Establishment of a fuzzy algorithm in a mobile robot for the detection and the avoidance of the obstacle using HC12 Compact interface

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Abstract

In this paper, we propose to establish an intelligence algorithm for a mobile robot to avoid obstacles by using a fuzzy controller. With this algorithm the mobile robot can avoid the different obstacles during its displacement. The robot can detect obstacles with a digital camera (CMU Cam). An infra red sensor will check the distance which separates it from the target. Firstly the robot acquires information from the camera to identify the obstacle, then it checks the distance. The infra red sensor will be a safety measure allowing to the robot the non collision. The identification and checking of the obstacle are controlled by a fuzzy algorithm implemented on the compact Motorola 68HC12, which is a Micro controller Motorola HC12À4 board, communicating with a PIC 16F877 using the predefined fuzzy function in the HC12.

I PRINCIPAL OBJECTIVES OF THE PROJECT:

I-1-Scientific:

The main objective of this work is to establish an intelligent network on a mobile model, for the automatic avoidance of the obstacles.
So we have to produce a mobile robot equipped with a camera, and to control it by a fuzzy network embarked on the robot itself.

I-2-Technico-economic:

It is known that the achievements of the robots is expensive but work achieved by the latter will be more precise and more rapid, thus the permanent availability, and the robustness of the system to robotize, from where profit in precision and time. For example for the dangerous processes it is preferable to use the robots, therefore in advanced technologies the robots are necessary. Now the robots will be more and more domestic, and then a factor of lux, when the robot which do the work in the house and sedentary when we talk about the robot bomb disposal experts and the assailing robot.

I-3-formation:

Concerning the formation, the realization of a robot requires three kinds of formations.

- A training in mechanics, for the design of the various robot parts and then the total structure realization.
- An electronic formation, all what concerns signal processing, systems control, electronic interfacing, electronic of power, and digital electronics.
- A data-processing or software training, for the programming of the various robot tasks and for the establishment of the intelligent networks, this training will have begun with the basic "assembler" language to the various evolutionary languages.

I-4-others:

Another objective is to return robotics more amusing and at the hand of the students, by the transmission of information and the setting concerned the various techniques of robotics.

The realization of the robots makes it possible to learn several things at the same time; it allows also the discovery of new technologies in the field.

II SCIENTIFIC ASSESSMENT:

II-1-Introduction:

The Mobile System Robot (MSR) take a great part in industry, by occupying a broad surface in the dangerous and precise activities, recently research on the MSR which lives between the human, in the house and in the hospitals etc..., are introduced.[1] [2].

In addition, research develops very quickly in the field of the fuzzy controller, by consequence the fuzzy systems and the theory of the fuzzy control, are used more and more in the industrial processes and the useful production of equipment.

Fuzzy control facilitates the control of the MSR by the decision obtained at the time of the linguistic base application with different membership functions and inference rules of the controller, but we can say that it is not an exact model for some systems [3].

In general, the recognition of the external environment is necessary for the navigation of the MSR. We use a fuzzy controller for the MSR, to detect the swing angle and the distance. We use the variation of speed and position of the MRS at the real time.

II-2 Structure of the MRS:

The MRS functions on a punt basis contained two DC engines, controlled independently by an H bridge which delivers the same power to the two engines. A special infra red sensor is used it is the GP2D02 of Sharp for checking the distance, a CMU CAM is connected on a HC12Compact v1.2 control chart , realized around a 68HC12À4, and which will deal of the fuzzy decisions, a communication between the compact HC12 and the PIC16F877 which will carry out the order and control the engines. Tactile sensors are used for reasons of safety. Figure 1 shows structure of the MRS

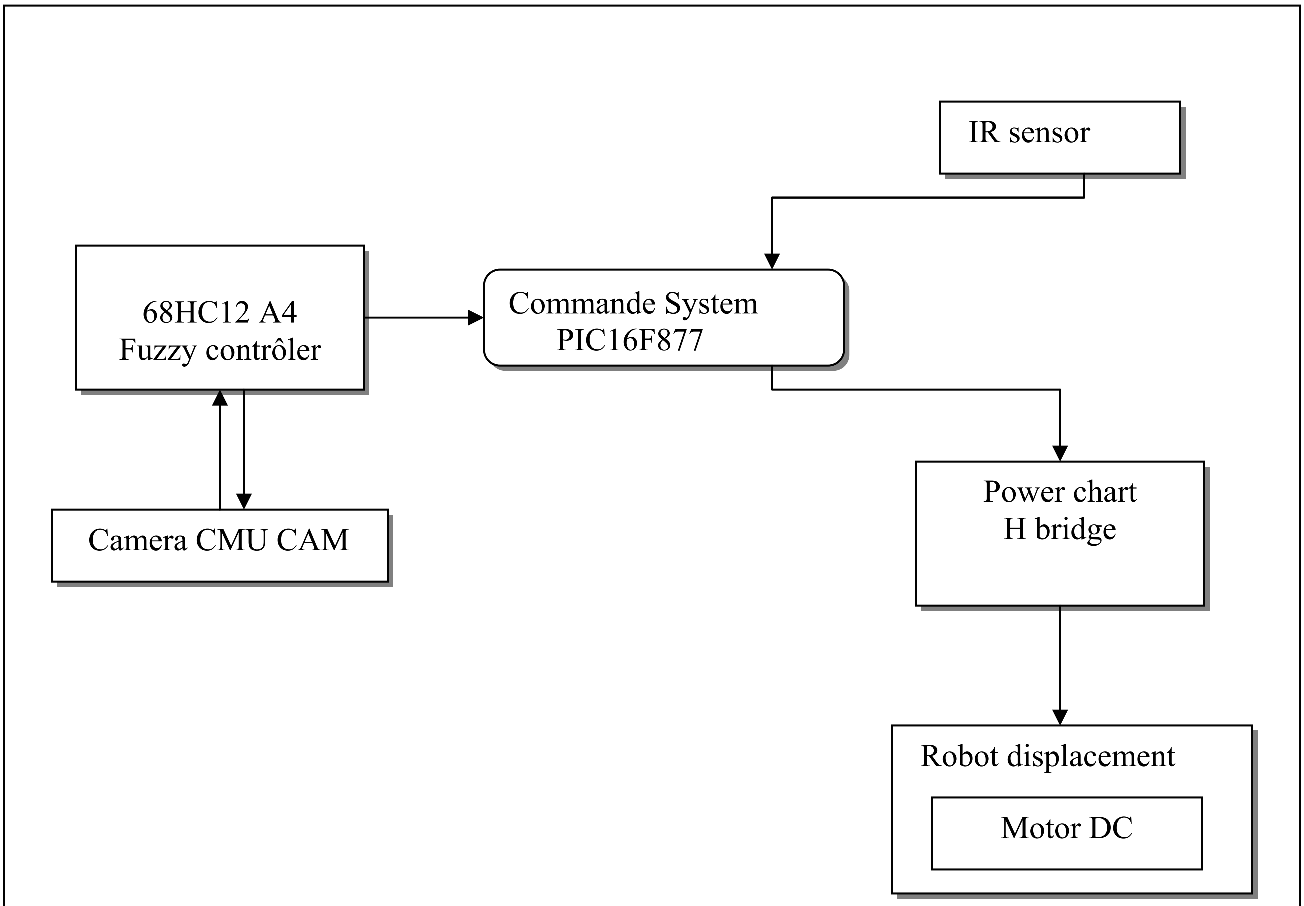

Fig.1 MRS structure

II-3 The Fuzzy Controller (FLC):

The architecture of the fuzzy controller lies between four mains components:

- The fuzzifier.
- Membership Functions
- Inference Rules
- The defuzzifier.

The fuzzifier has as a role the transformation of the data measured into linguistic rules[5][4], for example (distance = 50 cm = > distance far), the membership functions saves the empirical knowledge of the process operation; the inference rules are the core of the controller, because they are able to simulate the human decision performing an approximate reasoning to have the desired control ; the defuzzifier is used to provide the arithmetic values of the fuzzy outputs of the controller.

The inference rules of the fuzzy controller have generally the form bellow:

IF (condition 1) Op (condition 2) Op (.....) **THEN** (decision 1) Op (decision 2) Op.....

Op: it is a logical combination operator, between the different input output; it can vary according to the used concept.

In the concept we are used the trapezoidal method for the fuzzifier, Mamdani (Max-Min) for the inference rules and the middle masse (singleton) for the defuzzifier.

II-4 Fuzzy Logic on the HC12:

As stated in the introduction, Motorola designed the HC12 with advanced capabilities to handle Fuzzy Logic calculations. The HC12 contains four instructions that are specific to Fuzzy Logic. These instructions are:

- MEM Evaluates the trapezoidal membership functions
- REV/REVW Performs unweighted/weighted MIN-MAX rule evaluation
- WAV Performs weighted average defuzzification

The following section describes the basics of Fuzzy Logic on the Motorola HC12. This section will only serve as an introduction to fuzzy programming on the HC12 and is not a replacement for the manufacture's documentation. This section assumes that the reader has some knowledge of Fuzzy Logic.

II-4.1 Fuzzy logic basics

The design of a Fuzzy Logic interface for the HC12 consists of two parts. First, the user must design a knowledge base that contains the membership functions and the rule set. The second part is the inference kernel that takes the system inputs and produces the system outputs based on the knowledge base [5]. Figure 2 show the basic structure of the Fuzzy Logic system.

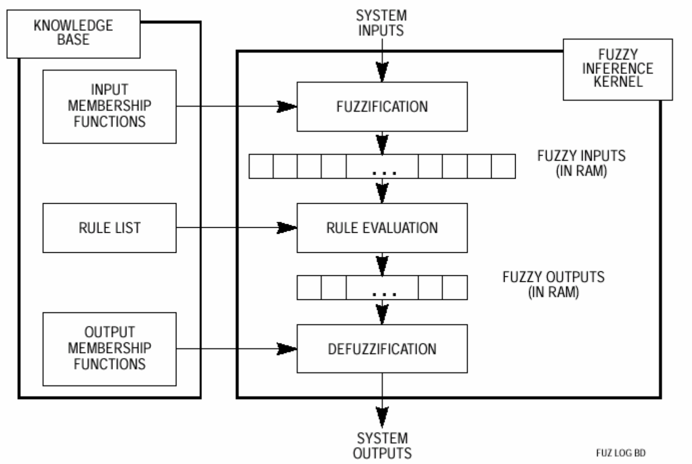

Fig2. Block diagram of a fuzzy logic system [6].

II-4.2 Fuzzification strategy (MEM)

Fuzzification is the process by which system inputs are evaluated to determine the degree at which they belong to a particular fuzzy set, on a scale from 00 to FF in hexadecimal [5]. The MEM instruction evaluates trapezoidal membership functions. These functions define the fuzzy set (the foundation of Fuzzy Logic).

A fuzzy set is a set without a crisp, clearly defined boundary. It can contain elements with only a partial degree of membership. For example, the membership function for FAR could equal FF for distance below 50cm and slope down to 00 toward 5cm. The MEM instruction compares the system input against the membership function to determine the degree of truth of a fuzzy input.

The y-axis in Figure 2 represents the degree of truth from completely false (00) to completely true (FF). The x-axis represents the range of input values for the particular system input. The MEM function works by finding the y-value, given a system input (x-value) and the membership function. MEM returns the percentage of truth (y-axis value) for the particular fuzzy set. The result is a set of fuzzy values that describe characteristics of input variables in the system.

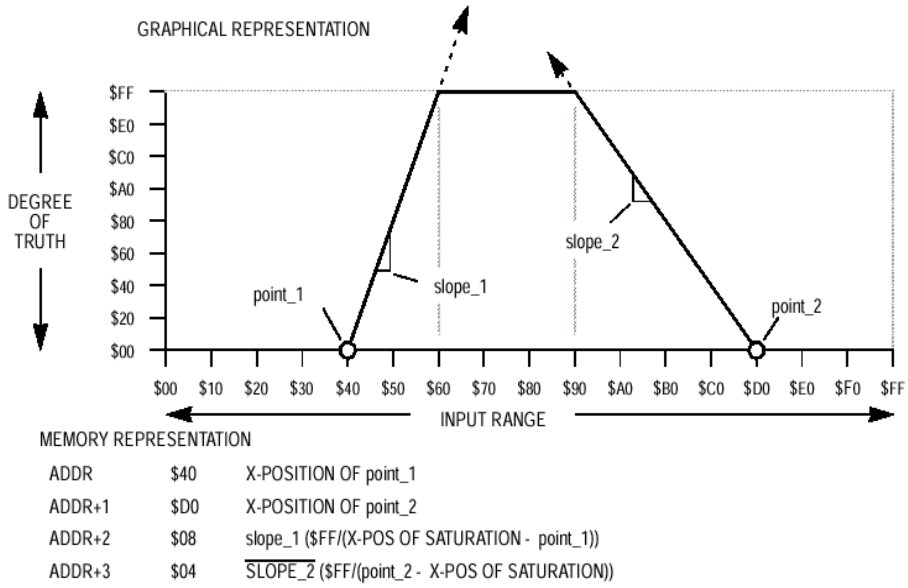

Fig 3: Trapezoidal membership function. The x-axis represents the input range and the y-axis represents the truth degree [5].

To define a trapezoidal membership function for the HC12, you need four values: (1) the start of the trapezoid, (2) the first slope, (3) second slope, and (4) the end point of the trapezoid. Figure 2 labels these points and shows the memory representation. The user should define the trapezoidal in memory as follows:

```
LABEL_MF  DC.B $40, $D0, $08, $04
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The program should use a descriptive label because the programmer will need this label during fuzzification.
A trapezoidal definition is needed for each membership function.

II-4.3 rule definition and evaluation (REV/REVW)

Rule evaluation is how Fuzzy Logic performs calculations. The fuzzy values produced by the MEM function are passed through the rule list to find the fuzzy output. The two types of rules that the HC12 allows are weighted (REVW), where each rule can have a different weights; and un-weighted, (REV) were all rules have equal weight. An example of a rule list:

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If distance is far and object is centred, then speed is HIGH.
If distance is Med and object is centred, then speed is Med.
If distance is near and object is centred, then speed is low.
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After the fuzzy inputs are evaluated with REV/REVW, the system's fuzzy outputs indicate the degree to which an output should have a specific value. These outputs must then undergo defuzzification before their values are useful. Creating the rule list is actually very simple. The antecedents (left side of the rule) are the fuzzy inputs created by the MEM instruction the consequents (right side of the rule) are the fuzzy outputs of the system. During REV, each antecedent is joined using the fuzzy *and* operator (MIN). This minimum value is compared to the current fuzzy output of each consequent using the fuzzy *or* operator (MAX), and the maximum of these two values is stored in each consequent (fuzzy output). In other words, the overall "truth" of a rule is stored in the fuzzy outputs and if a subsequent rule is "truer," then the fuzzy outputs are updated to reflect this new value.

The rule list is stored in memory as a list of pointers to fuzzy inputs (antecedents), a reserved separator value, a list of pointers to fuzzy outputs (consequents), and then another separator. Each rule follows this pattern and the rule list is terminated by an end rule reserved value.

II-4.4 Defuzzification strategy (WAV)

The final step in the Fuzzy Logic calculation is defuzzification, when the raw fuzzy outputs are evaluated to create a composite system output. Unlike the input, the fuzzy output membership function is not trapezoidal but a singleton. This singleton indicates one system output value for each fuzzy output. The output membership singletons are arraigned in memory in the same order as their corresponding fuzzy outputs. WAV calculates a sum of products of each fuzzy output value times its singleton value and a sum of all of the fuzzy output values. The first sum is divided by the second using EDIV to produce an overall value that is the defuzzified output of the system. Defuzzification creates a weighted average system output based on the truth of the fuzzy outputs.

III. Conclusion

Fuzzy Logic represents a tremendous advancement in autonomous robotic control systems. The Motorola MC68HC12's instruction set will make designing fuzzy solutions on microcontrollers much easier than in the past. Fuzzy Logic is well suited for complex control problems like autonomous control, but it may be too difficult for simple control systems. The HC12's fuzzy instructions simplify the design cycle for control system designers and provide an alternative to traditional control methodologies. The fuzzy system developed by Motorola is a very powerful set of instructions that will have a dramatic impact on control systems in many industries.

References:

[1] O. Causse and L.H.Pampagnin, Management of a multi-robot system in a public environment, *Proc. IEEE Int. Conf. Intelligent Robots and Systems*, pp. 246-252,
1995.

[2] S.J.Vestli and N. Tschichold-Gurman, MOPS, a system for Mail Distribution in Office Type Building, *Proc. IEEE Int. Conf. Intelligent Robots and Systems*, pp.
486-496, 1996.

[3] Z.Bien, *Fuzzy Logic Control*, Hong-Reung Pub., 1997.

[4] K.R.S.Kodagoda, W. S. Wijesoma, and E. K. Teoh, Fuzzy Speed and Steering Control of a AGV, *IEEE Tran. On Control Systems Technology*, Vol. 10, No. 1,

[5] Intelligent Trace Algorithm of Mobile Robot Using Fuzzy Logic
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[6] Fuzzy Logic Control in Autonomous Robotics: Investigating the Motorola MC68HC12 on a Line Following Robot, David Olsen, Department of Electrical and Computer Engineering, University of Minnesota Duluth
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