Implementation of Fuzzy-PID in Smart Car Control

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***Abstract*—An unmanued smart car control system and the fuzzy-PID control algorithm are produced . A design scheme of fuzzy-PID controller is put forward. The simulation analysis from matlab indicated that the dynamic performance of fuzzy-PID control algorithm is better than that of usual PID. Experimental result of smart car show that it can follow the black guid line well and fast-stable complete running the whole trip.**

Keywords* — *fuzzy-PID; samrt car; fuzzy controller;fuzzy control

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1 Introduction

In recent years, many countries are developing unmanned vehicle technology. This gives birth to many new theories and applied technology. Reference[1] presents the theory of turn ahead which uses real-time monitoring speed to change the turn-in point dynamically, then it implements the control strategy to achieve a perfect characteristics of steering. Reference[2] uses edge detection algorithm to extract track information and adopt P control. Reference[3] proposes a efficient, good anti-jamming and adaptive image processing dynamic algorithm which effectively solves the out of track caused by the changes of ambient light and track. Reference[4] reconstructs spatial relationships of track and calibrates camera using nonlinear optimization, then it can measure lateral deviation accurately. The above improve vehicle performance in one way but they are all lack of characteristics of car movement and based on lots of experiments. A fuzzy-PID control algorithm and a design scheme of fuzzy-PID controller are put forward in this paper. At last, the experimental result is given out to prove the validity of fuzzy-PID.

2 Hardware system design

To implement the design of fuzzy-PID algorithm, it's necessary to design a hardware system of smart car. Smart car would have a smart control unite which contain detection of guide line, steering angle value, speed value and so on. See details in Fig.1.

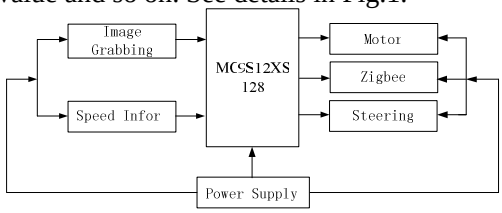

Fig.1 The functional block diagram of smart car

3 Basic principle of fuzzy-PID

It's difficult for usual PID control algorithm to achieve the best effect. Because, the parameters Kp, Ki, Kd can't adjust to different object or different state of the same object. Fuzzy control is based on fuzzy set and fuzzy logic. Without precise mathematical model it can determine the size of controlled variable according the rule table organized by experience. In general, fuzzy control input variables are based on system error E and error change EC, which is similar to PD control. Such control might have a good dynamic characteristic, but the static performance is not satisfactory.

Combining fuzzy control and PID control, this would make a system have both flexibility-adaptablity of fuzzy control and high accuracy of PID control. Fig.2 shows the structure diagram of fuzzy-PID control system, in which fuzzy controller is responsible for selecting a different PID parameter to improve the local performance thus increasing over all performance. [5]

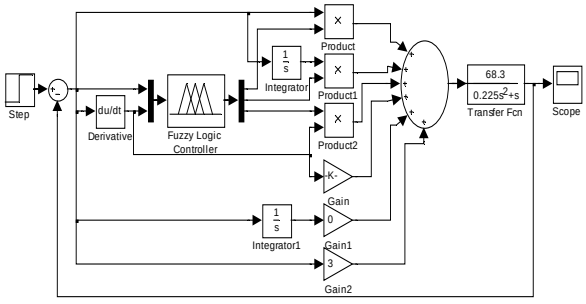

Fig.2 Simulation diagram of fuzzy-PID

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4 Design of fuzzy-PID controller

Speed drive motor controller design is similar to the following example for steering gear controller design. Fuzzy controller consists of fuzzification, fuzzy-inference and defuzzification, which are based on the knowledge base.[6] Controller input error and error change, output the parameters Kp,Ki,Kd.

Suppose the fuzzy set for E is{NB,NM,NS,NO, PO,PS，PM,PB}; the fuzzy set for EC, Kp,Ki and Kd is{NB,NM,NS,ZO,PS,PM,PB}. The linguistic meanings are: NB = negative big, NM = negative middle, NS = negative small, NO = negative zero, ZO = zero, PO = positive zero, PS = positive small, PM = positive middle, PB = positive big. So the membership function curves of fuzzy variables E, EC, Kp,Ki and Kd are shown in the Fig.3-Fig.7:

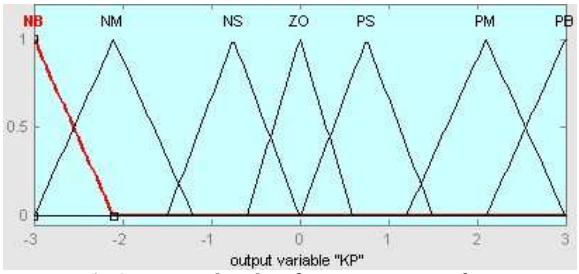

Fig.3 Membership function curves of Kp

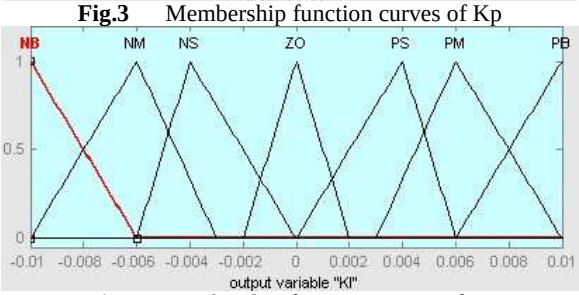

Fig.4 Membership function curves of Ki

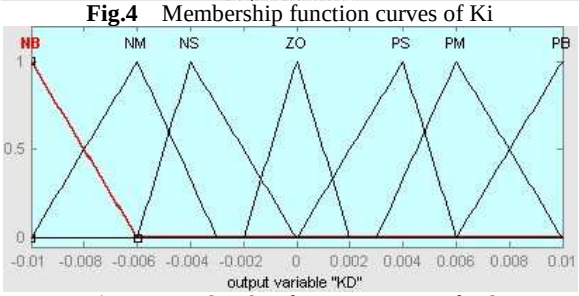

Fig.5 Membership function curves of Kd

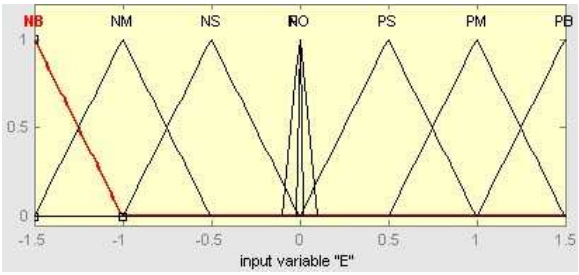

Fig.6 Membership function curves of E

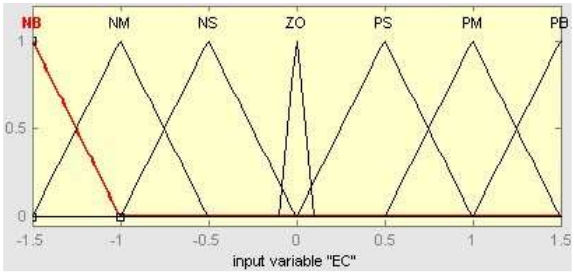

Fig.7 Membership function curves of EC

It's necessary to establish rule table after finishing fuzzification. According the describtion of rule table, 56 fuzzy conditional statements can be summed, which look like If (E is PB) and (EC is PB) then (Kp is PB) (Ki is ZO) (Kd is PB). See details in Tab.1-Tab.3.

Then, the last step is defuzzification and making a lookup table. During fuzzy control, the lookup table would be embed into the program. Suppose input value is fixed, the corresponding output value would be found in the table. Actually, this would save much computing time, and the control would become simply.

Tab.1 Rule table of Kp

E \ EC	PB	PM	PS	ZO	NS	NM	NB
PB	PB	PB	PB	PB	PM	ZO	ZO
PM	PB	PB	PB	PB	PM	ZO	ZO
PS	PM	PM	PM	PM	ZO	ZO	NS
PO	PM	PM	PS	ZO	NS	NM	NM
ZO	PM	PM	PS	ZO	NS	NM	NM
NS	PS	PS	ZO	NM	NM	NM	NM
NM	ZO	ZO	NM	NB	NB	NB	NB
NB	ZO	ZO	NM	NB	NB	NB	NB

Tab.2 Rule table of Ki

E \ EC	PB	PM	PS	ZO	NS	NM	NB
PB	ZO	ZO	ZO	ZO	ZO	ZO	ZO
PM	ZO	ZO	ZO	ZO	ZO	ZO	ZO
PS	NM	NM	NM	NM	ZO	ZO	PS
PO	NM	NM	NS	ZO	PS	PM	PM
ZO	NM	NM	NS	ZO	PS	PM	PM
NS	NS	ZO	ZO	PM	PM	PM	PM
NM	ZO	ZO	ZO	ZO	ZO	ZO	ZO
NB	ZO	ZO	ZO	ZO	ZO	ZO	ZO

Tab.3 Rule table of Kd

EC / Kd / E	PB	PM	PS	ZO	NS	NM	NB
PB	PB	PB	PB	PB	PM	ZO	ZO
PM	PB	PB	PB	PB	PM	ZO	ZO
PS	PM	PM	PM	PM	ZO	ZO	NS
PO	PM	PM	PS	ZO	NS	NM	NM
ZO	PM	PM	PS	ZO	NS	NM	NM
NS	PS	PS	ZO	NM	NM	NM	NM
NM	ZO	ZO	NM	NB	NB	NB	NB
NB	ZO	ZO	NM	NB	NB	NB	NB

5 Analysis of experimental results

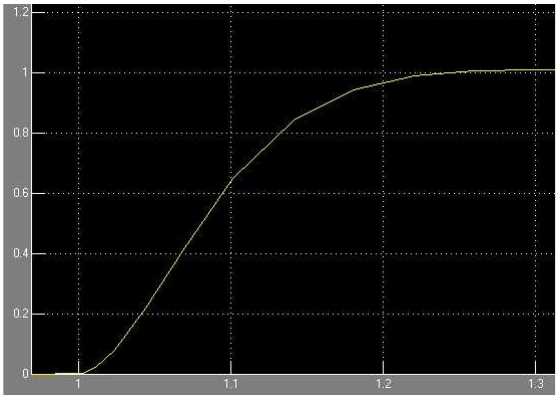

Fig.8 Responding curves of PID

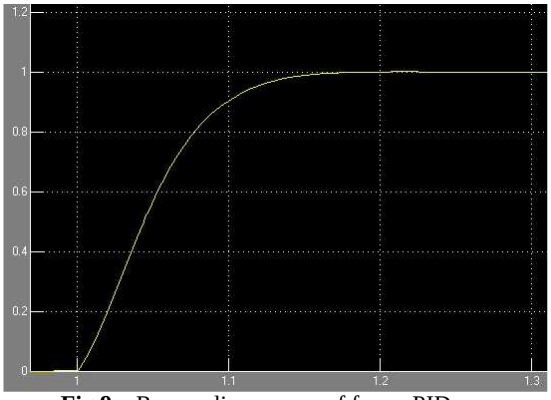

Fig.9 Responding curves of fuzzy-PID

Experiment used the steering gear model provides by reference[7]. The simulation circuit were shown in Fig.2. The usual PID and fuzzy PID algorithm were all simulnked in the Matlab. Responding curves obtained were shown in Fig.8 and Fig.9.

The experimental result show that compared with the usual PID, the responding time of fuzzy-PID algorithm is shorter without overswing. The system dynamic performance is improved significantly.

6 Conclution and outlook

This paper provided a design scheme for controlling a smart car, which is proved practically and superlatively though experiments.

Unmanned smart car is due to the development of computer technology, pattern recognition and intelligent control technique. Many countries and research groups are doing research in the area. But it's a complicated system, which involves a number of technologies. So the development of each technology is important, for it would become the bottleneck of the development of smart car.

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