Neural Network and Fuzzy Systems (EC8203)

Project Report

Fan Speed control using Fuzzy Logic Controller

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Abstract

Designing a controller is an integral part of any application be it robotics, automation, or industrial fields. It maps the digital world to the physical world. A **fuzzy control system** is a control systembased on fuzzy logic—a mathematical system that analyzes analog input values in terms of logic variables that take on continuous values between 0 and 1, in contrast to classical or digital logic, which operates on discrete values of either 1 or 0 (true or false, respectively). Fuzzy logic is widely used in machine control. The term "fuzzy" refers to the fact that the logic involved can deal with concepts that cannot be expressed as the "true" or "false" but rather as "partially true". Although alternative approaches such as genetic algorithms and neural networks can perform just as well as fuzzy logic in many cases, fuzzy logic has the advantage that the solution to the problem can be cast in terms that human operators can understand, so that their experience can be used in the design of the controller. This makes it easier to mechanize tasks that are already successfully performed by humans. Also a fuzzy controller is much more roboust in its operation. In this project I present a simple Fuzzy controller that controls the speed of a Fan taking the temparature as an analog input.

Introduction

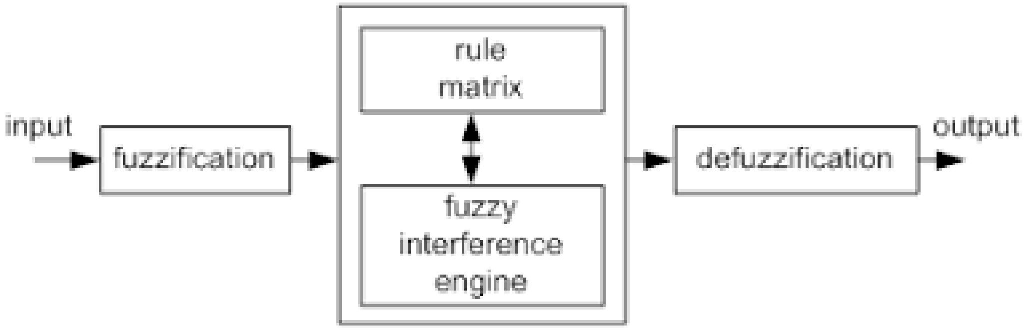
"Almost every mechanical movement that has been noticed around us is accomplished by an electric motor.Electric machines are a means of converting energy. Motors take electrical energy and produce mechanical energy. Electric motors are used to power hundreds of devices we use in everyday life.”

The controllers used to modify the behavior of this system so as it behaves in a specific desirable way over a time. One of these controllers is fuzzy logic controller. Fuzzy Logic Controller (FLC) which was proved analytically to be equivalent to a nonlinear controller when a nonlinear defuzzification method is used. Also, the results from the comparisons of conventional and fuzzy logic control techniques in the form of the FLC and fuzzy compensator showed that fuzzy logic can reduce the effects of nonlinearity in a DC motor and improve the performance of a controller.

Fuzzy Inference System (FIS) is the process of formulating the mapping from a given input to an output using fuzzy logic. Fuzzy inference systems have been successfully applied in fields such as automatic control, data classification, decision analysis, expert systems, and computer vision. There are two types of fuzzy inference systems that can be implemented Mamdani-type and Sugeno-type. In this project the Mamdani type FIS is used that requires finding the centroid of a two-dimensional shape by integrating across a continuously varying function.

Controller Description

Fuzzy logic control is a control algorithm based on a linguistic control strategy, which is derived from expert knowledge into an automatic control strategy. A block diagram for a fuzzy control system is given in fig below.
The fuzzy controller consists of the following four components:



A. Fuzzification
The first step in designing a fuzzy controller is to decide which state variables represent the system dynamic performance must be taken as the input signal to the controller. Fuzzy logic uses linguistic variables instead of numerical variables. The process of converting a numerical variable (real number or crisp variables) into a linguistic variable (fuzzy number) is called fuzzification. This is achieved with the different types of fuzzifiers. There are generally three types of fuzzifiers, which are used for the fuzzification process; they are

1)Singleton Fuzzifier
2)Gaussian Fuzzifier
3) Trapezoidal or Triangular Fuzzifier.

The triangular Fuzzifier is used in this project for both input and output.

B. Rule Matrix
A decision making logic which is, simulating a human decision process, inters fuzzy control action from the knowledge of the control rules and linguistic variable definitions.
Here-
if temp=[0:10]then speed=stop(0-30)
if temp=[8:20]then speed=slow(10-50)
if temp=[15:30]then speed=medium(40-60)
if temp=[25:70]then speed=fast(50-90)
if temp=[60:100]then speed=blast(70-100)

where temp is in Degree Celsius and Speed x100 rpm.

C. Inference engine
Inference engine is defined as the Software code which processes the rules, cases, objects or other type of knowledge and expertise based on the facts of a given

situation. When there is a problem to be solved that involves logic rather than fencing skills, we take a series of inference steps that may include deduction, association, recognition, and decision making. An inference engine is an information processing system (such as a computer program) that systematically employs inference steps similar to that of a human brain. There are two popular methods(max-min and max-product), in this project the max-min has been used.

D. Defuzzification

The reverse of Fuzzification is called Defuzzification. The use of Fuzzy Logic Controller (FLC) produces required output in a linguistic variable (fuzzy number). According to real world requirements, the linguistic variables have to be transformed to crisp output. There are many defuzzification methods but the most common method is as follows Center of gravity (COG) :

$$z^* = \frac{\int \mu_C(z) \cdot z \, dz}{\int \mu_C(z) \, dz}$$

where z* denotes the centroid of the area and thus we get the required output of the fan speed.

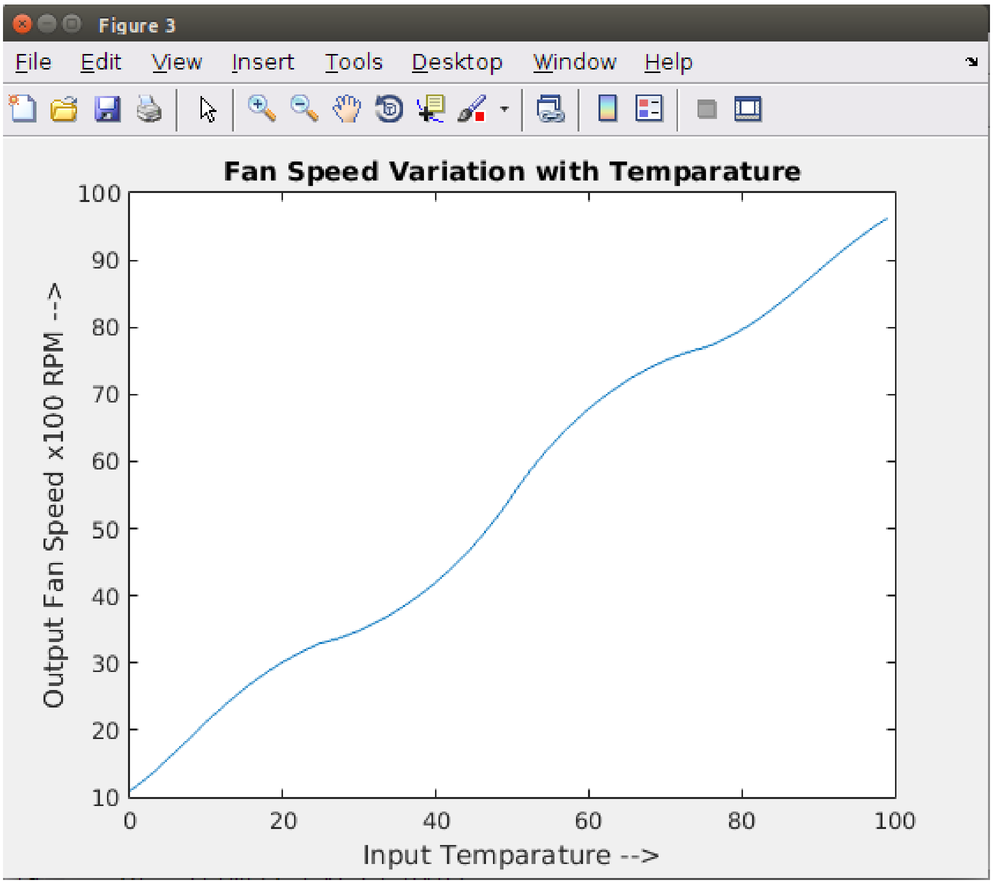
Controller Design Code (MATLAB)

```
% Fuzzy Logic FAN Speed Controller
clear;
%% Rule Base
% if temp=[0:10]then speed=stop(0-30)
% if temp=[8:20]then speed=slow(10-50)
% if temp=[15:30]then speed=medium(40-60)
% if temp=[25:70]then speed=fast(50-90)
% if temp=[60:100]then speed=blast(70-100)
%% Membership function
% Input
x=0:0.1:100;
x1 = trimf(x,[0 0 25]);
plot(x,x1,'r');
hold on;
x2 = trimf(x,[0 25 50]);
plot(x,x2,'g');
x3 = trimf(x,[25 50 75]);
plot(x,x3,'b');
x4 = trimf(x,[50 75 100]);
plot(x,x4,'--');
x5 = trimf(x,[75 100 100]);
plot(x,x5,'k');
title('Temparature Membership Function')
xlabel('Temparature -->');
legend('0-25','0-50','25-75','50-100','75-100')
%% Output
y1 = trimf(x,[0 0 30]);
figure,plot(x,y1,'r');
hold on;
y2 = trimf(x,[10 30 50]);
plot(x,y2,'g');
y3 = trimf(x,[40 50 60]);
plot(x,y3,'b');
y4 = trimf(x,[50 70 90]);
plot(x,y4,'--');
```

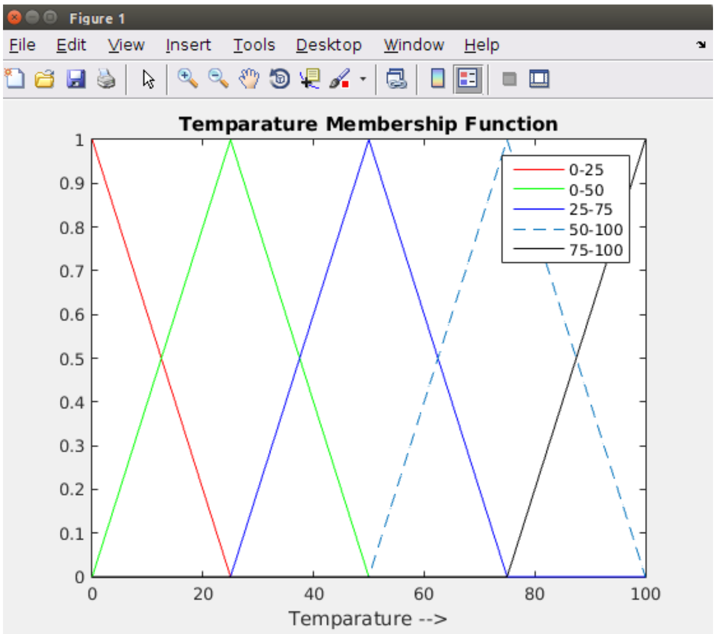
```
y5 = trimf(x,[70 90 110]);
plot(x,y5,'k');
title('Fan Speed Membership Function')
xlabel('Fan Speed x100 RPM -->');
legend('0-30','10-50','40-60','50-90','75-110')
%% Defuzzyfier
k=1;
for j=0:0.1:99
% j=input('Enter the value of tempareture: ');
a(1) = trimf(j,[0 0 25]);
a(2) = trimf(j,[0 25 50]);
a(3) = trimf(j,[25 50 75]);
a(4) = trimf(j,[50 75 100]);
a(5) = trimf(j,[75 100 100]);
%%
A(1,:) =a(1)*y1;
A(2,:) =a(2)*y2;
A(3,:) =a(3)*y3;
A(4,:) =a(4)*y4;
A(5,:) =a(5)*y5;
%%
B=max(A(:,1:1001));
%% Centroid Defuzzification
s=0;
d=0;
for i=1:1001
   s=s+((i-1)*(B(i))*(0.1));
   d=d+(B(i)*0.1);
end
%%
c(k)=((s/d)/1001)*110;
k=k+1;
end
%%
figure,plot([0:0.1:99],c)
title('Fan Speed Variation with Temparature')
xlabel('Input Temparature -->');
ylabel('Output Fan Speed x100 RPM -->');
```

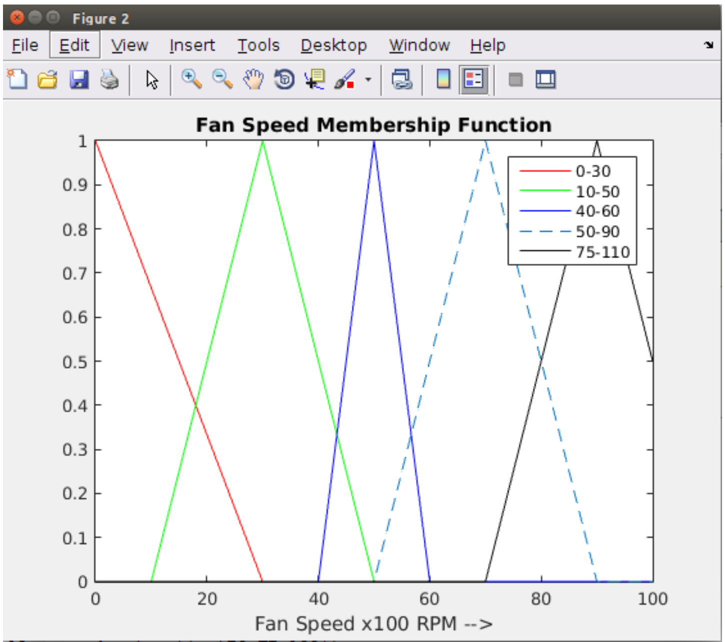
Results

The resultant variation of the Fan speed temparature is shown by the graph below:



The membership Function of the input and output is also shown below:





Refrences

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