EFFECT OF LIFESTYLE AND PHYSIOLOGICAL FACTORS OF THE HUMAN BODY ON THE BLOOD PRESSURE BY USING FUZZY LOGIC

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Abstract

The objective of this study was to determine the effect of lifestyle and physiological factors of the body on the blood pressure. The lifestyle of a person includes exercise, smoking, alcohol consumption and stress. These factors where analysed along with body mass index, age of the person and mean arterial pressure. By considering these factors a fuzzy expert system was developed by using the mathematical tool of Fuzzy Logic. In this system Mamdani model was considered and the programming was done by using MATLAB R2007a software. This system helps in predicting the blood pressure by considering the factors which can affect it.

1. Introduction

The problem of blood pressure is an extremely common disease, affecting approximately 1 billion people worldwide [1]. The Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure (JNC-7), defined a new entity, "pre-hypertension," to reflect the growing evidence that systolic blood pressure (SBP) values between 120 and 139 mm Hg and diastolic blood pressure (DP) values between 80 and 89 mm Hg are associated with increased cardiovascular risk [2]. It is estimated that an additional 30% of the adult population fall into this category [3].

Since the problem of blood pressure and cardiovascular diseases are a leading cause of morbidity and mortality in many countries and atherosclerotic risk factors, such as hypertension, smoking and alcohol, represent significant predictors for several cardiovascular diseases therefore examining these risk factors can efficiently reduce the risk associated with blood pressure and cardiovascular diseases [4,5] Evidence indicates that the problem of blood pressure in accordance with cardiovascular diseases can be viewed as a predictable and preventable disease.[6–8] However, the relative importance of the risk factors varies with lifestyle such as smoking, exercise, alcohol, stress and other factors which affects the blood pressure such as height, weight, age etc. Exercise plays an important role in alternating the blood pressure[11-14]. Blood pressure also varies with age.[15-21] This indicates that there is a certain degree of fuzziness in predicting the values of blood pressure as it depends upon many factors stated above.

Fuzzy logic is a computational paradigm that provides a mathematical tool for representing and manipulating information in a way that resembles human communication and reasoning processes (Yager & Zadeh, 1994). It is based on human reason of approximation. It differs from the traditional logic methods where crisp or exact results are expected. The concept of fuzzy logic was first put forth by Zadeh [9]. Fuzzy Logic is used in problems where the results can be approximate rather than exact. Hence, the results are determined by some degree of closeness to true or to false. Fuzzy set theory, which was developed by Zadeh [9], makes it possible to define inexact medical entities as fuzzy sets. It provides an excellent approach for approximating medical text. Furthermore, fuzzy logic provides reasoning methods for approximate inference. It has also been used in the biological and agricultural systems (Center & Verma, 1998). According to Guler, Hardalac and Barisci (2002) fuzzy logic is a functional method to determine the type of cardiac diseases. Depth of anesthesia can be predicted using fuzzy logic (Allen & Smith, 2001; Elkfafi, Shie, Linkens, & Peacock, 1997; Muthuswamy & Roy, 1999; Zhang & Roy, 2001). Data from different tools/methods such as ultrasonography, GCS and EEG can be used to develop models using fuzzy logic (Amin & Kulkarni, 2000; Guler et al., 2002; Muthuswamy & Roy, 1999; Zouridakis, Jansen, & Boutros, 1997).

The reading of blood pressure and the various other factors such as lifestyle, physical parameters of the body, can give information about the long term effect or severity of the blood pressure which can help in predicting cardiovascular diseases. Therefore according to this study an effort has been made in developing a diagnostic system for predicting the severity of the blood pressure by considering the factors affecting it, using the fuzzy logic.

1.1 Fuzzy Expert System

In FES model (Fig.1), the input and output values of the system are crisp values. In the fuzzification subprocess, the membership functions defined on the input variables are applied to their actual values, to determine the degree of truth for each rule premises. In the inference subprocess, the truth value for the premises of each rule is computed, and applied to the conclusion part of each rule. This results in one fuzzy subset to be assigned to each output variable for each rule. Sometimes, it is useful to just examine the fuzzy subsets that are the results of the composition process, but more often; this fuzzy value needs to be converted to a single number crisp value. This is what the defuzzification subprocess does.

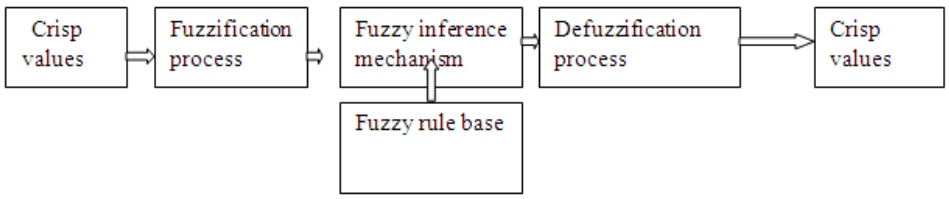


Fig.1 Fuzzy expert system

2. MATERIALS AND METHODS

Data from different hospitals were collected and were used as study group. 25 patients in different age groups were questioned and monitored for this study. The factors which were considered for this study were :-

1. Mean Arterial Pressure (MAP) :- Low, Normal, High
2. Body Mass Index :- Underweight, Normal, Overweight
3. Age :- Young, Adult, Middleaged, Old
4. Stress :- 1(Low), 2(Medium), 3(High)
5. Alcohol :- 1(Low), 2(Medium), 3(High)
6. Smoking level :- 1(Low), 2(Medium), 3(High)
7. Exercise level :- 1(Low), 2(Medium), 3(High)

Different patients in the age group of 10 to 80 were monitored and the Mean Arterial Pressure (MAP) was calculated by using the following expression:-

$$\mathbf{MAP = DP + 1/3(SBP - DP)}$$

Ideal mean arterial pressure is found to be 93 mm of Hg. The body mass Index of each patient was calculated and they were questioned about smoking habit, alcohol consumption, exercise and stress. The record of each patient was analyzed and was used for this study. These factors were considered and fuzzy logic algorithm was performed by using MATLAB R2007a software where Fuzzy Inference System (FIS), Mamdani model was used. The work was done in two parts. First by considering the factors of stress, alcohol, smoking, exercise in the form of input of fuzzification and life style as an output. Secondly by using Lifestyle as input of fuzzification along with Mean Arterial Pressure (MAP), age and body mass index

The general structure of fuzzy expert system is shown in Fig.2

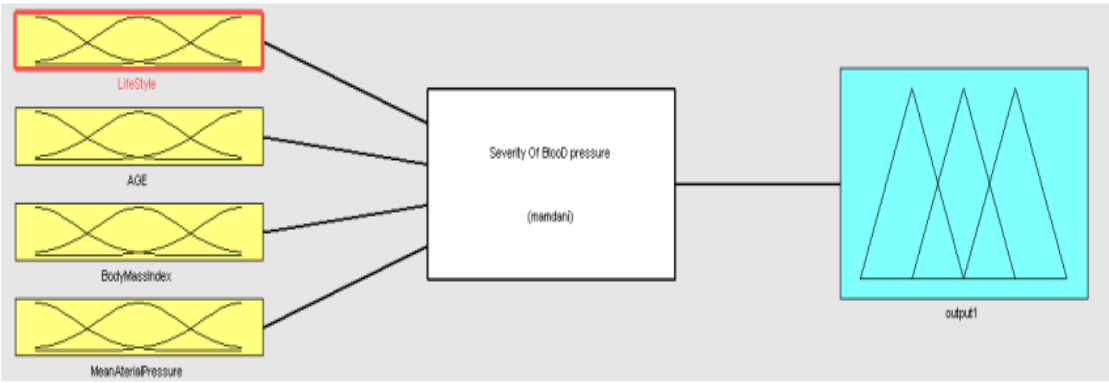
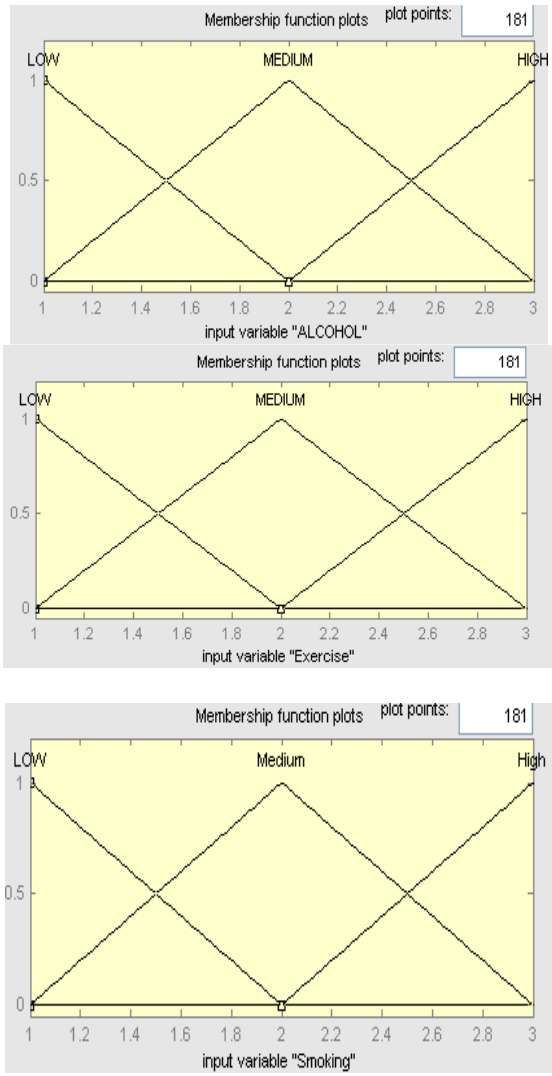


Fig 2. Fuzzy expert system by MATLAB R2007a

2.1. Fuzzification process

Multiple measured crisp inputs first have to be mapped into fuzzy membership functions. This process is called fuzzification (Guler et al., 2002). A trapezoid and triangular shapes were preferred to define fuzzy membership functions. The ranges of the input and the output with their membership function are shown in Fig 3.



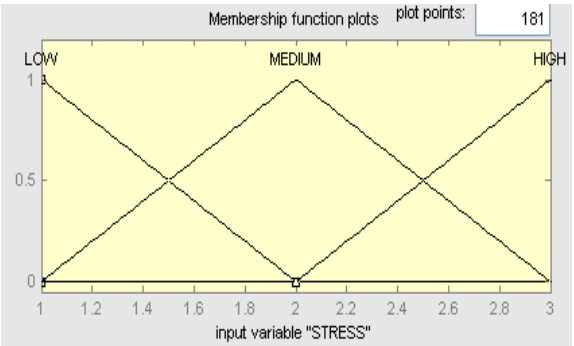


Fig. 3 Input of Fuzzification of Lifestyle

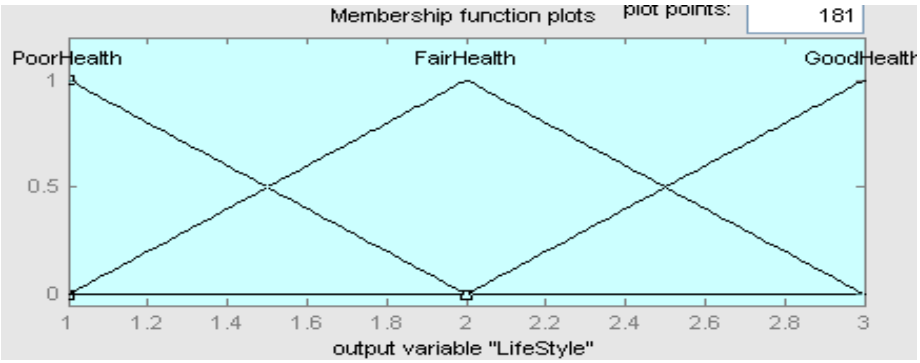
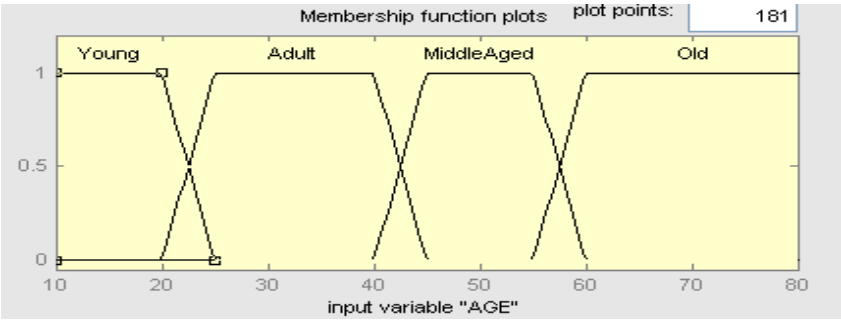
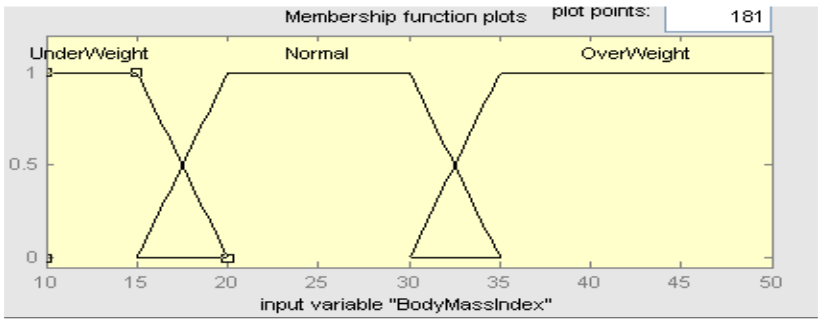


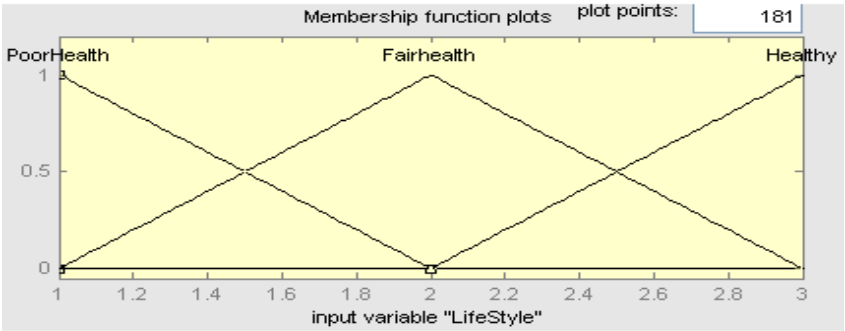
Fig. 4 Output of Lifestyle



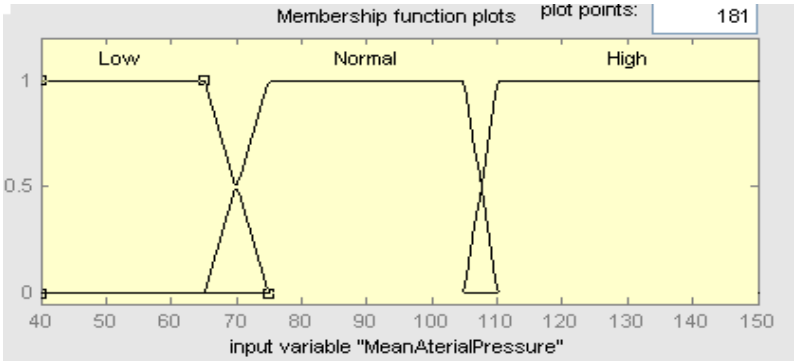
First input: AGE



Second input: BMI



Third input: Lifestyle



Fourth input: MAP

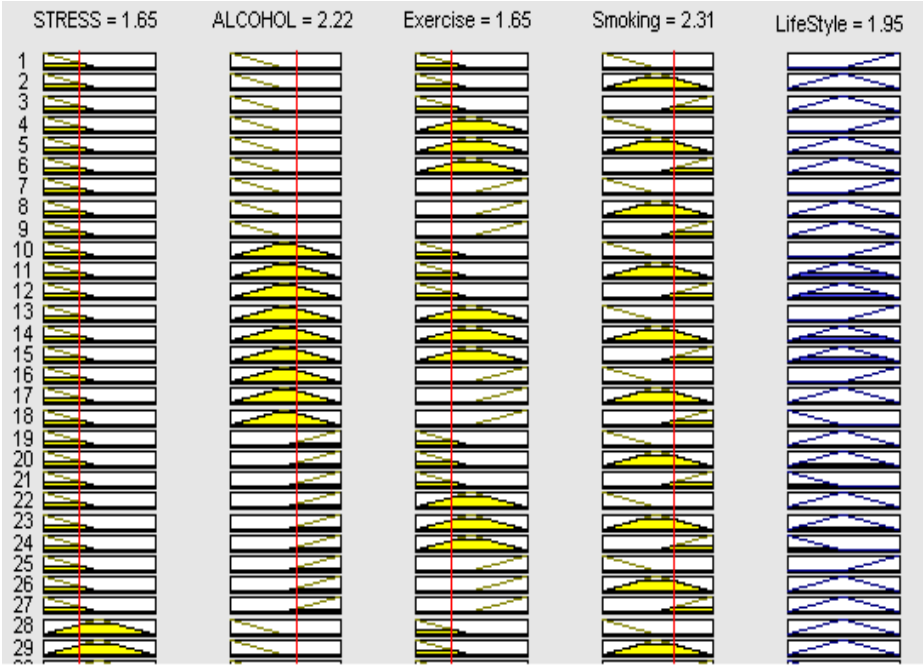
Fig 5. Final Inputs of Fuzzification

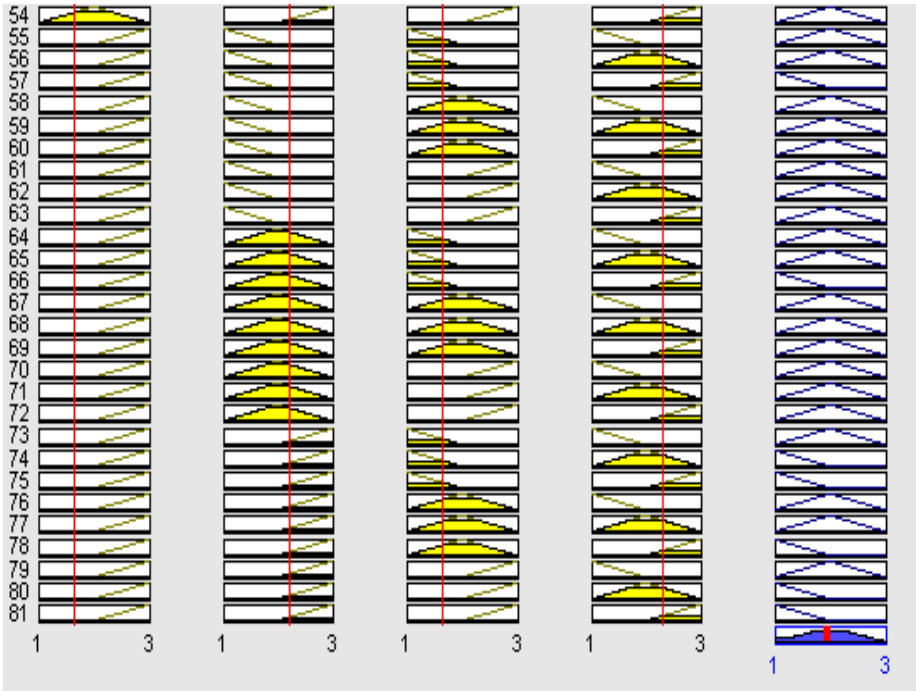
2.2. Fuzzy inference

The second step in fuzzy logic processing is fuzzy inference. A rule base was formed by consulting the experts and cardiologists. Rule base was the range of rules, which consists of outputs of fuzzification corresponding different inputs. Rule base was formed by consulting the experts. Five linguistic outputs were used in the rule base. Relations obtained from the rule base

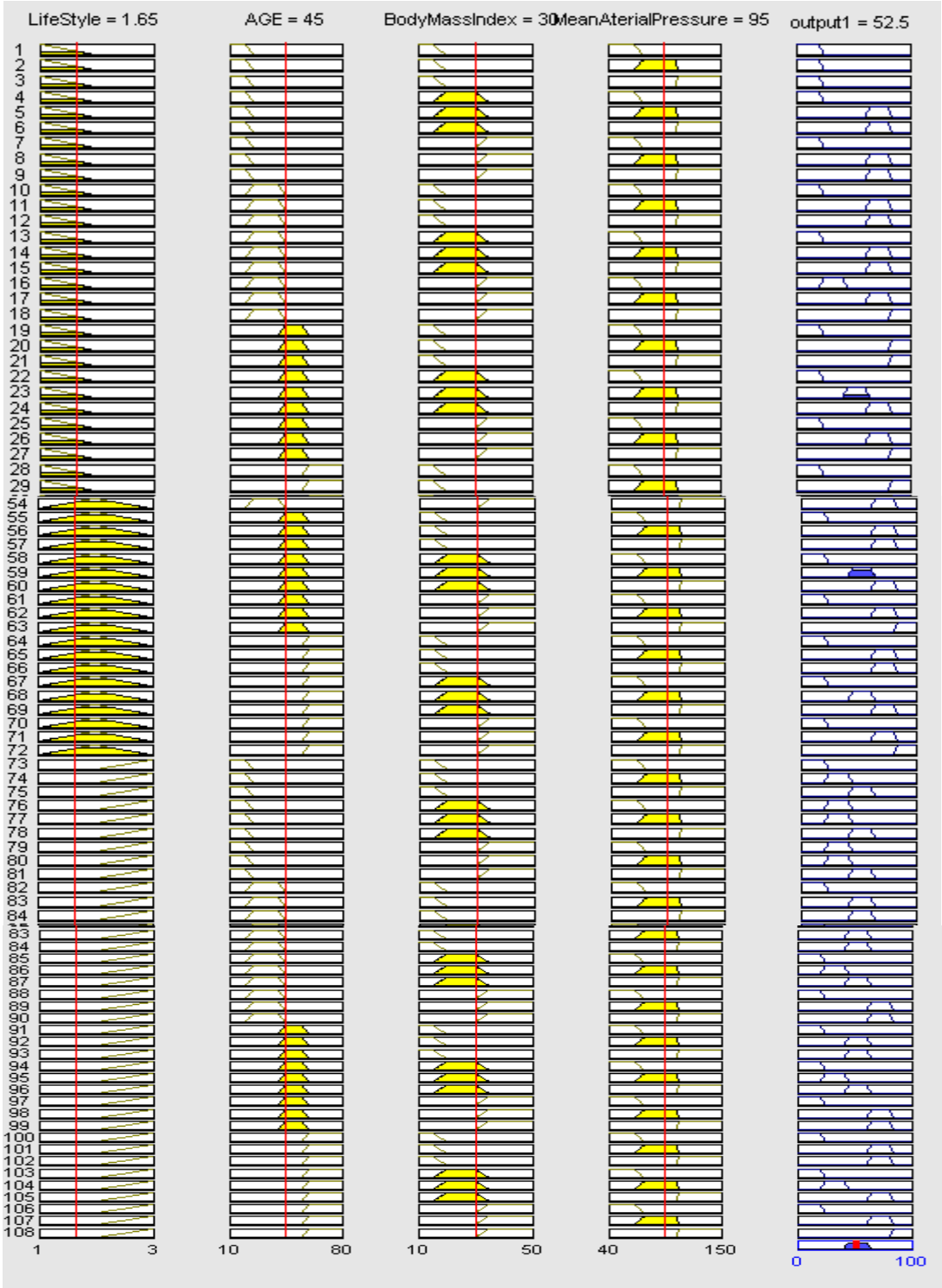
were interpreted using minimum operator, “AND”. The outputs obtained from rule base were interpreted using maximum operator, “OR”.

Rule base for finding Lifestyle





Rule base for output of Severity of Blood pressure



2.3. Defuzzification

The outputs of the inference mechanism are fuzzy output variables. The fuzzy logic controller must convert its internal fuzzy output variables into crisp values so that the actual system can use these variables. This conversion is called defuzzification (Guler et al., 2002). One may perform this operation in several ways. One of the most common ways is the use of height method. In this method, the centroid of each membership function for each rule is first evaluated. The final output COG, is then calculated as the average of the individual centroid, weighted by their heights as follows:

$$\mathbf{COG=\sum \mu(x).x/\sum \mu(x)}$$

where COG is defuzzification output and $\mu_A(x)$ is minimum/ maximum value of membership degree of input values. The output membership functions were converted into five linguistic variables which were between 0 and 100.

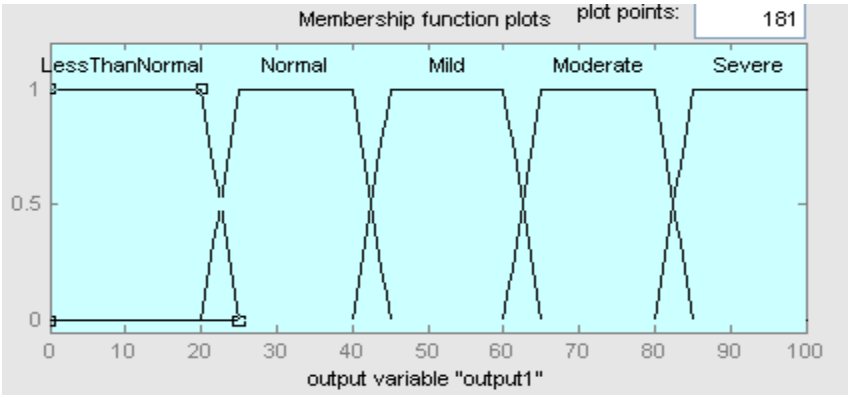


Fig 6. Output

3. RESULT

By considering the factors of lifestyle (smoking, exercise, stress and alcohol consumption), age, Body mass index and Mean arterial pressure the following output is obtained by utilizing the mathematical tool of fuzzy logic. The result shows that the output of blood pressure is found to be:-

Low or less than normal when the output is in the range of 0 to 22
Normal, when the output is in the range of 22 to 42
Mild, when the output is in the range of 42 to 62
Moderate, when the output is in the range of 62 to 82
Severe, when the output is the range of 82 to 100

4. DISCUSSION AND CONCLUSION

In this study FES is used to determine the effect of lifestyle and physiological factors of the human body in determining the blood pressure. As the lifestyle plays an important role such as smoking, alcohol, exercise, stress. Smoking, alcohol consumption and stress can increase the risk of blood pressure therefore this system will helps in predicting which can leads to controls of these factors in maintaining healthy lifestyle of a person. From this study it is also found that exercise is also an important factor for the health of a person. The various exercise levels which is used in this study can also help in predicting the health of a person to maintain blood pressure in normal condition. The physical parameters of the body such as body mass index and age can also affect the person's blood pressure

S.No	LifeStyle	AGE	BMI	MAP	OUTPUT	Severity
1	1	45	30	95	52.5	Mild
2	1	24	25	80	72.5	Moderate
3	3	52	48	93	11	Low
4	2	36	33	76	62.8	Mild
5	1	46	23	131	72.5	Moderate
6	2	40	29	129	56.5	Mild
7	3	70	24	125	72.5	Moderate
8	2	53	26	83	52.2	Mild
9	1	69	34	73	54.1	Mild
10	2	31	40	100	72.5	Moderate
11	3	25	25	93	32.5	normal
12	3	30	28	70	21.6	Normal
13	2	15	30	90	32.5	Normal
14	3	20	24	88	32.5	Normal
15	2	30	40	100	72.5	Moderate
16	1	40	20	120	72.5	Moderate
18	1	18	15	70	11.6	low
20	3	40	30	90	32.5	Normal
21	1	18	15	50	11	low
22	3	20	30	100	32.5	Normal
23	2	50	28	140	72.5	Moderate
24	3	24	40	88	63.6	Moderate
25	1	25	25	93	32.5	Normal

REFERENCE

[1] World Health Report 2002, Reducing Risks, Promoting Healthy Life. Geneva, Switzerland: World Health Organization, 2002. Available at: http://www.who.int/whr/2002. Accessed June 12, 2006.

[2] Chobanian A.V, Bakris G.L, Black H.R, et al. The Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and treatment of High Blood Pressure: the JNC-7 report. JAMA 2003; int national committee guidelines: new challenges of the old problem. Arch Intern Med 2004; 164: 2126 –34.

[3] Cleroux J, Kouame´ N, Nadeau A, Coulombe D, Lacourciere Y. Aftereffects of exercise on regional and systemic hemodynamics in hypertension. Hypertension 1992; 19: 183–91.

[4] Grundy S.M., Balady G.J, Criqui M.H., Fletcher G., Greenland P., Hiratzka L.F., et al. Primary prevention of coronary heart disease: guidance from Framingham: a statement for healthcare professionals from the AHA Task Force on Risk Reduction, American Heart Association. Circulation1998; 97: 1876–87.

[5] Dyken M.L., Wolf P.A., Barnett H.J.M., Bergan J.J., Hass W.K., Kannel W.B., et al. Risk factors in stroke: A statement for physicians by the subcommittee on risk factors and stroke of the stroke council. Stroke 1984; 15: 1105–11.

[6] Multiple Risk Factor Intervention Trial Research Group, Multiple risk factor intervention trial. Risk factor changes and mortality results, JAMA 1982; 248: 1465–77.

[7] Multiple Risk Factor Intervention Trial Research Group. Mortality after 16 years for participants randomized to the Multiple Risk Factor Intervention Trial. Circulation 1996; 94: 946–51

[8] Qizibash N, Lewington S, Duffy S, Peto R. Cholesterol, diastolic blood pressure, and stroke: 13,000 strokes in 450,000 people in 45 prospective cohorts. Prospective studies collaboration. Lancet 1995; 346: 1647–53.

[9] Zadeh L,A. Fuzzy sets. Information and Control 3: 1965; 338-53.

[10] Cleroux J, Kouame´ N, Nadeau A, Coulombe D, Lacourciere Y. Aftereffects of exercise on regional and systemic hemodynamics in hypertension. Hypertension 1992; 19: 183–91.

[11] Pescatello L.S., Fargo A.E., Leach C.N., Scherzer H.H., Short-term effect of dynamic exercise on arterial blood pressure. Circulation 1991; 83: 1557–61.

[12] Hagberg J.M, Montain S.J, Martin W.H, Blood pressure and hemodynamic responses after exercise in older hypertensives. J Appl. Physiol. 1987; 63:270–6.

[13] Kauffman F.L, Hughson R.L, Schaman J.P. Effect of exercise recovery blood pressure in normotensive and hypertensive subjects. Med Sci. Sports Exercise 1987; 19: 17–20.

[14] Bilato C., Crow M.T. Atherosclerosis and the vascular biology of aging. Aging 1996; 8: Quinn T.J. Twenty-four-hour ambulatory blood pressure responses following acute exercise: impact of exercise intensity. J Hum Hypertens 2000; 14:547–53221–34.

[15] Kroeker E.J, Wood E.H. Comparison of simultaneously recorded central and peripheral arterial pulses during rest, exercise and tilted position in man. Circ Res 1955; 3: 623–32.

[16] Ebert T.J, Morgan B.J, Barney J.A, Denahan T., Smith J.J. Effects of aging on baroreflex regulation of sympathetic activity in humans. Am J Physiol 1992; 263: H798–803.

[17] Taylor-Tolbert NS, Dengel D.R, Brown M.D, et al. Ambulatory blood pressure after acute exercise in older men with essential hypertension. Am J Hypertens 2000; 13: 44–51.

[18] Bloomfied D, Maurer M, Bigger J.T.,Effects of age on outcome of tilt-table testing. Am J Cardiol 1999; 83: 1055–8.

[19] Pahor M, Guralnik J.M, Corti M.C, Foley D.J, Carbonin P, Havlik R.J. Long-term survival and use of antihypertensive medications in older persons. J Am Geriatr Soc 1995; 3: 1191–7.

[20] Staessen J, Thijs L, Fagard R, et al. Predicting cardiovascular risk using conventional vs. ambulatory blood pressure in older patients with systolic hypertension. Systolic Hypertension in Europe Trial Investigators. JAMA 1999; 282: 539–46.

[21] Pescatello L.S., Fargo A.E., Leach C.N., Scherzer H.H., Short-term effect of dynamic exercise on arterial blood pressure. Circulation 1991; 83: 1557–61.