Kufa Journal of Engineering
Vol. 9, No. 4, October 2018, P.P. 88-98
Received 1 August 2017, accepted 28 December 2017

IDENTIFICATION, FUZZY CONTROLLER FOR ELECTRICAL DISCHARGE MACHINE SERVO SYSTEM

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ABSTRACT

This paper utilizes a system identification to model EDM using Arduino and fuzzy controller. System identification is a useful tool for identifying the model depending on the input and output data of the controller. However, derivation of modeling process from first principles is often difficult due to its complexity. The proposed method is used for identifying the mathematical model of EDM from the real time experimental data from gather data from the systemy feeding the DC motor sine sweep or white noise inputs. The model identification of EDM servo system was conducted by using MATLAB/Simulink program and after that the obtained transfer function for the system. The proposed controller has been applied by using FLC .The results showed that the controller can work well with a quick response, no overshoot output and high control precision.

KEYWORDS: System identification; Fuzzy controller; EDM; DC motor

1. INTRODUCTION

Electrical Discharge Machining (EDM) is a method used to eliminate the material electrically from conductive and semi conductive material through series of quickly repeated current discharges between a work piece and electrode in existence of a dielectric (Morimoto and Kunieda, 2009).

The EDM process eradicates material through originating controlled sparks between an electrically conductive work piece and a shaped electrode. In the EDM process an electric spark is used to cut the workpiece, which takes the shape opposite to that of the cutting tool or electrode (Stampfl et al, 2000). Fig. 1 shows the EDM system components.

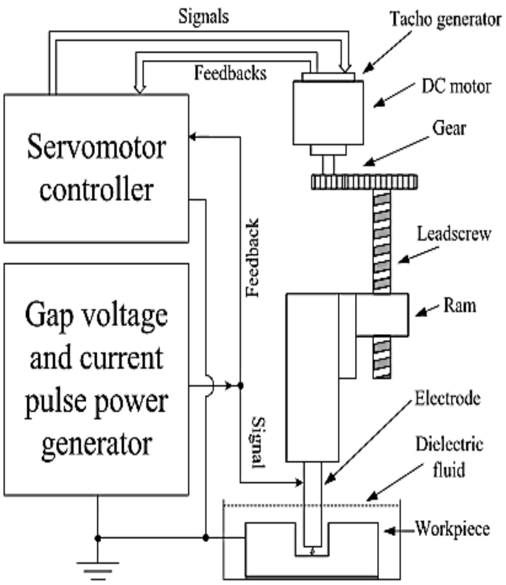


Fig. 1. EDM System Components (Yahya, A, 2005).

Many of controllers have been explored for the EDM process control for years. In (Chang, 2007), the study included the design of robust PI controller for gap control that enhanced the H2 performance. The suitable feed rate and transferred signals for the interpolator are produced from the signals, which are transmitted in a computerized numerical controller (CNC). Via EDM method, the feedback is expanded and disturbed because of the created powder in the gap. The H2 decrease the square of the tracking errors for the insignificant system, including perturbation to develop the tracking performance of the perturbed system. The speed of erosion system with an optimal robustness is faster than those without the optimal robustness. Research (Andromeda et al, 2014) used a servo control system to control the gap between electrode and work piece. A PID controller is developed for EDM servo system. The research optimized the PID parameters utilizing particle swarm optimization algorithm to guarantee a durable, stable, and controlled system. Research by (Trias et al., 2015) utilized the same method to control the gap between the electrode and the work piece, but by using a differential evolution algorithm to optimize the PID parameters.

A research in (Puri and Bhattacharyya, 2003) designed an intelligent controller based on fuzzy RBF (Radial Basis Function) and neural network to achieve a real-time control of EDM online parameters. The simulation results illustrated that this intelligent controller can recognize the real-time adjustment of EDM online parameters, which meets the condition of developing machining effectiveness and enhancing processing stability.

2. MODELING METHOD TECHNIQUE

The performance of the model is derived from measuring the input and output signal of a real DC motor for EDM. To accumulate the data, the Arduino board is connected to DC motor to send voltage commands to the motor, which converts them into angles. Table 1 shows the DC motor parameters.

Table 1. Parameter of DC motor.

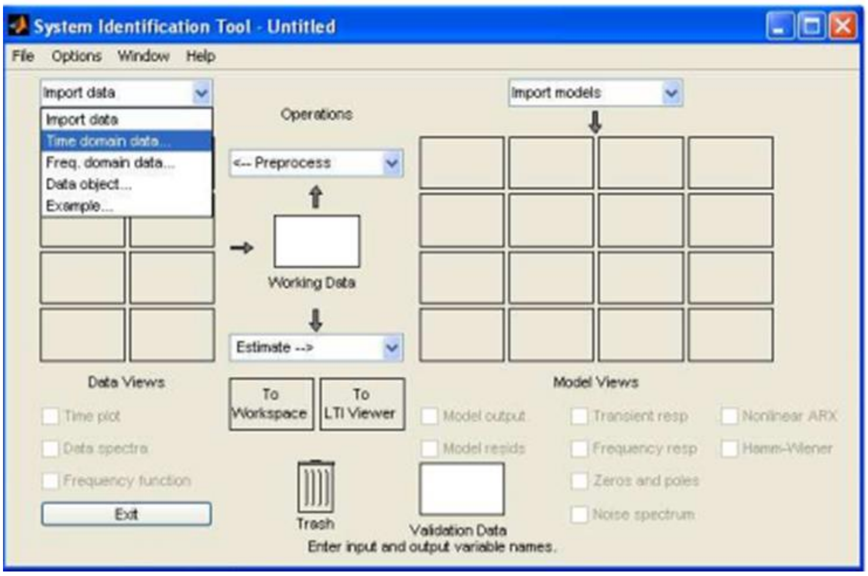
Motor Parameters	Symbols	Unit
Armature resistance	R	Ω
Armature inductance	L	H
Back e.m.f constant	K	V.s/rad
Inertia of rotor	J	$Kg.m^2$
Friction constant	B	N.m/rpm

The transfer function of the input voltage V(s) and the output angle θ(s) are represented in the equation below (Trias et al., 2013).

$$Ga = \frac{\theta(s)}{V(s)} = \frac{K}{S\left((R+LS)(JS+B)+K^2\right)} \qquad 1$$

2.1. System Identification

System Identification (SI) is the procedure of developing the mathematical illustration by using experimental data for a physical system. The SI is suitable to create a transfer function that is denoted as a system model (Aras et al., 2013). The ID method is extra useful mainly in the processes of manufacturing production (Kealy et al., 2013). Efficient and effective control of these processes have immense economic advantages and their success depends on the type of control strategy, such as maintaining the liquid at a specific height or a certain range (Abbas et al., 2013). Via using MATLAB, the SI tool can be opened and by coding of “ident”. The SI tool shown in Fig. 2 is used to model the system using measurements of the system's input and output data, so, it is used to define the processes of experimental modeling.



Enter input and output variable names.

Fig. 2. System identification tool.

2.2. Simulation Algorithm

The system identification procedures are illustrated in Fig. 3. The first step is to collect a set of data that describes how the system acts over its entire range of operation. The second step is to select the appropriate model structures for describing the system. In the last step, the model must be evaluated to investigate the transfer function.

2.3. Simulation and Experimental Results

The first step of the SI procedure includes importing data into ident from the workspace and substitutes the input-output into it. The model of estimating data depends on the working data, which is used to create dynamic linear models with different structures, orders, and delays.

Two types of data are chosen as inputs to the model as show in Fig. 4. The data have been separated into working and validation data using choice range.

Fig. 6 displays the complete transfer function model. Eq. 2 represents the transfer function that has been obtained from the experiment.

$$G(s) = \frac{1.428\, e^{4}}{s^2+19.05s+50.85} \qquad 2$$

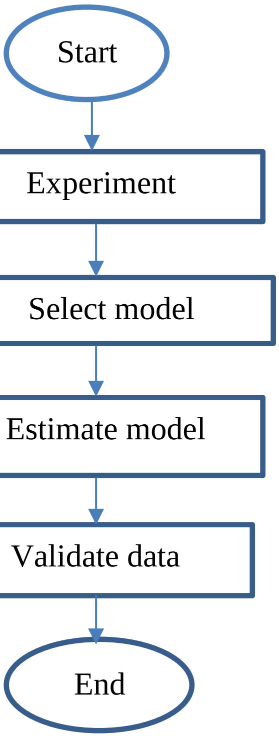


Fig. 3. Flow chart for system identification procedures.

Data Format for Signals: Time-Domain Signals

Workspace Variable
Input: input1
Output: output1

Data Information
Data name: mydata1
Starting time: 1
Sampling interval: 2.7

Data set mydata1 inserted. Double click on icon (right mouse) for text information.

Fig .4. Estimating data.

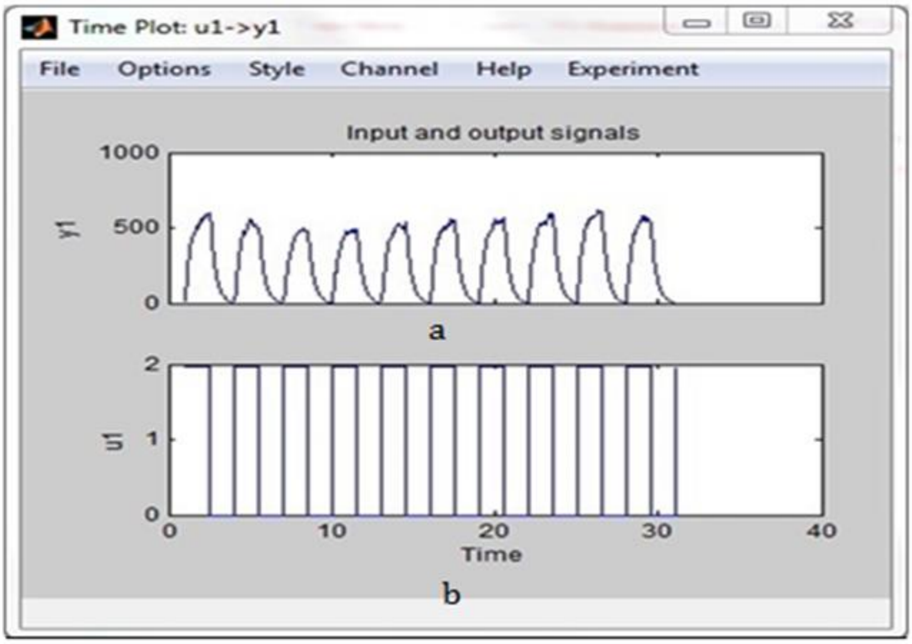
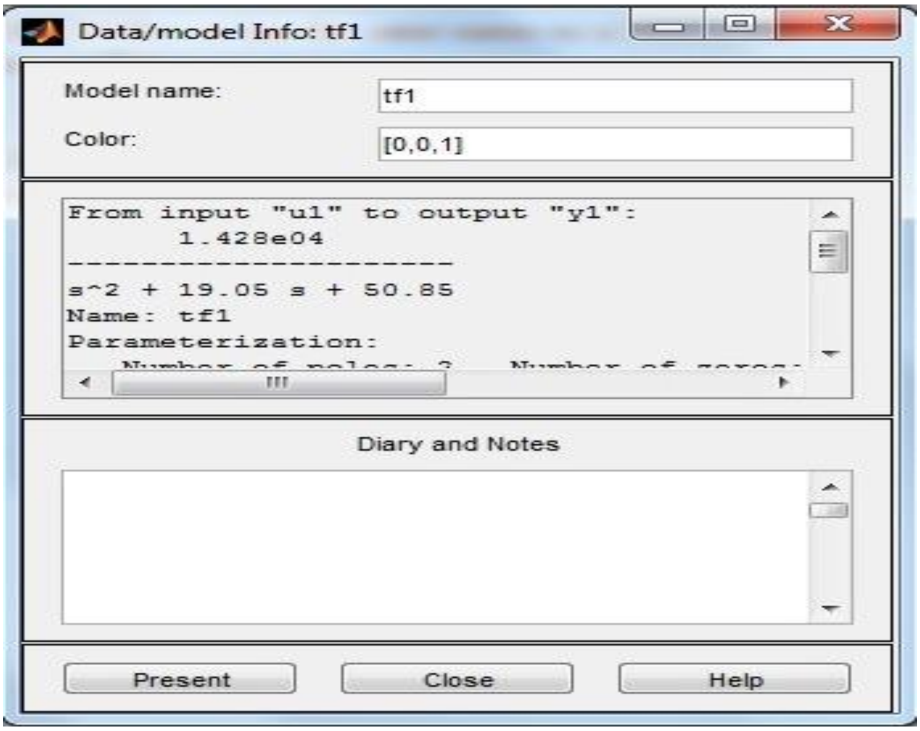


Fig. 5. Parts of the data collected: (b) Input signal, (a) Corresponding output.



Model name: tf1
Color: [0,0,1]

```
From input "u1" to output "y1":
      1.428e04
---------------------
s^2 + 19.05 s + 50.85
Name: tf1
Parameterization:
```

Fig. 6. Transfer function model obtained from the experiment.

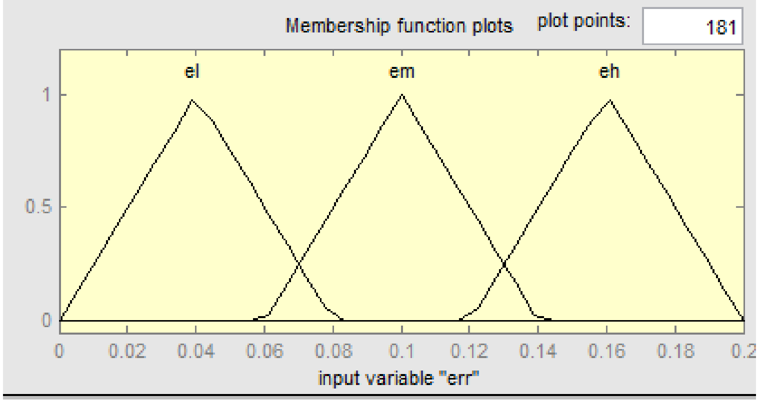
3. FUZZY LOGIC CONTROLLER

Fuzzy logic control (FLC) is a control algorithm based on a linguistic control strategy (Chakravorty and Sharma, 2013). A fuzzy controller transforms a linguistic control strategy into an automatic control strategy, and fuzzy rules are created by expert experience or knowing database. FLC is less mathematical computation cost than other control systems; it just uses a straightforward mathematical computation process to emulate the expert knowing. A fuzzy logic control generally contains the following:

1. Fuzzification
2. Rule base and Inference engine
3. Defuzzification

The FLC has membership functions (MF's) for inputs error (err) and for change of error (cherr) as displayed in Fig. 7 and Fig. 8.

Fig. 9 shows the voltage control u (t) of the output variable for the FLC. Table 2 displays the fuzzy controller rules.



Fi.g. 7. Membership function for error.

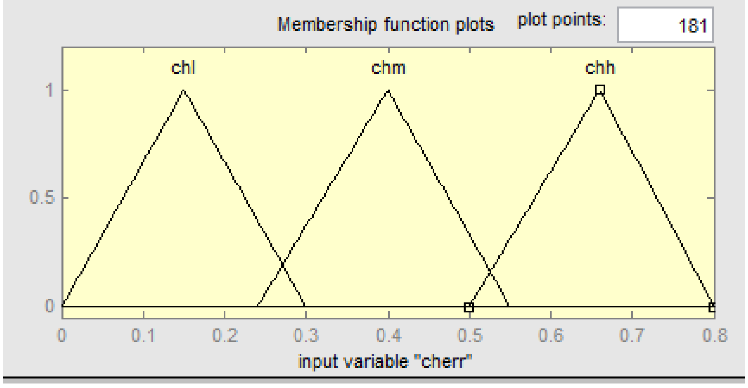


Fig. 8.Change of error.

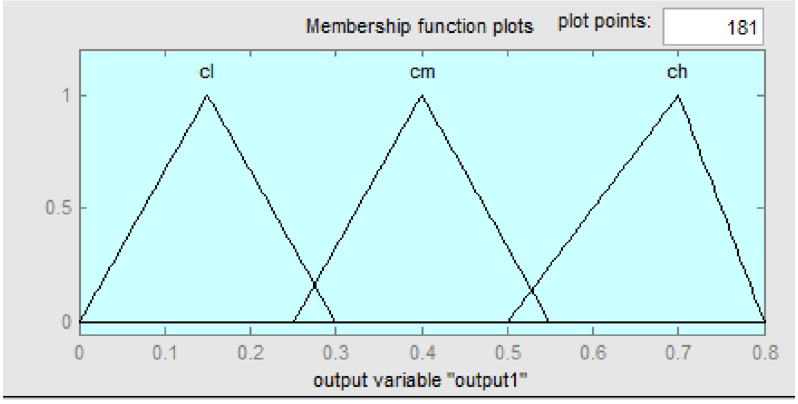


Fig. 9. Output control signal.

Table 2. Fuzzy controller rules.

Err / cherr	N(errl)	Z(errm)	P(errh)
N(cherrl)	N	N	Z
Z(cherrm)	Z	Z	Z
P(cherrl)	Z	P	P

4. RESULTS AND DISCUSSION

The transfer function is gained from system identification prior part. The voltage of input that is inserted to the plant is 1 volt. Fig. 10 shows the transfer function that is obtained from the experiment, and Fig. 11 shows the model of simulation with the fuzzy controller for the speed control of DC servo motor.

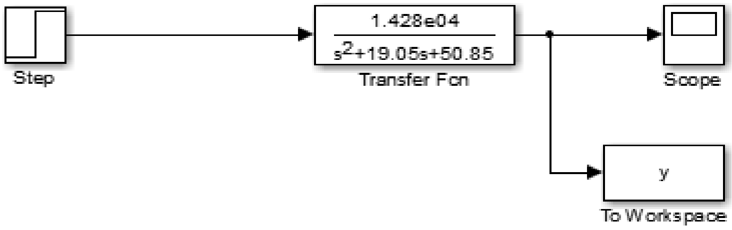


Fig. 10. Block diagram for open loop system.

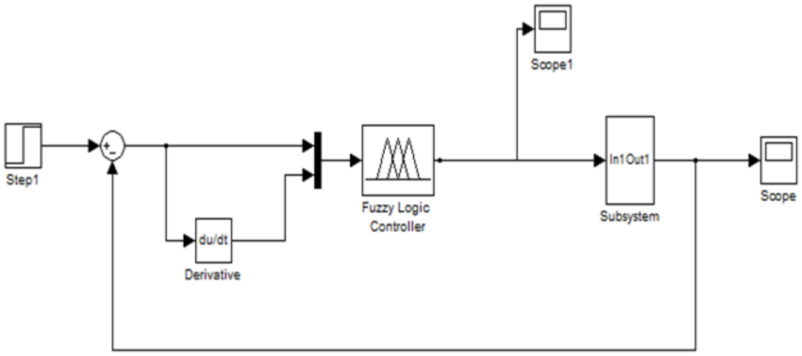


Fig. 11.Simulink model of DC motor speed control for closed loop system.

Fig. 12 represents the transient response for an open loop system, and Fig. 13 displays the simulation output of the FLC for the system.

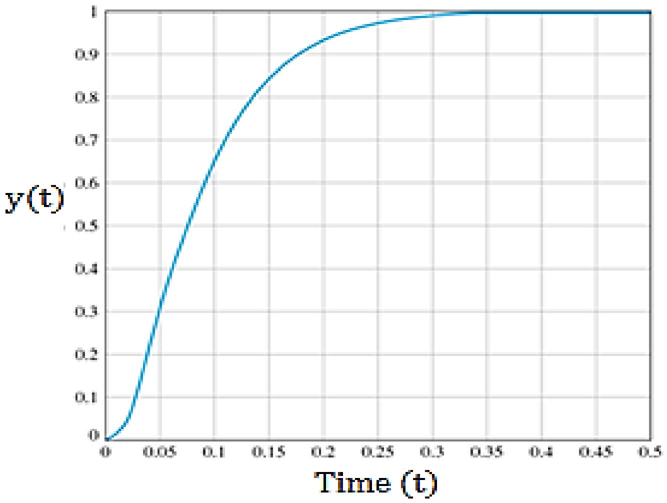


Fig. 12. Transient response for open loop system.

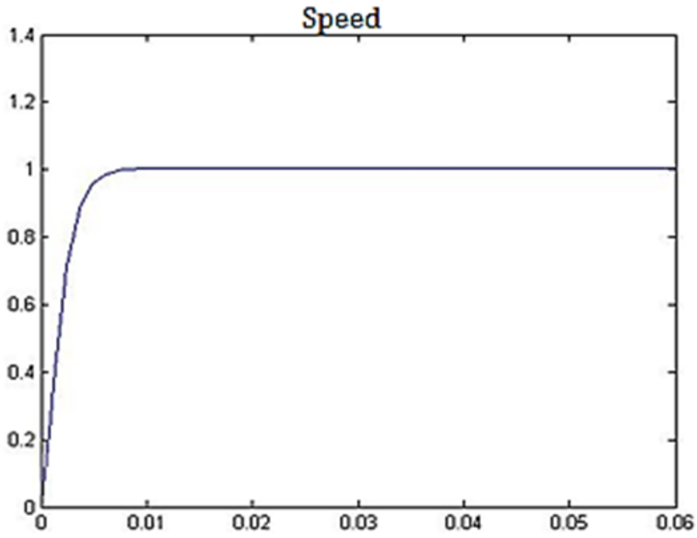


Fig. 13. Transient response for closed loop system with controller.

5. CONCLUSION

In this paper, the mathematical model of EDM servo system is developed by using a system identification (SI). The overall process is captured from experimental data collection based on Arduino. The data are noted in the MATLAB SI toolbox to conclude a model in TF form. The successfully implementation of transfer function was done during open and closed loop way, which shows the transient responses and stability of the system. Then, the transfer function model can be used for another experiment. Hence, a fuzzy based DC motor speed control system was designed. This method improves the characteristics of DC motor, such as smooth starting, acceleration, precision, performance, and small change of reference speed with no over shoot. The method indicates robustness in speed drive controller comparing with conventional speed drive controller.

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