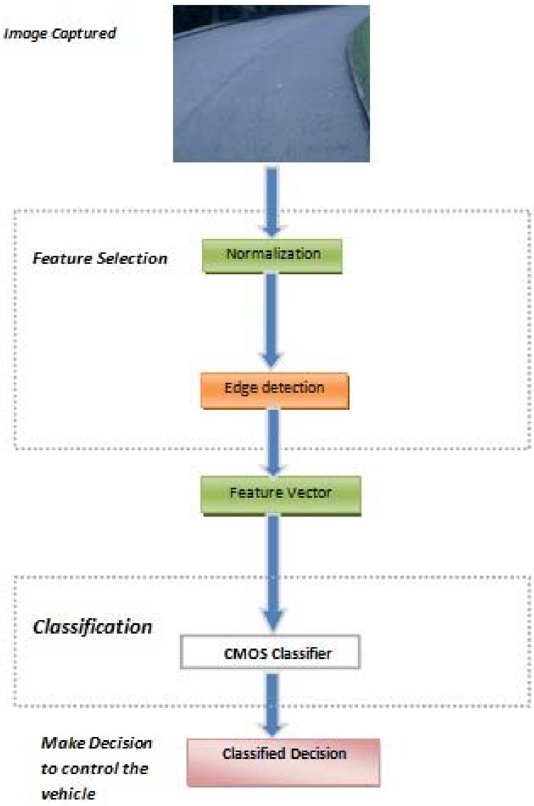

Fig 1: Approach to navigate the vehicle using ANN

B. *Reasoning*

Reasoning part of this system includes two vital processes of the operating algorithm. The first one performs the feature selection process and the second one includes the classification process.

1) Feature Selection: In the feature selection portion modification, normalization and edge detection of the input images are done.

Modification of the input image aggregates the conversion of the image RGB to gray scale and resizing. Conversion of the image from RGB to gray scale and resizing are required to make the computation fast and easy for the classifier.

Normalization is done to perform linear and logarithmic scaling and histogram equalization over the image data. Scaling has great importance because SOM measure Euclidean distance between vectors and thus greater valued variables will dominate over the measurement as they have greater impact.

Edge detection method discards the entire unwanted phenomenon from the image to do more smooth processing over the image. Canny Edge Detector is used as the edge detection algorithm as it is very popular in detecting optimal edge in an image and also gives precision [11]. When we use this algorithm to our work, a binary image of the same size as the input image is obtained, with the points belonging to edges marked as 1's and others marked as 0's. So all information stored in the system only 1's or 0's. That why a large amount of useless information will be out from the system and reducing the total amount of data to the further processed (by the classifier), while preserving the structural properties of the input image.

2) Classification: The heart of the system is the classification process, which makes decision for the system. Concurrent Self Organizing Map (CSOM) classifier is used as the classification model. Classification evolves through two processes.

i) *Architecture:* Three SOM modules are used each of which individually detects one direction (left, right or straight).The input vector is applied to all three modules at the same time. Each module is trained individually for the training phase to detect one direction.

ii) Training of the modules: Each SOM network is trained individually. To train each network, images of the corresponding class is used i.e. to train the SOM module that will recognize only left directed road, only the image subset that contains the left directed road images is used. Thus the other SOM networks are also trained.

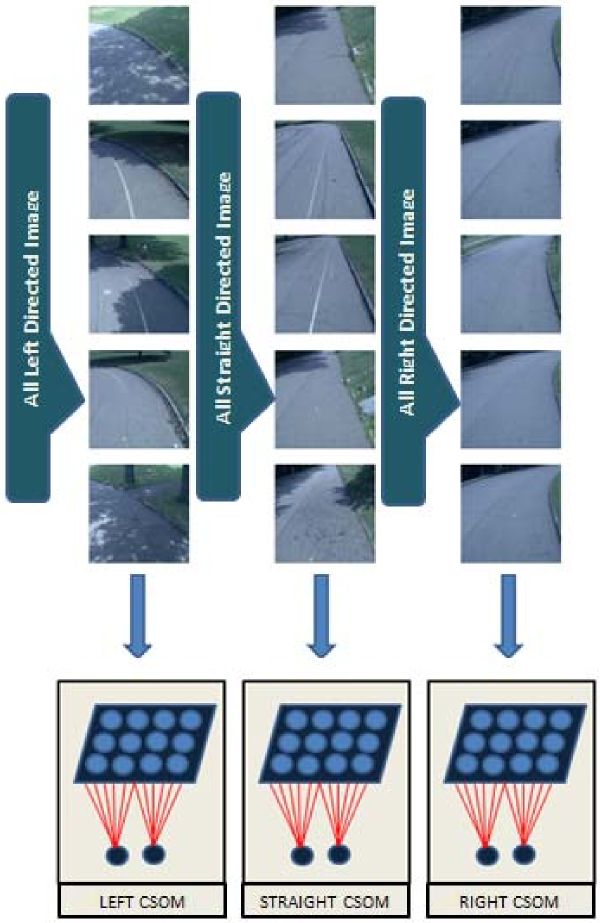

Fig 2: The architecture of the CSOM classifier.

iii) *Recognition Phase:* The road image to be classified is fed to all three SOM modules at the same time (Fig 3). Then the distance between the input vector and the neurons of the modules are calculated. Calculate all possible distance and hence find out the minimum distance between input vector and the neurons of the module. As "Winner takes all" is the working principle of the CSOM classifier, the nearest neuron from the input vector is selected as the winner and the module containing the neuron is assigned to the image (input vector) and the robot is thus directed.

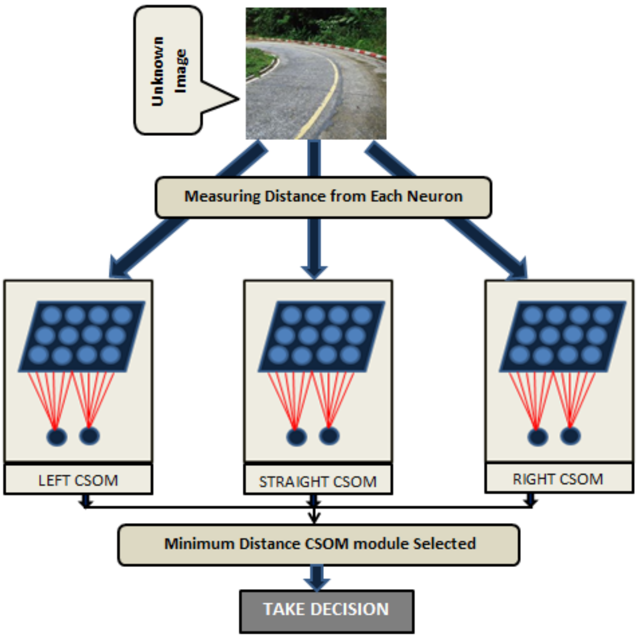

Fig 3: Classification of CSOM model.

C. *Feed The Output To The Device*

The decision taken by the classifier is then sent to the vehicle as DTMF tone using RF transmitter. DTMF stands for Dual Tone Multi Frequency, which is intended for controlling purpose, is composed of two different sine waves of different given frequencies. After receiving the DTMF tone, a DTMF decoder at the receiver's end perceives the tone and generates 4-bit binary equivalent representation. The result is then fed to a preconfigured microcontroller. The micro controller then navigates the vehicle according to the command. The whole process works like-

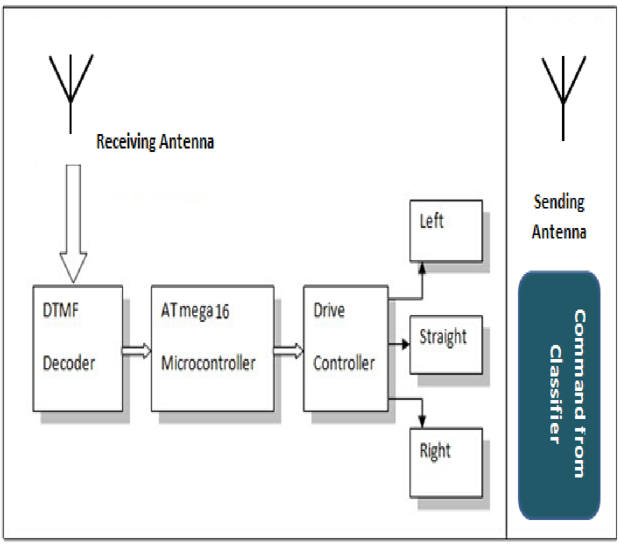

Fig 4: Block diagram of the process of sending the output to the vehicle

IV. Experimental Results

A. *Database*

We used CMU (Carnegie Mellon University) Vision and Autonomous Systems Centre's Image Database as the database includes a large number of road images captured as part of the extensive research they conduct at their Robotics Institute, for the NAVLAB series of vehicles.

60 images (20 images for each module) are used to train the network. Road images from the CMU (Carnegie Mellon University) Vision and Autonomous Systems Centre's Image Database are used to train the network.

And 30 images (10images for each module) from the CMU (Carnegie Mellon University) Vision and Autonomous Systems Centre's Image Database are again used to test the network. The test images are different from the images those were used to train the network.

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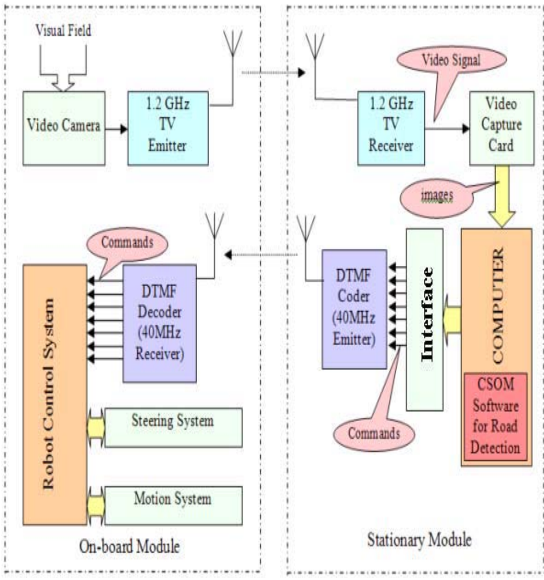

Fig 5: General block diagram of the automated vehicle system using CSOM [7].

B. *CSOM in real detection*

We used three individual SOM modules each having square topology with 10 x 10 neurons. We used a toy car as mobile robot. A webcam is mounted on the vehicle. The webcam captures images at 3 seconds gap and sends those images to the computer through data cable. The images are processed in the computer to take decision by following the approach.

The robot has first driven manually to get its network trained and the captured images during this time were stored. Then the classifier has made decision by selecting the closest neuron to the input image as output. Every direction (left, right or straight) have it own form. This input combination is used to select output direction, which lead to drive vehicle to a specific direction. The output formed as 0100 to define left, 0010 to define straight and 0110 to define right.

Input	Output/ Decision
0100	left
0010	straight
0110	right

Table 1: Input form to output form for the vehicle.

Then the decision is fed to the mobile robot using RF transmitter. And a microcontroller has been stacked on the robot to drive it according to the command from the computer. The microcontroller is pre-programmed to drive the robot to left, right or straight. Camera will take road images every 3second and same process is applied to the images to detect next the right path to drive the robot.
The CSOM algorithm gives 95% accuracy in detecting left directed road (can recognize 19 images from 20 images) and 100% accuracy in detecting straight and right directed road images (can recognizes 20 out of 20 images). The overall accuracy of the CSOM is 98.33% in detecting correct road images.
The whole process has been employed in MATLAB [8].
The block diagram of our working procedure is as following.

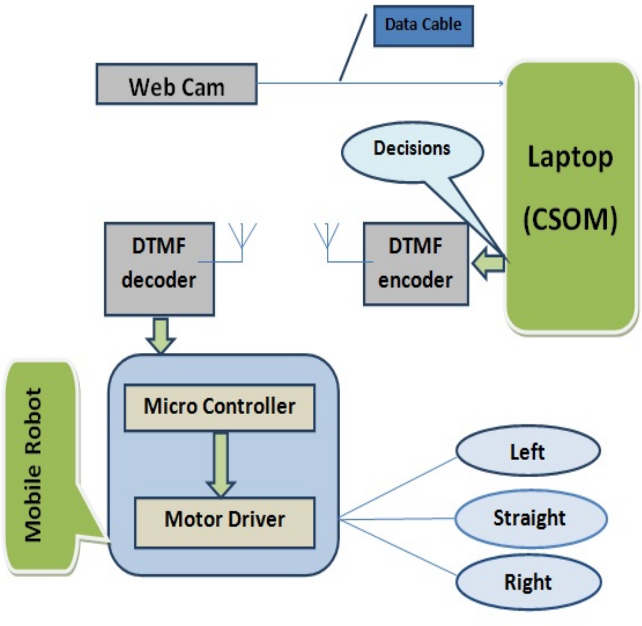

Fig 6: Block diagram of our working procedure.

V. Conclusions

In this paper we presented an approach to navigate a vehicle using an artificial neural network classifier named CSOM. The CSOM classifier gives much more precision and flexibility in classifying road directions. Feature selection method like normalization and edge detection brings better accuracy in classification process.
We demonstrated how we implemented the algorithm in software. We have run our simulation in MATLAB and our simulation result shows us the generalization and adaption capabilities of neural network. In future we would like to concentrate on to give this vehicle obstacle avoidance capability and make it more robust and dynamic.

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