Fuzzy Logic Control of Hair Blow-Dryer

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Abstract— **In this term paper, we aim to implement fuzzy logic control to hair blow-dryers where the output air flow and temperature will be controlled automatically instead of manually. Conventional hair blow dryers have two to three discrete setting options which leads to a permanent setting to a fixed air speed and temperature for a long time. This setting leads to unnecessary power consumption. Along with being power efficient, our proposed controller will not only save the machine parts from getting damaged but will also prevent the human hairs from getting damaged because of excessive heat flow from the dryer by also considering the dampness or moisture of the hair.**

I. INTRODUCTION

Most of the hair blow-dryers are manually operated, where temperature and air flow intensity are controlled manually. We aim to implement fuzzy logic control to blow dryers where the output air flow and temperature will be automatically controlled by our fuzzy controller. Normally a simple manually operated hair dryers have discrete level intensities with only 2-3 options. When a dryer operates on such fixed intensity for a long period of time, it not only damages the machine parts and consumes more power leading to unnecessary power consumption but it also damages the hair because it doesn't take into account the amount of heat flow hairs need to get dry. Implementing a fuzzy logic controller will give suitable continuous intensities as output. The inputs will be room temperature, humidity and dampness of hair through conventional sensors taking inputs in real time. The sensors will pass the information of the inputs to the controller which will process the information according to the rule base given by us and send the output intensity to the output devices. Output devices, here, will be motor controlling the torque of the fan which will control the air flow and heater which will control the heat level being sent along with the air. For colder temperatures and high humidity, the dryers must work with higher intensity while for hot temperatures and low humidity, the dryers should send lesser intensity output. Along with that, it should also take into account the dampness of the hair. On such basis, the fuzzy rule base are created and a fuzzy controller for hair blow-dryer is designed. Being power efficient it will also address the problem of power saving. As power resources are limited, cutting power consumption requirements from such daily used appliances will help in saving power.

II. RELATED WORKS

We are far from the first to implement a fuzzy logic controller on drying automation, for instance [1], [2]. Several studies have already been made to implement these controllers in various industrial equipment's. Santos et al. [2] have studied Nonlinear Fuzzy Tracking Real-time-based Control of Drying Parameters. Their work contributed in the field of drying chemicals, food, textile etc and was developed to solve the cumbersome problem of drying raw materials in the industries. Mansor et al.[1] developed a fuzzy logic controller specifically for a grain drying plant. Our work is inspired from all of them and we extend it to develop a fuzzy controller for hair blow-dryers. To our knowledge, no previous work has been done on a hair blow-dryer with such input conditions specially considering the moisture level of hairs.

III. PRELIMINARIES

Fuzzy Logic : Fuzzy logic is the representation of how a human brain works, and that we can mimic this in machines so they will perform somewhat like humans, not to be confused with Artificial Intelligence, where the thus far unattainable goal is for machines to perform exactly like humans.Fuzzy logic is that the attempt at formalization of approximate reasoning, which is characteristic of the way during which humans reason in an environment of uncertainty and approximation. Fuzzy logic holds that each one things are a matter of degree. Fuzzy logic has been utilized in automation of industrial equipment's.

SciKit-Fuzzy : Scikit-Fuzzy is a collection of fuzzy logic algorithms pledged for use in the SciPy Stack and is written in the Python computing language. This package contains many useful tools and functions for computation and projects involving fuzzy logic. There are various basic fuzzy logic functions in the base namespace, as well as a Pythonic, object-oriented system for fuzzy control systems in the skfuzzy.control submodule.

Directional coupler sensor for measuring moisture of hair : A sensor[3] used for measuring the moisture content of hair developed by Faiz Feisal Sherman, Vladimir Gartstein, Kendal William Kerr, Herman William Meyer and Jim Allen Mccurdy.

IV. System Design

A. Fuzzy Logic Controller

Fig. 1 illustrates the simple block diagram of fuzzy logic controller. The current sensor value of room temperature, humidity and moisture of hair is send to fuzzyfication from the input. In the analysis part, we apply fuzzy arithmetic and criterion on the input variables with certain rules. Then, at the final stage results are defuzzyfied to yield the following output results as fan-speed and heating coil temperature.

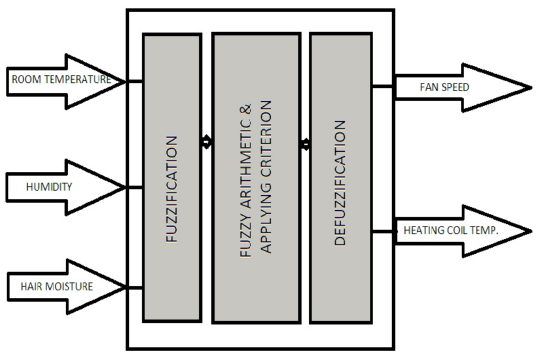

Fig. 1. Block diagram of Fuzzy Logic Controller

B. System Parameter and Fuzzy Rules

The input and output parameters of out fuzzy logic controller are defined as in Table I and Table II respectively. The column titled as Status in TABLE I presents different conditions of the room temperature, humidity and moisture levels which accordingly represent various changes in the surrounding environment. Accordingly, a set of twenty-two fuzzy rules is used in this study. The rules are set to change the output parameters according to the different conditions of input parameter.

TABLE I : INPUTS PARAMETERS

Parameters	Status	Units
Room-Temperature	Low, Moderate, High	0-60°C
Humidity	Very-low, Low, Moderate, Humid, Very-humid	20-80
Hair moisture	Almost dry, Less wet, Moderately wet, Wet, Very wet	0-100%

TABLE II : OUTPUT PARAMETERS

Parameters	Status	Units
Fan Speed	Very-slow, Slow, Average, Fast, Very-fast	4000-6000 rpm
O/P power to heating coil	Normal, Hot, Very-hot	1500-2000 watt

C. Input and Output parameters

In this section we will discuss about the membership function and the input and output parameters range values. Considering the input parameters, "Room-temperature" takes the current room-temperature in degree Celsius and have a triangular membership function where status "low" ranges between 0 to 40°C with peak value at 0°C, "Moderate" ranges between 0 to 60°C with peak value at 20°C and "High" ranging between 40 to 60with peak value at 60°C. Parameter "Humidity" takes the input relative humidity in percentage and is equal to the the ratio of water vapor currently in the air to the maximum water vapor at that temperature, multiplied by 100 and thus ranges between 20 to 80 and have an auto triangular membership function. Current Moisture value of the human hair is taken between 0 to 100% and also have an auto triangular membership function same as humidity.

Looking at the output parameters, fan speed ranges between 4000 to 6000 rpm having an auto triangular membership function uniformly distributes across the range. Output power to heating coil is in watt and have a triangular membership function where status "Normal" ranges from 1500 to 1600 Watt with peak at 1500 watt, "Hot" ranges from 1500 to 2000 watt with peak at 1800 watt and "Very-hot" ranging from 1600 to 2000 watt with peak value at 2000 watt.

V. SYSTEM SIMULATION

The results of this intelligent hair dryer is simulated using the Scikit-Fuzzy library written in python. At first the Antecedent and Consequent objects hold the universal variables and membership function an then skfuzzy is used to define the membership function by defining the start, peak and end values for each input parameters.

A. Membership Functions :

Membership functions for the input parameters room-temperature, humidity and moisture can be visualised in the Fig. 2, Fig. 3 and Fig. 4 and membership functions for output parameters fan-speed and output voltage to heating coil can be visualised in Fig. 5 and Fig.6 respectively.

B. Rule Base

Fig. 7 shows the rule base defined by us. With the help of these twenty-two rules, values of output parameters varies accordingly to the input values of input parameters provided by the sensors.

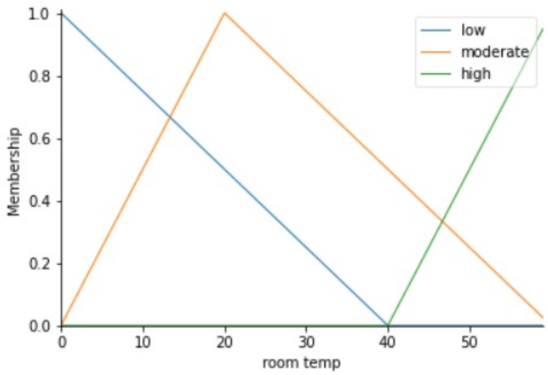

Fig. 2. Membership function for Room-temperature

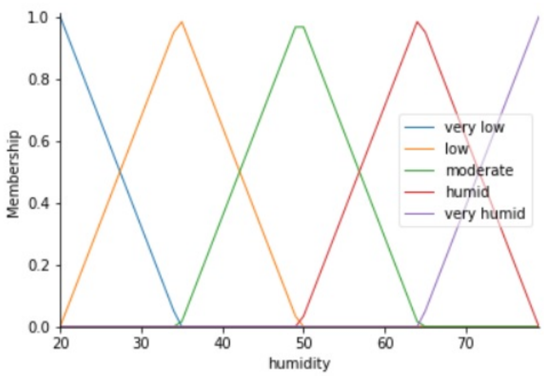

Fig. 3. Membership function for Humidity

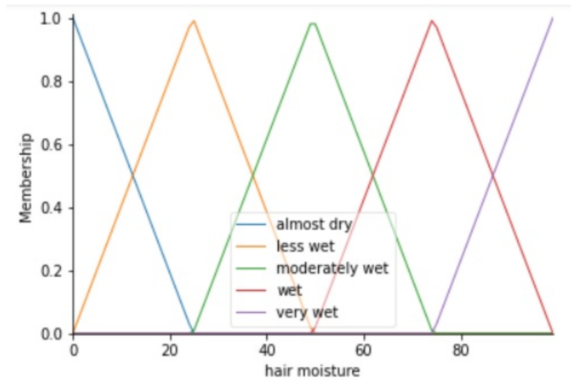

Fig. 4. Membership function for Moisture in hair

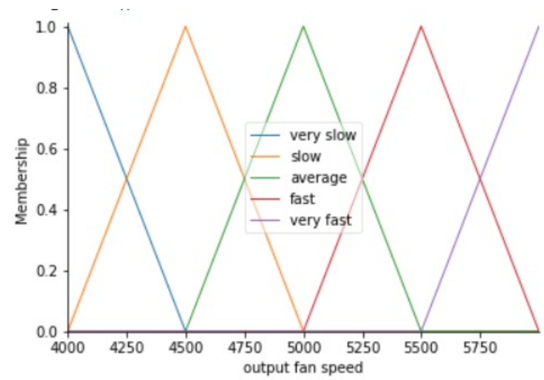

Fig. 5. Membership function for Fan-Speed

VI. Results and Discussions

Once the fuzzy logic controller for the hair blow-dryer is setup, we considered three test cases for input parameters.

Test case 1: Extremely Less Power Requirement
Input: Room temperature(60°C), Humidity(20), Hair Moisture(0%)
Output: Fan speed(4457.52 rpm) , Output power(1577.33 watt)
Analysis: We observe for hot temperature, low humidity and Moisture content, the hair-dryer should send lesser intensity output therefore fan is rotating at a low speed and thus output power is also low. See Fig. 8.

Test case 2: Average Power Requirement
Input: Room temperature(35°C), Humidity(50), Hair Moisture(60%)
Output: Fan speed(5281.32 rpm) , Output power(1780.07 watt)
Analysis: We observe for average temperature, humidity and Moisture content, the hair-dryer should send average intensity output therefore fan is rotating at an average speed and thus output power consumption is also average. See Fig. 9.

Test case 3: High Power Requirement
Input: Room temperature(10°C), Humidity(60), Hair Moisture(100%)
Output: Fan speed(5603.36 rpm) , Output power(1812.78 watt)
Analysis: We observe for low temperature, with high humidity and Moisture content, the hair-dryer should send high intensity output therefore fan is rotating on a high speed and thus output power consumption is also high as expected. See Fig. 10.

Analysing all the three test cases, we arrive on a conclusion that the designed Fuzzy Logic Controller is working as expected, that is for colder temperatures and high humidity, the dryer must work with higher intensity while for hot temperatures and low humidity, the dryer should send lesser intensity output.Along with that the controller also take into account the moisture content of human hair and adjust the fan speed and heating of coil accordingly. The designed hair-dryer not only possess the decision making capabilities of a human but also is power efficient, thus saving an ample amount of power.

VII. Conclusions and Future Work

In this term paper, we have tried to design a fuzzy logic controller for an eco-friendly hair blow-dryer. The performance of the controller is simulated using Scikit-Fuzzy library. The proposed controller is smart enough to control the output parameters, fan speed and output power of heating

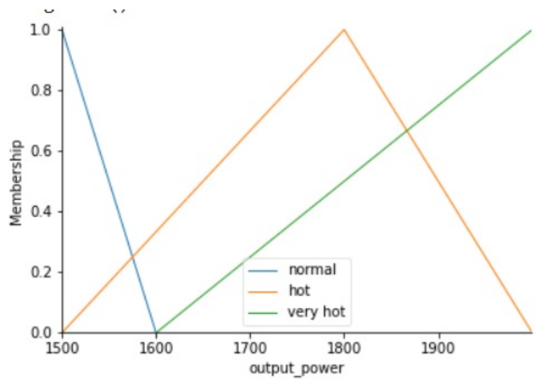

Fig. 6. Membership function for Output power to Heating Coil

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rule1 = ctrl.Rule(room_temp['low'] , fan_speed['very fast'])
rule2 = ctrl.Rule(room_temp['moderate'] , fan_speed['fast'])
rule3 = ctrl.Rule(humidity['very low'], fan_speed['very slow'])
rule4 = ctrl.Rule(humidity['very humid'],fan_speed['very fast'])
rule5 = ctrl.Rule( humidity['moderate'],fan_speed['fast'])

rule6 = ctrl.Rule(room_temp['low'] , op_watt['very hot'])
rule7 = ctrl.Rule(room_temp['moderate'] , op_watt['hot'])
rule8 = ctrl.Rule(humidity['very low'], op_watt['normal'])
rule9 = ctrl.Rule(humidity['very humid'],op_watt['very hot'])
rule10 = ctrl.Rule( humidity['moderate'],op_watt['hot'])

rule11 = ctrl.Rule( hair_moisture['very wet'],op_watt['very hot'])
rule12 = ctrl.Rule( hair_moisture['wet'],op_watt['very hot'])
rule13 = ctrl.Rule( hair_moisture['moderately wet'],op_watt['hot'])
rule14 = ctrl.Rule( hair_moisture['less wet'],op_watt['hot'])
rule15 = ctrl.Rule( hair_moisture['almost dry'],op_watt['normal'])

rule16 = ctrl.Rule( hair_moisture['very wet'],fan_speed['very fast'])
rule17 = ctrl.Rule( hair_moisture['wet'],fan_speed['fast'])
rule18 = ctrl.Rule( hair_moisture['moderately wet'],fan_speed['average'])
rule19 = ctrl.Rule( hair_moisture['less wet'],fan_speed['slow'])
rule20 = ctrl.Rule( hair_moisture['almost dry'],fan_speed['very slow'])

rule21 = ctrl.Rule( room_temp['high'],fan_speed['slow'])
rule22 = ctrl.Rule( room_temp['high'],op_watt['normal'])
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Fig. 7. Rule Base

coil by sensing the indoor environment and hair moisture and providing the output which is actually needed and not just a discrete set of output values. Considering the existing temperature, humidity of the room and the hair dampness value, the proposed fuzzy controller achieves a better control performance and self-adaptability character. Therefore, we can say that the efficiency of the system can be easily improved by manipulating the parameters of the intelligent hair blow-dryer system.
The sensor we have mentioned for measuring the hair dampness or hair moisture shall be somehow connected to human hair via a hairbrush to provide the current values of hair moisture to the fuzzy logic controller as input. Future work may include developing a sensor that can sense moisture level of hair from a distance and the that sensor can be attached at the head of hair blow-dryer to provide better

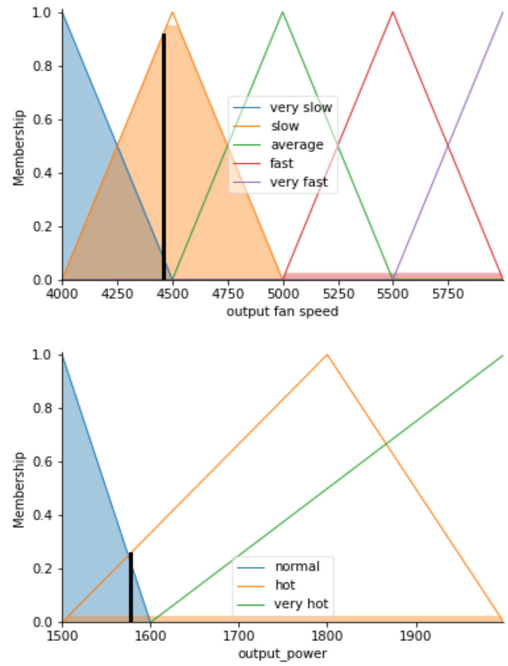

Fig. 8. Result of Test case 1

mobility.

VIII. ACKNOWLEDGEMENT

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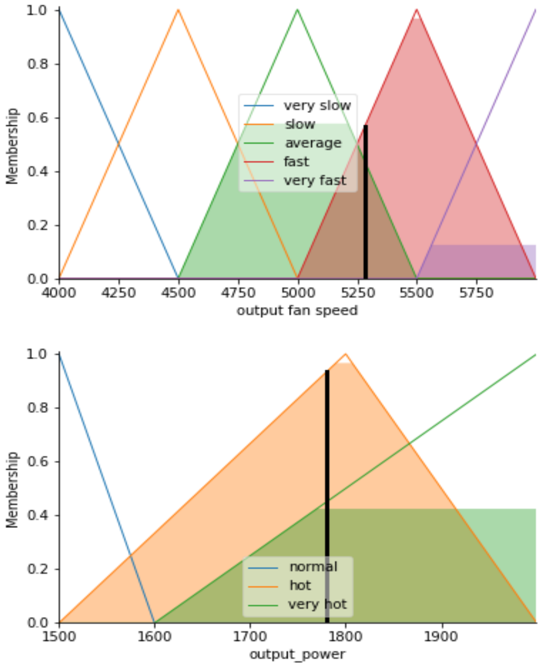

Fig. 9. Result of Test case 2

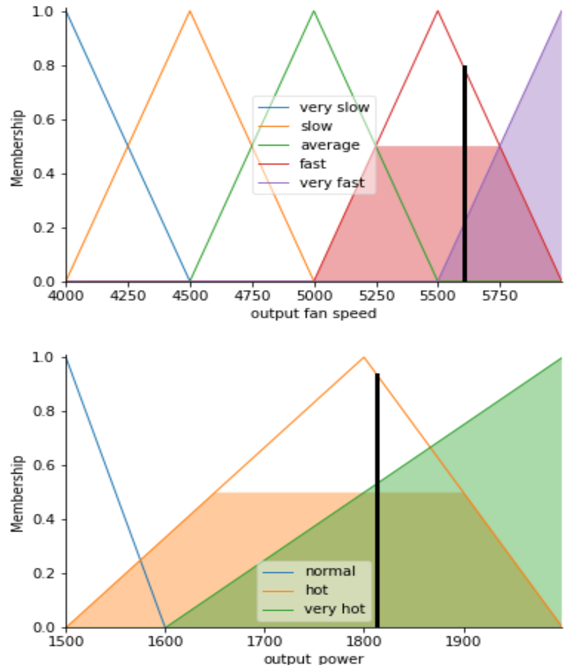

Fig. 10. Result of Test case 3