Study and Applications of Fuzzy Systems in Domestic Products

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Abstract In the recent past, it has been observed that many domestic products have been produced with fuzzy systems. This paper explains the various programming made for the effective utilization of domestic products. This paper also explains about fuzzy and its models. To initiate with the products which are otherwise not utilizing fuzzy systems, this paper suggests a way of incorporating the fuzzy techniques in such products. With the help of this, the products will save time and human energy.

Keywords Fuzzy logic · Fuzzy logic controller (FLC) · Automated oven · Automated iron and temperature control system

1 Introduction

With increased workload and hectic living schedules, time spent and energy expended by an individual in domestic operations are becoming a strain. The need of the hour now is to adopt some superior appliances in domestic operations that can reduce human efforts and increased efficiency. The application of fuzzy logic on domestic products is now deemed to be a future solution. Fuzzy welcomes a value between 0 and 1 and uses the human linguistic variables to more accurately define the current state of input which uses predefined rules to determine the output.

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The paper is arranged as follows—Sect. 2 provides a brief study about fuzzy logic, fuzzy logic toolbox available in MATLAB and the advantages of fuzzy logic controllers over conventional PID controllers [1, 2]. In Sect. 3, we discussed the various domestic products and applications of fuzzy logic in those products that are currently in practice namely—microwave oven [3], domestic flour mill [4], gas heater [5]. Section 4 gives an extended study for automated domestic iron where fuzzy can be incorporated to deliver better results. Section 5 gives our conclusion on the basis of various studies between the PID controller and the fuzzy logic controller.

2 Fuzzy Logic

Fuzzy logic is an approach of making a decision based on computing the "degree of truthfulness" rather than the usual "true or false" (0, 1). The idea of fuzzy logic was first introduced by Dr. Lotfi Zadeh in the 1960s. While working on Natural Language Processing, a branch of machine learning, he found that natural language that human uses cannot be easily converted into a binary of 0 or 1. Many states between these two are frequently used and needed to be addressed with proper care. While dealing with fuzzy logic, 0 and 1 are taken as extreme values that show either completely false or completely true. In between these, it includes various states of truth, e.g., how much a piece of cloth is dirty can be recorded as "0.78 degrees of dirtiness." These intermediate values help any device to set output parameters according to requirements [6].

In application, fuzzy logic is defined basically as a set of if-then rules, based on linguistic variables instead of numerical variables, i.e., variables have value words rather than numbers.

Fuzzy logic since it is formulated during the 1960s has gradually developed into one of the most significant subjects of the cutting-edge world. It is valuable for individuals engaged with innovative work, mathematicians, regular researchers (science, material science, biology, and earth science), social researchers (financial matters, political theory, the board, and brain science), programming designers, examiners, architects, and therapeutic scientists. Earlier, it was considered to be a topic of mathematical concern, but now its applications can be found in varied fields such as facial pattern recognition, anti-skid braking systems, unmanned helicopters, weather forecasting, split air conditioners, stock trading, medical help, domestic flour mill, gas heater, wastewater management [7–14].

2.1 Fuzzy Logic Toolbox

Application of fuzzy logic involves the use of MATLAB fuzzy logic toolbox, "a software which interprets fuzzy logic as a theory which relates to a class of objects with unsharp boundaries which uses membership functions having values between

0 and 1." MATLAB functions and Simulink block are provided by the fuzzy logic toolbox that helps in building an environment for building and analyzing the fuzzy model. The tool stash lets you model complex framework practices utilizing straight-forward rationale rules, and afterward actualize these principles in a fluffy derivation framework [2, 15].

2.2 PID Controller Versus Fuzzy Controller

Proportional derivative controller is the traditional controller that we have been using for times and takes a substantial portion of our domestic market. The goal for a PID controller is to change output when a certain setpoint is coordinated. It is commonly utilized when the contribution to the framework changes much of the time and the controller is relied upon to counterbalance it [16]. Fuzzy control is an incredible recipient in those zones of industry where because of the absence of appropriate details among input and output relations conventional PID controller strategy cannot be employed. In contrast with PID controllers, fuzzy controllers utilize a semantic framework practically identical to human observation and verbal.

A PID controller is complex and costlier than a fuzzy logic controller. Also, FLCs are more robust as they cover a wide range of operations without human intervention, and it also improves systems response time. While fuzzy logic has a well-defined set of if-then rules, a PID controller has only a fixed model, using which it outputs the result. An FLC has zero steady-state error [1, 17, 18].

3 Domestic Product Methodologies

3.1 Microwave Oven

The use of a microwave oven is prevalent in many households nowadays. A large variety of food items can be cooked and processed in it. But the amount of cooking time expected for various types and quantity of food items fluctuates considerably over a certain span of time. It makes it difficult to get the desired results every time we use it. We may have to check again and again if food is properly cooked or not, and it would lead to a decrease in efficiency and an increase in electricity consumption, in addition to extra efforts of repeating it again and again. So, we need to define a fixed set of rules for a different set of inputs and corresponding output times and implement it using a fuzzy controller to get better results (Fig. 1).

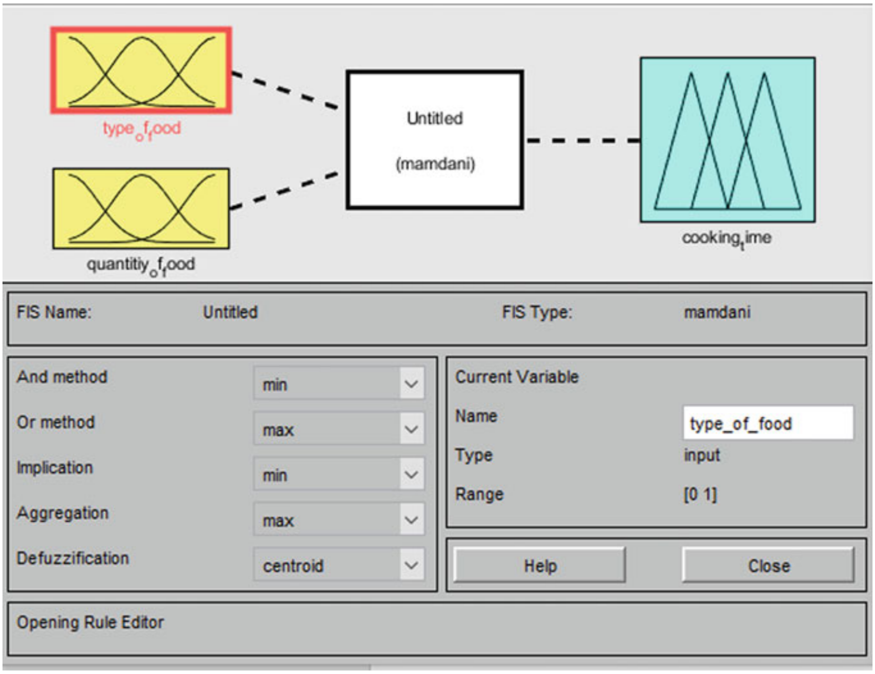

Fig. 1 Inputs and output for the model (microwave oven)

Working Principle. Fuzzy logic is already in use in the current microwave ovens. A model for automated microwave oven using intuitionistic fuzzy inference system was developed by Afsghan and Shiny Jose in their paper "Intuitionistic Fuzzy Logic Control for Microwave Ovens." Using fuzzy inputs of type of food (raw, semi-cooked, fully cooked) and quantity of food (large, medium, regular), an output regarding the cooking time of the oven (very long, long, very medium, medium, very short, short) was anticipated. Although fuzzy logic is already in practice for a microwave oven, the paper pointed out that the use of intuitionistic fuzzy will further improve the efficiency of the microwave oven [3] (Figs. 2 and 3).

3.2 *Domestic Flour Mill*

A flour mill is a machinery of the flour mill industry in which grain is converted into flour. Flour mills can be commercial as well as domestic. It takes raw wheat as input and gives edible wheat as output. In a flour mill, the wheat is passed between rollers, where it is ground into coarse particles of flour of varying sizes. These particles are

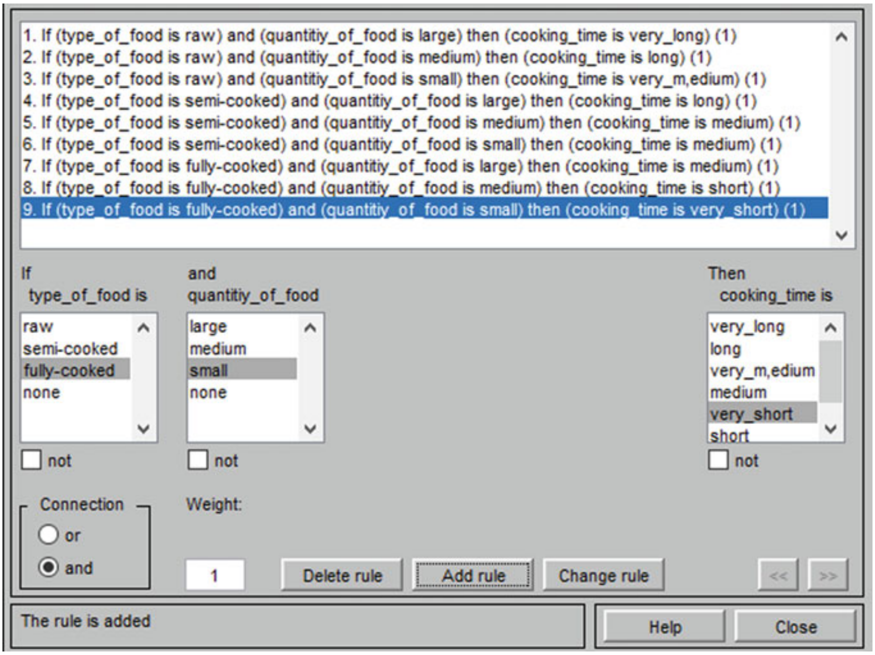

Fig. 2 If-then rules for inputs and corresponding output (microwave oven)

passed through sieves of various sizes. This process is repeated multiple times, and each time impurities are removed and flour gets finer, whiter and better in quality.

Working Principle. K. Sudha in the paper Automation of Domestic Flour Mill Using Fuzzy Logic Control proposed automation of domestic flour mill. A fuzzy logic model is proposed for the grinding process using MATLAB. Quantity (small, medium, large) and material type (soft, medium, hard) were taken as two input variables, while range (slow, intermediate, fast) is taken as an output variable. A comparison between FLC and PID controller showed that FLC gave faster response with a smaller overshoot compare to PID. This model helped in the faster and easier calculation of “range” [4].

3.3 Gas Heater

The traditional gas heater, routinely utilized for washing at home where gas and water are accessible, is a famous home machine. It fills in as follows: cool water streams into the warmer with temperature t, and stream rate u, goes through the warmth exchanger and streams out as constant boiling water with temperature t' through the heated water pipe. Right off the bat, working water pressure has a wide

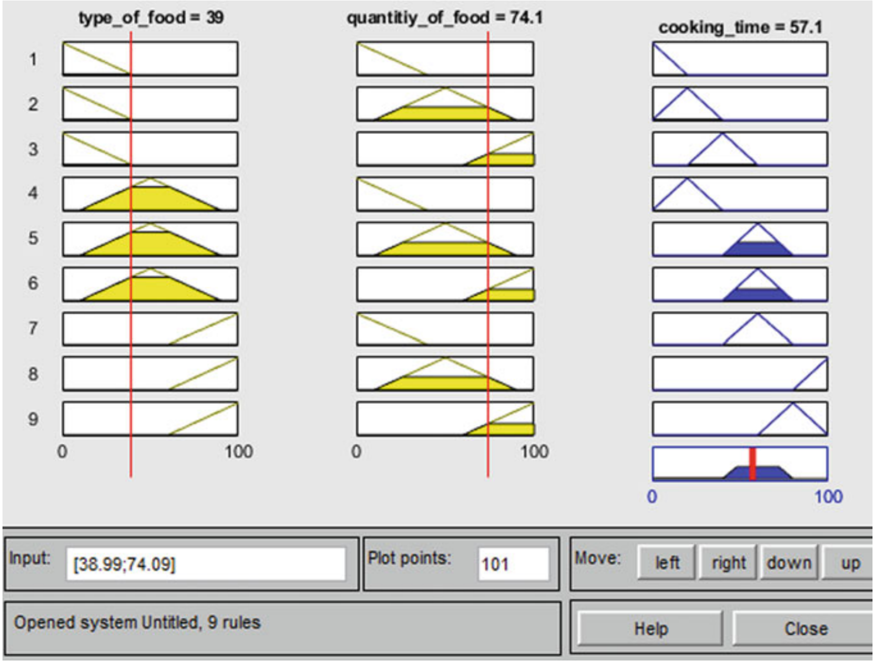

Fig. 3 Rule view of the model (microwave oven)

range. Also, the water stream rate is promptly influenced by neighboring water use, which is a major issue in urban communities of developing nations. Because of these inconsistencies, water that will turn out will have a fluctuating temperature. The absence of versatility to manage different breakdowns brought about by antagonistic working conditions has raised extraordinary issues about well-being issues.

Working Principle. In "Application of Fuzzy Logic in Home Appliance: Gas Heater Controller Design," a model dependent on the utilization of fuzzy logic alongside the PID controller was proposed. It uses temperature error and error change rate as input variables, and the open position of the gas valve was predicted as the output [5]. When analyzed against the use of only the PID controller, it gave increasingly more secure and open to washing conditions for clients with its "human brain" control approach and status checking innovation. Furthermore, the MCU enfolded in the gas warmer empowers engineers to execute a flexible and fast structure with full development highlights using contemporary innovation.

4 Extended Study: Domestic Iron

Among all domestic appliances, iron is most frequently used. Domestic iron is used to press over any fabric in order to remove its crease and wrinkles. Heat to iron plate is usually provided through coal or electricity. For domestic purpose, we consider electric iron. Electric iron has various assemblies with varying applications.

4.1 Inside Mechanism

The electric current passes through the coil present inside electric iron and raises the temp of the coil. That heat further passes to the lower plate and so pass to the clothes on pressing against it. We know that ironing is result of temperature and pressure. But overheating is an issue as it can ruin the fabric and consume energy. To avoid this, we use thermostat. A thermostat is a major component of an electric iron. As the name suggests "Thermo" means "Heat" and "stats" comes from "static", so the functioning of a thermostat is to maintain heat as constant.

4.2 Bimetallic Strip

A bimetallic strip is used in a thermostat. A bimetallic strip is a strip formed by two metal and having different coefficients of expansion, which means, on different temp, they expand by different dimensions. Both the strips are used as a component of the circuit. At normal temperature, strip stays normal and does not disturb the formation of the circuit, so the temperature can still rise. But after a particular increase when strip will encounter its expansion temperature, it starts expanding and bend toward the small pin. Small pin gets deviated and hence breaks the circuit and flow of current [6].

After some time, temperature will fall automatically, strip regain its shape. Small pin well relocates its original position and flow of current will start. Until power is switched off this cycle repeat itself.

4.3 Model Proposed

After the study of domestic iron and it's working, we proposed a model for automated domestic iron using fuzzy if-then rules. This model sets the temperature of the thermostat according to the given input parameters and hence reduces individual efforts while boosting the performance of the iron. We took the type of material, dampness of cloth and degree of wrinkles as input parameters. Type of materials

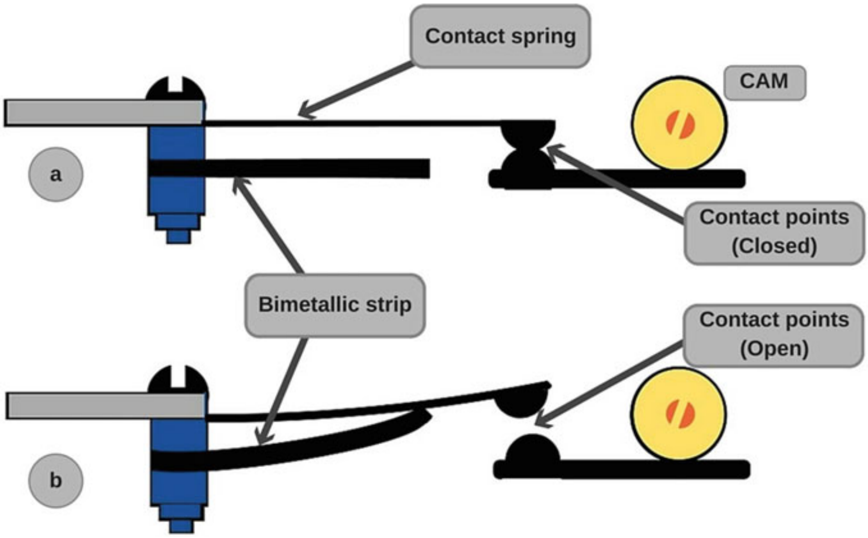

Fig. 4 **a** Under normal temperature and **b** when the iron becomes too hot

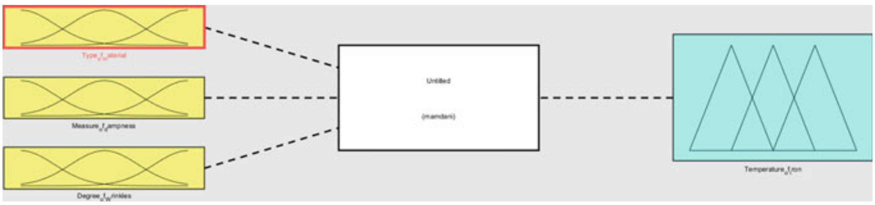

Fig. 5 Various inputs and the output of the model

used are—silk, cotton, wool. Measures of the dampness of cloth are—too moist, moist, dry and degree of wrinkles are high, low. We created a fuzzy model using MATLAB fuzzy logic toolbox and the temperature of iron is drawn as output. We draw graphs, scales and membership functions regarding how the three input parameters affect the output parameters. If a cloth has embroidery or sticky material on it, then its care has to be taken manually as done in regular iron. This model will set the temperature according to the material of the rest of the cloth piece (Figs. 4, 5, 6 and Table 1).

5 Results and Conclusion

In this paper, we made a study regarding the automation of various domestic products using fuzzy logic and its various components. These domestic products precisely include microwave oven, domestic flour mill and gas heater. Fuzzy programming by

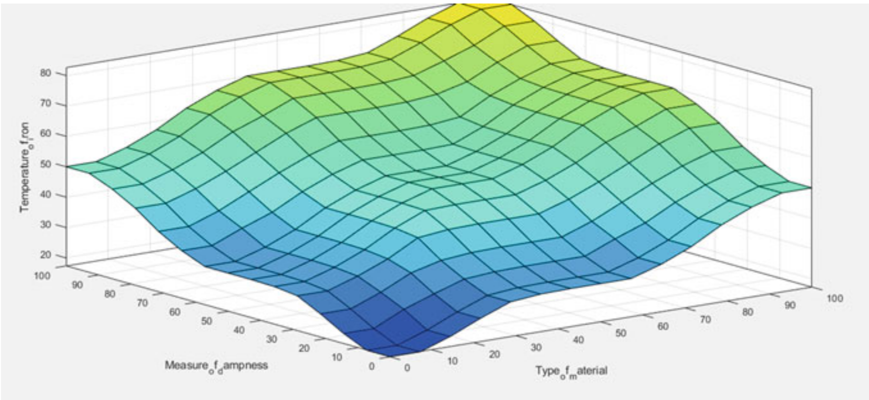

Fig. 6 A curve which portrays the relationship between various inputs and output

Table 1 Depicting rules for fuzzy model

Type of material	Dampness of cloth	Degree of wrinkle	Temperature of iron
Synthetic	Dry	Low	Very low
Synthetic	Dry	High	Low
Synthetic	Moist	Low	Low
Synthetic	Moist	High	Medium
Synthetic	Very moist	Low	Medium
Synthetic	Very moist	High	Slightly High
Wool	Dry	Low	Low
Wool	Dry	High	Medium
Wool	Moist	Low	Medium
Wool	Moist	High	Slightly high
Wool	Very moist	Low	Slightly high
Wool	Very moist	High	High
Cotton	Dry	Low	Medium
Cotton	Dry	High	Slightly high
Cotton	Moist	Low	Slightly high
Cotton	Moist	High	High
Cotton	Very moist	Low	High
Cotton	Very moist	High	Very high

the use of MATLAB fuzzy logic toolbox for different domestic products has been shown. After that, we made an extended study on domestic iron and made an attempt to propose a model for automated iron. With the help of this study, we were able to find that the use of fuzzy reduces human efforts and improvises efficiency (Fig. 7).

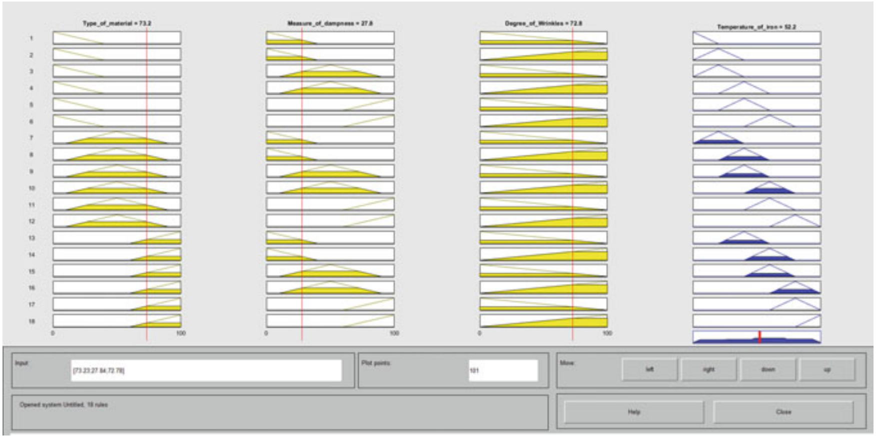

Fig. 7 Ruler representation points that at an input set of (73.2, 27.8, 72.8%) for (a type of material, a measure of dampness, degree of wrinkles), the output iron temperature is 52.2%

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