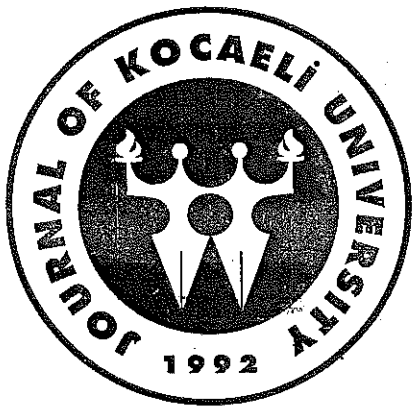
ISSN 1300 - 7394

JOURNAL OF KOCAELİ UNIVERSITY



PURE AND APPLIED MATHEMATICS

ENGINEERING SCIENCES

EARTH SCIENCES

December 1997, No. 4

JOURNAL OF KOCAELI UNIVERSITY

Principal Editor :
Prof.Dr. Atıf URAL

Chief Editor :
Prof.Dr. Selçuk TOKEL

SECTION EDITORS

Pure and Applied Mathematics :
Prof.Dr. Alemdar HASANOV

Engineering Sciences :
Prof.Dr. Şinasi ONUR

Earth Sciences :
Prof.Dr. Selçuk TOKEL

Journal of Kocaeli University is published once or twice annually.

All correspondance and material submitted for publication should be addressed to Editor,
Journal of Kocaeli University, İzmit, 41300 Kocaeli - TURKEY
Fax: 262 / 331 39 19

JOURNAL OF KOCAELİ UNIVERSITY

ENGINEERING SCIENCES

Journal of Kocaeli University
No. 4, December 1997

Pure and Applied Mathematics Section

H.HALİLOV ; On Mixed Problem for Quasilinear Pseudoparabolic Equation 1
S.BAYRAMOV & Ç.ARAS ; Homotophy Relation in the Category of Inverse and Direct Spectrums of Topological Spaces 8

Engineering Sciences Section

Y.HATAY ÖNEN ; Dynamic Analysis of Structures With Shear Walls and Frames 20
S.YILMAZ & A.GEDİK & H.DİNÇER & H.OTMANBÖLÜK ; Speed Control of Motor by Means of Fuzzy Logic Unit Aided PLC 31
N.DURU & T.DURU & N.ABUT & H.DİNÇER ; Fuzzy Logic Based Detection and Elimination of Noisy Parts of Digitally Recorded Speech Signal 37
Z.ALADAĞ ; A Parametric Analysis for Purchasing Problem in Jit Environment 44
N.GÜZEL & A.KURUÜZÜM ; Linear Programming With Fuzzy Resources and Its Application 50

Earth Science Section

C.KURTULUŞ ; Seismic Stratigraphy of the Bandırma Gulf 57
H.ŞENEL ; Inversion of Gravity Anomaly of Büyük Menderes Faults 66

Production / KOÜ İletişim Teknolojileri ve Hizmetleri Arş.Uygulama Birimi Tel: 262.331 15 37 - 41300 İZMİT/KOCAELİ and printed by KOÜ Basımevi

Journal of Kocaeli University, Engineering Sciences Section, No.4, December 1997 (pp.31-36)

SPEED CONTROL OF MOTOR BY MEANS OF FUZZY LOGIC UNIT AIDED PLC

Serhat YILMAZ , Adem GEDİK , Hasan DİNÇER , Hikmet OTMANBÖLÜK

The University of Kocaeli , Electronic and Communication Systems Research and Application Center (EHSAM) , İzmit - Turkey
e-mail: ehsam@ehb.kou.edu.tr

Abstract

Programmable Logic Controllers are microprocessor based control systems which manage a machine or an industrial foundation by means of change of situations and a program edited before . Basically , a PLC is composed of a microprocessor , a power supply and input/output units (Kurtulan S. ,1996) . Beside these units mentioned above , some certain units were developed which respond to requirement of faster and more effective processing in industrial controlling systems . These special units , such as high speed counters , heat controllers and pH controllers increase the controlling performance of PLCs . Application of fuzzy logic theory in control systems proved to be superior to the conventional control systems . Fuzzy logic controllers can infer coherent results in uncertain conditions when it is necessary to control a complex system which is impossible to model using mathematical ways . In this paper , the applicability of a special unit to PLCs were investigated which is controlled by a software that performs fuzzy logic processes , by means of improvement on a real industrial control system .

INTRODUCTION

PLC is the most widespread area of microprocessor applications on industrial control . PLCs can easily process continuous signals such as speed and heat by means of analog input/output modules . Speed data , that is acquired from encoder of a motor is sampled by an ADC on the analog input unit and is transferred to a memory area as a digital data . Then it is compared to the set value entered before .

Requirements of a high performance motor driver system are below (Li and Lau , 1989):

- It must follow the set point variations rapidly without exceeding boundaries .
- Maximum decreasing time of the speed caused by instantaneous load changes and re-rising and setting time must be as small as possible .
- Stable status errors of comment tracing and load regulation situations must be zero . To respond these requirements , external feedback loops are added to the driver system . This is done in PLCs by means of PID subroutines or instructions .

Because it is unnecessary to model a dynamic driver system to design a Fuzzy Controller , and performance of fuzzy controller is insensitive to change of parameters , it is rather suitable for applications of motor driver systems (Lee ,1990).

FUZZY LOGIC UNIT

C200H-FZ001 Fuzzy Logic Unit , manufactured by OMRON Electronics , carries fuzzy logic processing out in three stages : condition part processing , conclusion part processing and deffuzification processing .

Speed data , obtained from analog input module , is transferred to the data area of inputs in a 10 words area which is allocated for fuzzy logic unit .

These inputs are evaluated and defuzzification results are transferred to the data area allocated for outputs and then they are transferred to analog output unit (Omron ,1992)

Program and Knowledge Base

There are two software requirements for running Fuzzy Logic Unit . They are ; a ladder subprogram for PLC and a knowledge base used in the Fuzzy Logic Unit .

Subprogram for Ladder Diagram

A subprogram must be prepared for transferring data between PLC and the Unit .This program can be written by standard transferring instructions such as 'MOV ' . Four main steps of this program are as follow :

- The words which is used in input and output data is specified in the Fuzzy Logic Settings.
- Input data is transferred to the words specified above .
- Processing Start Bit is activated to initialize fuzzy processing
- The output data which is saved in the words that are specified above is transferred when the "Results Output Flag" is on .

Table1. Fuzzy logic settings

Word	Function	Value
IR 150	Number of Inputs (8)	008
IR 151	First Input Address (DM 0100)	0100
IR 152	Number of Outputs(3)	0003
IR 153	First Output Address(DM 0110)	0110

Example ladder diagram for transferring data of system which has 8 analog input and 3 analog output to relevant areas is shown below:

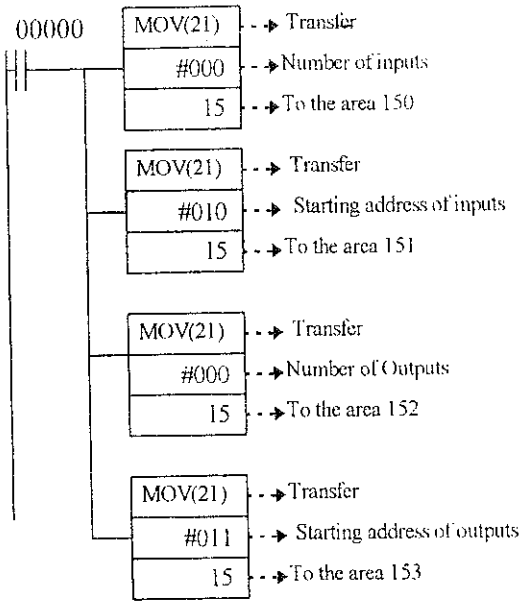


Figure1. Example ladder diagram

APPLICATION : CONTROL OF CONVEYOR SYSTEM

In this application , Fuzzy Logic Unit is used for controlling of two conveyors which are used for packaging products . Products are carried at irregular intervals but at a fixed speed on conveyor A . Boxes are carried at regular intervals on conveyor B , which processes parallel to conveyor A

Fuzzy Logic Unit allows to synchronize the arriving time of products and boxes to assemble area by means of adjusting speed of Conveyor B .

Required information are the distance between the product and the box , the change of rate of the distance (Ross ,1995).

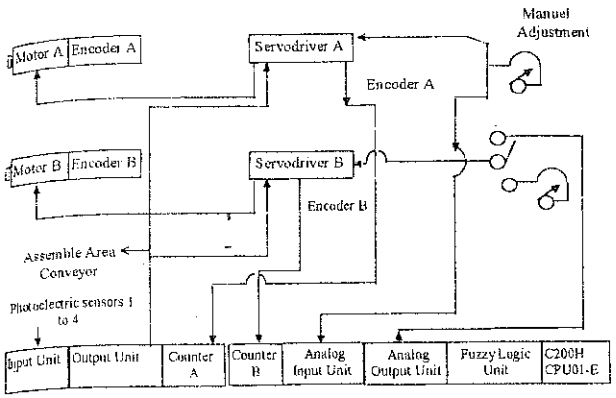


Figure2. Control system of conveyors

Operating of System :

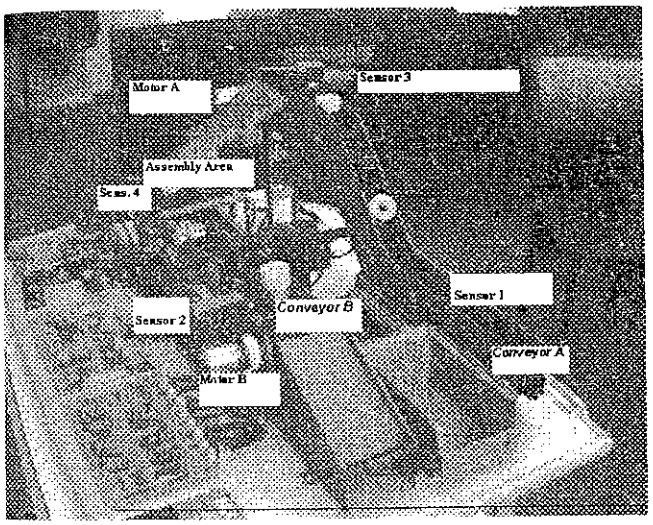


Figure 3. Industrial control trainer set

The distance to the first photoelectric sensor (PH2) that the box is carried on the conveyor B is determined , before the product reaches to the first photoelectric sensor (PH1) on conveyor A . The distance can be calculated by the rotary encoders and High Speed Counters mounted at the back of motors . The distance is called to be product/box offset .

This offset determines the main fuzzy linguistic rules of the system . They are as follow :

" If the product/box offset is large , then slow down conveyor B ."

" If the product/box offset is small , then don't change conveyor B's speed much "

Fuzzy logic processing runs under these rules and the rules related to the change of rate of the product/box offset allows us very smooth adjustment of conveyor B's speed .

Forming of Knowledge Base

Input Data : Input data of product/box offset is calculated by means of taking relative position of product to box (E) as shown below .

E= (Rotary encoder A value) - (Rotary encoder B value) (1)

Input data for change of rate of offset (Δ E) , is the difference between the last value of E , (E_n) and the previous value of E , (E_{n-1}) :

$$\Delta E = (E_n) - (E_{n-1})) \quad (2)$$

Membership Functions:

The figures shown below represent condition and conclusion membership functions . Condition membership functions represent product/box offset and offset change of rate . Conclusion membership function represents conveyor B speed adjustment (Bose and Sausa , 1994).

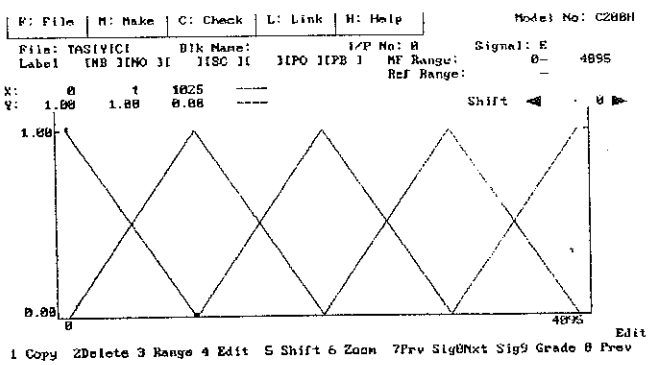


Figure 4. Membership functions for product/box distance offset

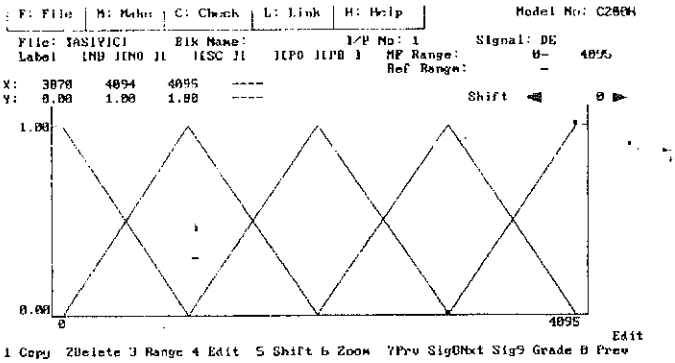


Figure 5. Membership functions for offset change of rate

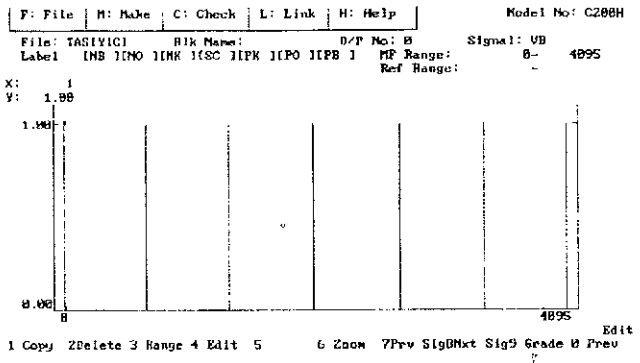


Figure 6. Membership functions which belongs to the variable that adjusts speed of conveyor B

Forming Of Rules

Expressing The Rules : Rules are created by organizing our information and past experiences about a system , with expressions which is being used in daily life . In organizing these expressions a way may be followed such as below :

Table 2. Organizing the rules

E / ΔE	Box is ahead		About even	Product is ahead	
Box is faster	Slow box a lot	Slow box a lot	Slow box a little	Speed it up a little	Speed it up
	Slow box a lot	Slow box	Slow box a little	Speed it up a little	Speed it up
About even	Slow box	Slow box a little	Do not change	Speed it up a little	Speed it up
	Slow box	Slow box a little	Speed it up a little	Speed it up	Speed it up a lot
Box is slower	Slow box	Slow box a little	Speed it up a little	Speed it up	Speed it up a lot

Converting to Labels : So , input data ,output data and expressions in the table above are converted to labels as shown below :

Input Data :

Product/box Offset : E
Offset Rate of Change : DE (Δ E)

Output Data :

Speed Adjustment of Conveyor B

Expressions above can be converted to labels as shown below :

Table 3 . Rule Base

E / DE	NB	NK	SC	PK	PB
PB	NB	NB	NK	PK	PO
PK	NB	NO	NK	PK	PO
SC	NO	NK	SC	PK	PO
NK	NO	NK	PK	PO	PB
NB	NO	NK	PK	PO	PB

Simulation Results

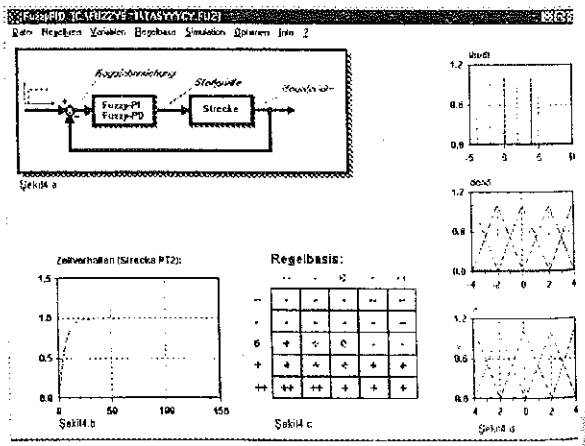


Figure 7. Operations and results of simulation

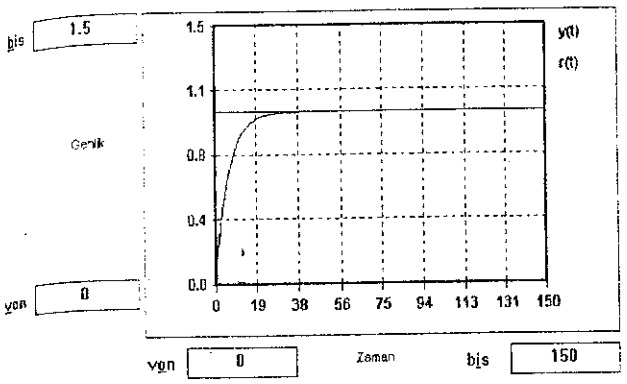


Figure 8 . Simulation result

Because of limitations in simulation program which can not define more than 5 labels, Label of Negative Medium (NO) and Label of Negative Small (NK) are called as Negative Medium (NO). In the same way Labels of Positive Medium (PO) and Positive Small (PK) are called to be Positive Medium (PO). Although reducing of sensitivity for controlling the process shown in Figure 7.a and in Figure 8 , it reaches to set value without oscillations as shown in Figure 7.b and Figure 8. Rule base is shown in Figure 7.c. Conditions membership functions of offset, rate of chance of control output for speed of conveyor B are shown below in Figure 7.d.

PLC Program

Steps , used for PLC subprogram concerned with control of conveyor system are shown below. They may be put in practise either with ladder program or with instrucion set.

Program Steps :

1. Servo drivers being started .
2. Starts input for High speed counter A and B .
3. Writes the present count for high speed counter A and B to other Data areas.
4. Present product/box offset is calculated and refreshed in certain periods.
5. Rate of chance of offset is calculated.
6. Product/box offset data is tried to be centered about 2048 which represents label Zero (E is centered about zero).
7. Rate of chance of offset data is centered about 2048.
8. Number of inputs and first input adress is entered.
9. Number of outputs and first output adress is entered.
10. Product/box offset data is moved to the first input address.
11. Rate of chance of offset data is moved to second input address.
12. Start Processing Bit to initialize fuzzy logic processing is turned on .
13. Fuzzy Logic Units output is converted to BCD .
14. 2048 value is subtracted from Fuzzy Logic Units output to calculate the control value .
15. Servodriver A data and servodriver B data (converted by the Analog Input Unit) are moved to a Data Areas which will be used later .
16. Analog Input Unit data is read .
17. Analog Input Unit data is moved to Analog Output Unit .
18. Output to conveyor B is calculated by adding or substracting the fuzzy logic final result to the conveyor A value according to speed of the box which will be reduced or increased .

19. Output for Conveyor B is transferred to Analog Output Unit .

CONCLUSION

PLCs are industrial control system and they have an important role especially for medium and large scaled industries . Nowadays using fuzzy logic for control is on the point of one of the most popular control methods and industry has great expectations . In this study the applicability of a special unit to PLCs were investigated which is controlled by software that performs fuzzy logic processes . Therefore , with the help of fuzzy logic theory , some examples and concepts in OMRON manuals tried to put in practice on an actual industrial control trainer set which was used for PLC applications . Combinations of fuzzy logic control and conventional control approaches may prove the best solutions.

REFERENCES

BOSE B.K., SAUSA G.C.D , 1994 , A Fuzzy Set Theory Based Control of A Phase Controlled Converter DC Machine drive , *IEEE Transaction On Industry Application*, vol. 30 , January , 34-44

KURTULAN S. , 1996 , Programlanabilir Lojik Kontrolörler ve Uygulamaları , Bileşim Yayıncılık , 2-9

LEE C.C., 1990 , Fuzzy Logic in Control Systems: Fuzzy Logic Controller-Part I , *IEEE Trans. On systems , Man , and Cybernetics* , vol. 20 , April , 404-418

LI Y.F., LAU C.C., 1989 , Development of Fuzzy Algorithms for Servo Systems , *IEEE Control System Magazine* , April , 65-70

ROSS J.T. , 1995 , Fuzzy Logic with n Engineering Applications , Mc Graw-Hill Inc.

OMRON , 1992 , Sysmate Fuzzy Support Software Operation Manual

OMRON , 1991 , Sysmac C Serial Omron Programmable Controllers Manual

OMRON , 1992 , Sysmac C200H-FZ001 Fuzzy Logic Unit Operation Manual