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The Prediction of the Critical Condition for a Weak Entity Using Fuzzy System

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Abstract: There is huge technological advancement in India in most of the sectors. Security of the woman is always a crucial factor. Only few percentages of the woman harassment cases are reported, out of happened. Looking at harassment statistics in the year 2021, we can say they are unable to ask for help and not able to use the facility. The reason can be woman can't take any action manually whenever they able to recognize the critical condition, may be due to mental pressure. Currently electronic gadgets like smart watches are available in the market, which keep on measuring body parameters runtime. These observations can be used to identify the critical condition automatically. The challenge is changes in the body parameters during critical conditions cannot be monitored. Machine learning technique fuzzy system is proposed here to analyse the body parameters recorded. It ignores the normal condition based on the dataset feed and predict abnormal condition.

Keywords: *Machine Learning (ML), Body parameters, Critical condition, Woman, Security.*

1. Introduction

After observing the crime rate in India for the year 2021, provided by Statista [1] we can say that the crime rate is increasing in India, city wise counts are shown in fig 1.

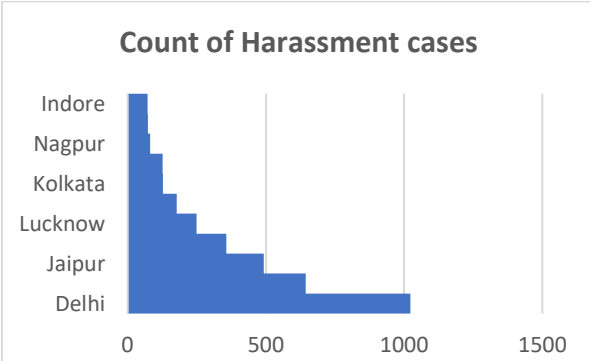

Fig. 1. Women harassment cases-2021 in major cities in India

According to a survey in 2019, India ranked highest in the list of dangerous countries for women. All concerned reports are published by government. Government also has provision for providing security to woman, like help lines. Mobile applications are also available through which woman can notify the people who can help them. But this advancement in the technology not able to help in reducing this count of woman harassment cases. Weak entities like woman not able to take corrective action. One of the reasons can be they can't have that presence of mind in such a situation.

When someone is in a critical situation it can be sensed by the mind as well as through the body. When human beings are afraid of something few body parameter values get changed as compared to the values observed regularly. Usually, smart devices measure the body parameters like temperature, Oxygen level, pulse rate etc. The normal ranges for such parameters are well known, can be verified from any physician. These ranges vary a little bit according to age group and whether a person is disease free or suffering from any disease.

Supervised machine learning technique needs the labelled dataset as input. If the dataset belongs to a particular group of entities, then it works (predict or classify or recommend) accurately for the entity belongs to the respective group only. So once the labelled dataset of the same group of people is available, we can easily identify the critical condition using ML. In case critical condition identified, it can be notified further automatically through the smart devices to the concerned persons. Concerned people can help to avoid the consequences.

2. Literature Survey

As per the statistics woman harassment cases in metro cities like Delhi, Mumbai is more [1], where the people are more used to with smart devices, aware of facilities. Women are less safe and face numerous security-related difficulties in the modern world. They must endure a variety of trying circumstances and consistently demonstrate their mental under pressure [2]. Even if there are already several security

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measures in place, demand for cutting-edge smart security systems is rising. For solving the problems, a complex

security system for women has put in place. This study describes a secure and safe electronic system for ladies. Every female today worries most about their safety and security in the modern society. A woman had to use the social system (social media) a few years ago to express her outrage and warn others about the sexual harassment they had experienced [3].

There are some websites available for women's safety. Online self-defense points for ladies seek to familiarize them with fundamental self-defense techniques which can help in a crisis. An objective is assisting girls in creating a good plan before something occurs [4]. Similar websites available are suite101.com, Safetyforwomen.com.

Software applications (App) are also available for security measures. This is all in one women's security app called 112 India, which is used for sending an SOS (Save Our Souls) warning by tapping a single button in any circumstance [5], here user need to tap a button. My Safetipin is the App which will inform your loved ones if you take the wrong route, it enables you to choose the safest route, it will alert your family if you enter a location with a low safety rating, you are able to see nearby medical facilities as well. One of the smart devices will be attached to a woman's shoes [6] and can secretly initiated by only tapping their feet few times in space of five seconds or using a one-touch switch method, here also some action is required by user. There is a knife attached to the device for her self-defense. A smart phone that runs on Android and has a built-in feature which alerts and provides location-based information [7]. This describes GSM and GPS-based system for women's security that combines GPS devices with warnings and messages as well as a trigger for an emergency button. The only thing someone needs to do when they are in trouble is press the volume key, so again user action is expected. One of the applications uses GPS tracking to determine its location and then sends a message to the contacts it has been registered with, as well as messages to nearby mobile devices that also have this app installed [8]. Here all the users' victims and people in the vicinity need to have that application in their mobile device. FIGHTBACK, this app was proposed by Mahindra faction [9]. Earlier, this app was not free, customers had to pay for this app. But after Delhi gang rape incident, this app is now available at no cost. This app sends a message to your friend or contacts that the person is in danger and needs help through E-mail, SMS and GPRS. This application does not analyse situations automatically based on human body parameters. Vith U App, this app is developed to help women to get security when they are in any danger. In this they avoid dialling of any phone number as it is not possible all the time to dial number and contact the other person so here, they provide a app which lets girl to double click her power button to send a alert message with the current location which keeps on sending after every 2 minutes and which keeps updating the location of the user [10]. There can be a false alert which may cause inconvenience to the user.

Some of the systems are designed to record evidence. Where the incident will be simultaneously recorded using the application's audio recording capability, which can afterwards be used as proof if needed [5]. "FEMME," can help put an end to the atrocities committed against women [11]. This security system was created specifically for use by women who are in danger. One of system proposed for Rajasthani women, where customized the "Borla" (an ornament) design [12], which would ensure the woman's protection with features like a live location capture with a continuous server update, a high-definition camera with quick capture and speech recording.

Most of the systems available need to be handled by the user. Artificial Intelligence (AI) is also introduced in this field. SWMS, is a mobile app with a crucial feature that should offer support in an emergency [13]. When the yelling warning is activated, the device, which resembles a collar-mounted monitor with a button as a source, activates the monitor, contacts' locations, the electric shock device, and some other safety measures. M. A. Vidhyavani discussed about the he GPS (location tracking system), Android-based, and women-based security systems [14]. Women press the button on this safety device when they sense danger. With only one click, one can dial and send the police station's number, the location of the emergency contacts, and their most recent addresses. Though various systems are available for Women's safety there, there is increase in crime against woman in 2021 [15]. Here we are introducing intelligence through machine learning with some different aspects.

3. Dataset Collection and Expert Opinion

There are some physical parameters that can directly affect the fear coefficient. The fear coefficient depends on the generalized threat for a particular event concerning the amount of fear for the incoming event in the same domain [16], fig. 2 gives more details about the same.

Serial No.	Parameters	Ranges of Parameters for Fear
1.	Electroencephalogram(A1)	Alpha(13-15 Hz) Beta(7.5-13 Hz)
2.	Heart Rate(A2)	High(84-120 BPM)
3.	Heart Rate Variability (A3)	High(0.15-0.4 Hz)
4.	Pre Ejection Period(A4)	Low(0-800 ms)
5.	Stroke Volume(A5)	High(240-400 ml)
6.	Systolic Pressure(A6)	High(120-147 Hg)
7.	Diastolic Pressure(A7)	Low(77-88 Hg)
8.	Skin Conductance Response(A8)	High(0.85-1.5ms)
9.	Tidal Volume(A9)	Rapid(100-150ml)
10.	Oscillatory Response(A10)	High(0.5-1 breadths/minute)
11.	Respiration Rate(A11)	High(15-24 breadths/minute)
12.	Non specific Skin Conductance Response(A12)	Low(0-2 /minute)
13.	Skin Conductance Level(A13)	Low(0-2 ms)
14.	Finger Temperature(A14)	Low(65F-75F)

Fig. 2. Physical Parameters change with respect to Fear [16]

Fear is a chain of reactions in the brain that starts with a stressful stimulus and ends with the release of chemicals that cause an increase in heart rate, fast breathing, and energized muscle. Fig 2 shown, how various fourteen parameters are affected by fear. Out of the parameters listed in the table the parameters feasible to measure are heart rate (2), heart rate variability (3), stroke volume (5), respiration rate (11) and additionally temperature, voice etc.

It is really challenging to determine the features of the dataset to consider for critical condition. We cannot measure the body parameters of the person in critical condition. Here the condition refers to any unwanted/ wrong situation, become fearful. But machine learning techniques works well with the available dataset, and we have decided to identify the fearful and stress condition. To avoid the false identification of it, data gathered here is about tired conditions, rest conditions and accordingly predicted critical condition with expert opinion and ignoring false conditions.

From all the parameters we studied, we were only reliably able to measure the heart rate, oxygen levels and temperature of a person. Heart rate was measured using a pulse-oximeter and temperature was measured using an infrared thermometer on individuals belonging in the age group of 15-35 years. Parameters was measured pre and post exercise to get threshold values so that our model doesn't incorrectly classify exercise or similar high intensity workouts as "critical condition".

After collecting the required data, we consulted with experts/specialists/medical practitioners about the veracity of the data collected and ways to differentiate high stress or fright scenarios from other harmless situations. To do so we asked the medical practitioners the following questions:

1. What are the parameters which can be used to detect fear (fight/flight scenario) within a person? Ex. High Heart Rate, high breathing rate, drop in body temperature, etc.
2. Verification of the data we have collected - Are there any anomalies? If yes then what are they and where can we improve?
3. What can the maximum heart rate of a person (threshold values) be who is not under threat? And what is your opinion about the heart rate of an individual who might be under threat?
4. Do other vital body signs (heart rate, breathing rate, temperature) differ in high adrenaline situations such as excitement (when going on a rollercoaster) v/s fear(while watching a horror movie) v/s fight situation. If yes, then how?

The responses we received were as follows:

Dr. Bhanwar Ranwa (MBBS, M.D., D.M.(Cardiology)), Associate professor and HOD, GMC, Kota. Their conclusions were as follows:

1. The various parameters studied do certain to fear scenarios and are consistent with available literature.
2. Data collected is in line with normal heartrate of a person.
3. Maximum Heart rate in normal healthy adults should not exceed 180 BPM.
4. There is no fear-specific body response that can differentiate it from other scenarios like exercise and the cardiac conditions as described in Literature.

Dr.Naman Jain(M.B.B.S.) too they mentioned

1. Parameters that can be used to detect fight or fight/flight scenarios can be heart rate and breathing rate which are secondary to activation of the Sympathetic Nervous System.
2. We can use heart rate as a basis to detect fear in someone as heart rate will increase due to activation of the sympathetic system. But it's not possible to differentiate it from exercise, fight, and excitement just based on heart rate.
3. By looking into the data, we can say that there will be an increase in heart rate after exercise.

Dr. Neena Kasliwal (MD Pathology, Senior Professor JLN, Ajmer) mentioned:

1. Other factors which are helpful in determining fear are cholecystokinin, neuropeptide, natriuretic peptide.
2. The data collected are genuine and authentic but should include a wide variety of age groups. Current dataset includes people up to 40 years. The study should also be conducted in a medical college with the help of available sensors.
3. Biology of fear and excitement are similar and there are different stages of physiology. A person can react actively or passively according to personality in frightful situation. Therefore, it needs further documentation with stimulus on cases & control.

We also consulted with Dr. Sumeet More their opinion is all the parameters have some range and are not the same for all individuals. Also, it may change variably during the height of excitement and fear for different individuals. Also, these parameters vary due to underlying diseases, physiological conditions, and medicines. So, it's difficult to draw a line to determine the standard range to record the level of fear. Also, they shared thresholds of parameters like heart rate a normal resting heart rate for the adults ranging from 60 to 100 beats per minute. Body temperature ranges from 96.8 F to 99.5 F (36 to 37.5 degrees Celsius). Hypothermia occurs when the body is at 95 F (35 degrees Celsius) or lower in adults.

Dr. Sheetal Bidwe-Dhadkar (BAMS MUHS), Pune said that, sometimes there can be quite similar values of the body parameters in critical condition as well as exercise/activity state. The major difference will be in the pattern of these values for certain duration like maximum for 2 minutes. If the changes the parameters are gradual it means the changes are due to some planned activity which may not be harmful for your body, so no need to label it as critical condition, but if the changes are sudden then it is harmful and can be labelled as critical condition. Different key features can be monitored in human behaviour during fear condition [17], blood pressure [18], temperature [19] obviously initial testing is done on animal like rat and treatments are available to normalize it.

4. Proposed System

Whenever any human being, specifically woman undergoes any unwanted/ wrong situation, become fearful.

Table 1. Changes in maximum heart rate age-wise [20]

Sr No	***Age***	***Target Heart Rate (HR) Zone (60%-80%)***	***Predicted Maximum Heart Rate***
1	20	120-170	200
2	25	117-166	195
3	30	114-162	190
4	35	111-157	185
5	40	108-153	180
6	45	105-149	175
7	50	102-145	170
8	55	99-140	165
9	60	96-136	160
10	65	93-132	155
11	70	90-128	150

we found that following major body parameters could help us to identify when a person is said to be showing signs of fear/stress:

1. Increased Heart Rate
2. Faster Breathing/Shortness of Breath
3. Sweating and chills (body temperature plummets)
4. Increased presence of the hormones

Using the smart devices available the first three parameters are already observed. We can also monitor it using devices like pulse oximeter, thermometer etc. Every physician mentions that according to the age group little bit fluctuation is natural for body parameters, for example for the heart rate Table 1 shows the age-wise normal ranges and fluctuations found naturally.

The fluctuations found out of the regular range indicate some abnormal conditions. According to the physicians, heart rate gets increased during exercise as well. So, such conditions cannot be considered as fear conditions, but there are some combinations of body parameter values which cannot be just exercised condition rather it would be fear condition as shown in Table 2.

Table 2. Physical parameters change with respect to fear [16]

Sr No	*Parameters*	*Ranges of Parameters for Fear*
1	Heart Rate	High(84-120 BPM)
2	Heart Rate Variability	High(0.15-0.4 Hz)
3	Finger Temperature	Low(65F-75F)
4	Respiration Rate	High(15-24 breadths/minute)

With the help of available data composition and regularly monitored body parameters, fear condition can be detected by applying the AI, ML techniques, over the data captured by smart devices used now a days. Other terms used for smart devices are smart watch or smart band etc. Here we are proposing one of the methodologies to identify the critical situation discussed in further section. Also used pulse oximeter device to measure body parameters.

5. Methodology and Results

We have collected the dataset for the age group 20-25 years. The conditions taken into consideration are rest conditions, before and after exercise, before and after fast running, before and after gym activity. The sample dataset is as shown in Table III. Here pulse indicates Pulse rate, Temp indicates temperature and SPO2 indicates oxygen.

Table 3. Sample dataset for age group 20-25

Date (DD/MM)	*Exercise*			*Resting*		
Year 2022	*Pulse*	*Temp*	*SPO2*	*Pulse*	*Temp*	*SPO2*
05-May	147	36.6	98	79	36.8	98
06-May	149	36.9	98	91	36.7	96
07-May	165	36.6	98	93	36.7	98
08-May	164	37	97	91	36.1	98
09-May	167	36.3	99	104	36.8	98
10-May	166	36.2	96	106	36.2	96
11-May	167	36.8	97	90	36.5	98
12-May	160	36.2	96	98	36.4	97
13-May	168	36.4	99	74	36.3	96
14-May	158	36.6	98	84	36.7	97

The above dataset belongs to Month of May similarly, data captured during the remaining two seasons. Different timings are also taken into consideration like Morning, Afternoon and Evening.

Sometimes there is uncertainty in the expert opinions. This uncertainty may lead to complex interpretation with available opinion mining models [21]. Fuzzy system is popular model wherever the output expected is in the form of rule determination [22]. It is one of the popular models for soft computing applications [23], [24].

We have proposed fuzzy systems here. The term fuzzy refers to things that are not clear or are vague. Fuzzy Logic is used with Neural Networks, it mimics how a person would make decisions. The normal or abnormal condition of a person cannot be binary (yes or no). In the fuzzy system, there is no logic for the absolute truth and absolute false value, there is an intermediate value present which is partially true and partially false. We took three input parameters, Temperature, Pulse rate, and SPO2(oxygen rate), and one output parameter 'Condition', as shown in Fig. 3. We used the Mamdani-based Fuzzy rule model [25], a type of fuzzy relational model where an If-Then Relationship represents each rule.

Mamdani-based Fuzzy Model

With single antecedent the model works work as below

1. If x is A Then y is B

   x- is input.

   y- is output.

   A is a fuzzy set (Ex. Let's say A is heart rate variability in Hz takes values as below

   $A \rightarrow \{ 0.15, 0.16, \ldots., 0.4 \}$

   A Takes fuzzy value for A

   A'- fuzzy set excluding A (Ex. heart rate variability in Hz takes

   value other than A}).

   B'- Fuzzy value for A'

2. After super imposing A and A' the weight w=0.5 as shown in fig 6.

   i. If the value is below 0.5 condition is normal

      y= B'

   ii. if it is above 0.5 then condition is abnormal accordingly the output B decided based on weight. Above 0.5 means output B condition is not normal (critical condition),

      y=B.

Steps 1 and 2 get repeated for every input xi and fuzzy rules generated as shown in fig 7.

For each input, we gave the range of parameters between resting condition to post-exercise condition as shown in

Table 4.

Table 4. Ranges of the measurable body parameters

Parameter	***Temperature***	***Pulse Rate***	***SPO2***
low	30-36.1	0-60	85-90(very low)
normal	36.1-37.2	60-180	90-95(low)
high	37.2-42.0	180-220	95-100(normal)

Steps 1 and 2 get repeated for every input xi and fuzzy rules generated as shown in fig. 7.

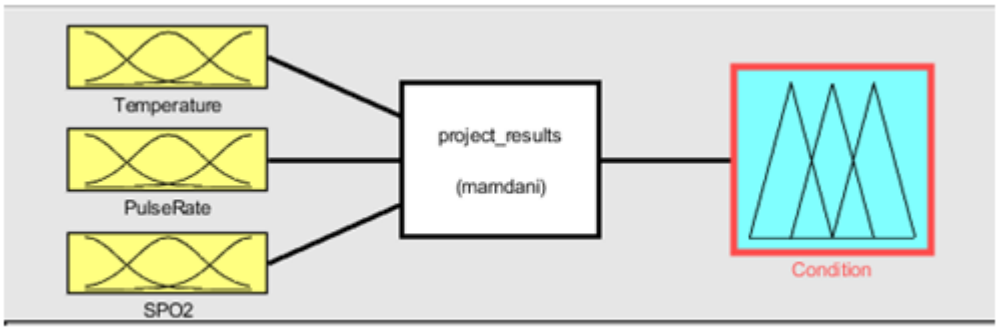

Fig. 3. Fuzzy Logic model used for prediction.

We used the Gaussian function to represent the same. If the value exceeds the range, the condition is considered ‘abnormal’. Few input parameters are discussed with the help of graphical view in fig 4 and fig 5.

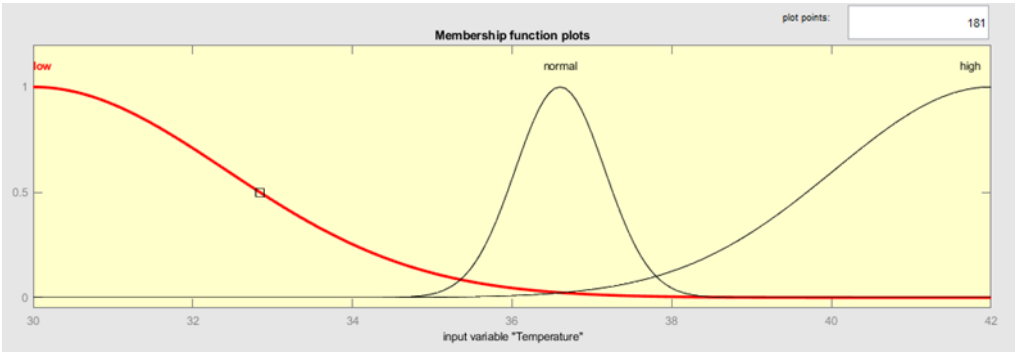

Fig. 4. Membership functions for Temperature

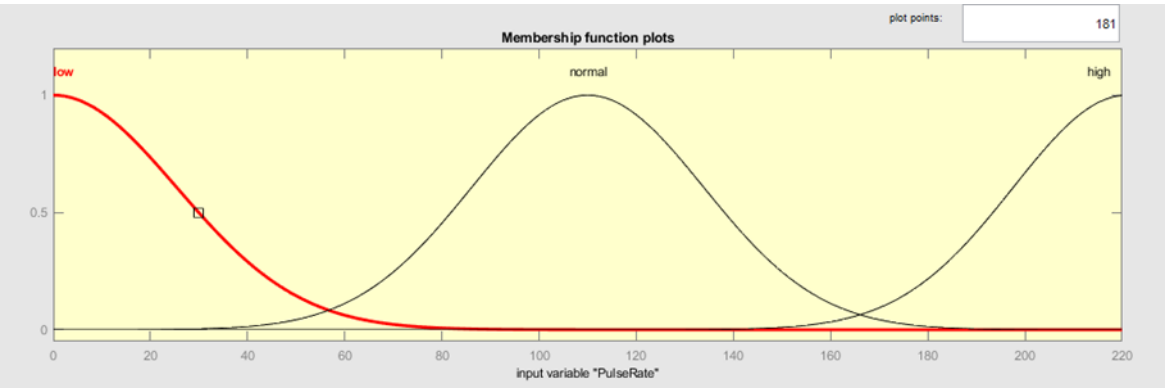

Fig. 5. Membership functions for Pulse Rate

As an outcome, the resulting rules generated are shown below in Fig. 6. If the value drops below 0.5, the condition is abnormal and if the value is above 0.5, the condition is normal. To decide whether the condition is normal or

abnormal, we made a set of fuzzy rules, considering Temperature, Pulse Rate, and SPO2. Graphically output parameter is shown in Fig. 6

If the If the value drops below 0.5, the condition is abnormal and if the value is above 0.5, the condition is normal. To decide whether the condition is normal or abnormal, we made a set of fuzzy rules, considering Temperature, Pulse Rate, and SPO2 as shown in Fig 7 and Fig 8 and Fig 9 shows output viewer.

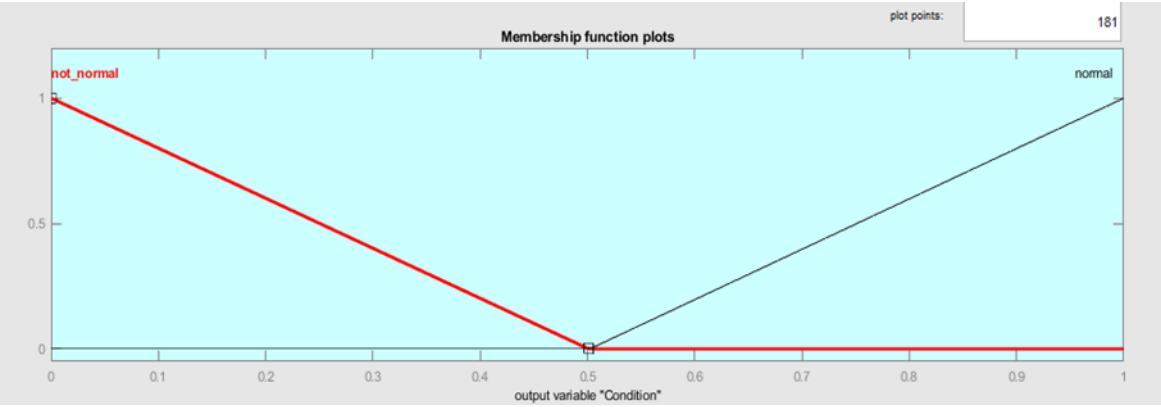

Fig. 6. Output parameter

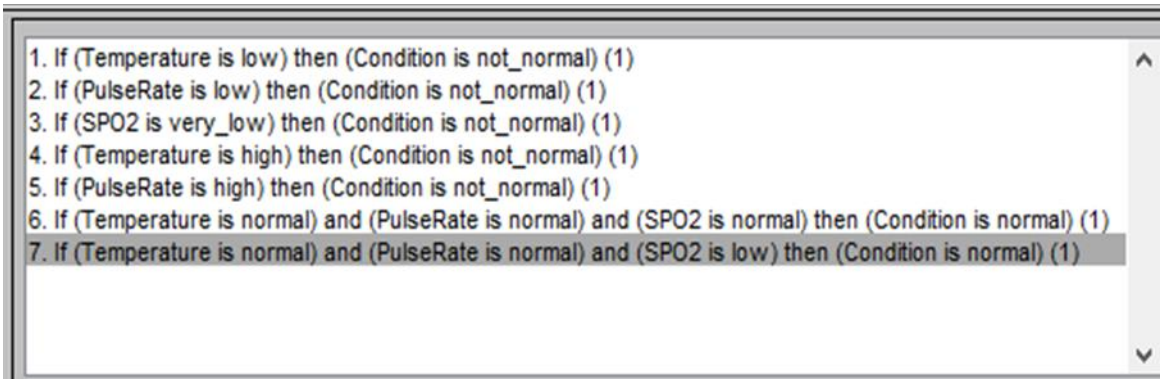

Fig. 7. Rules as a result of prediction

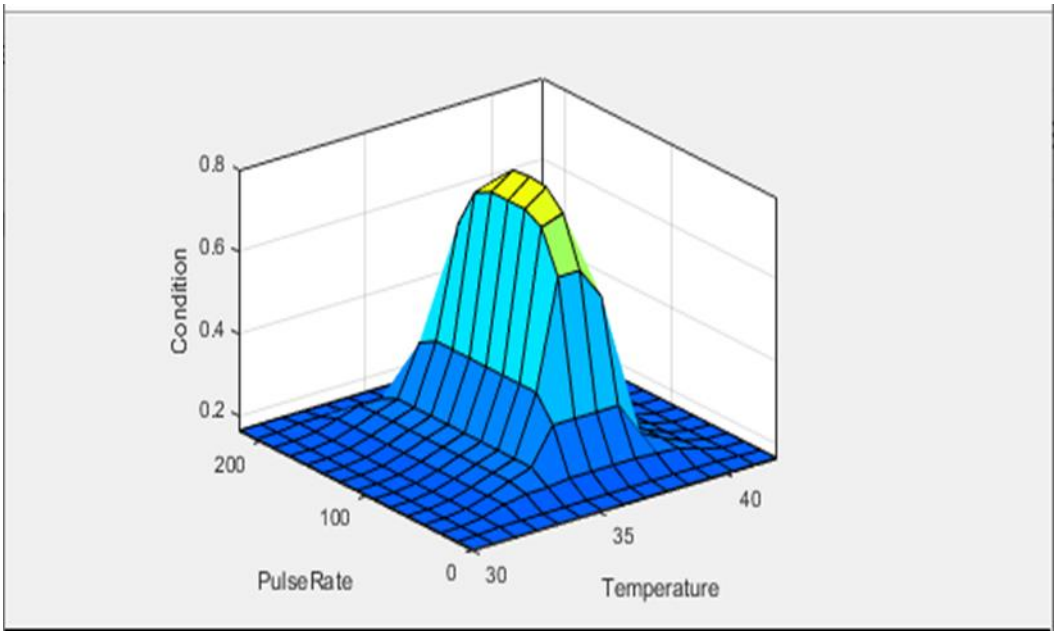

Fig. 8 Output as a Surface Viewer

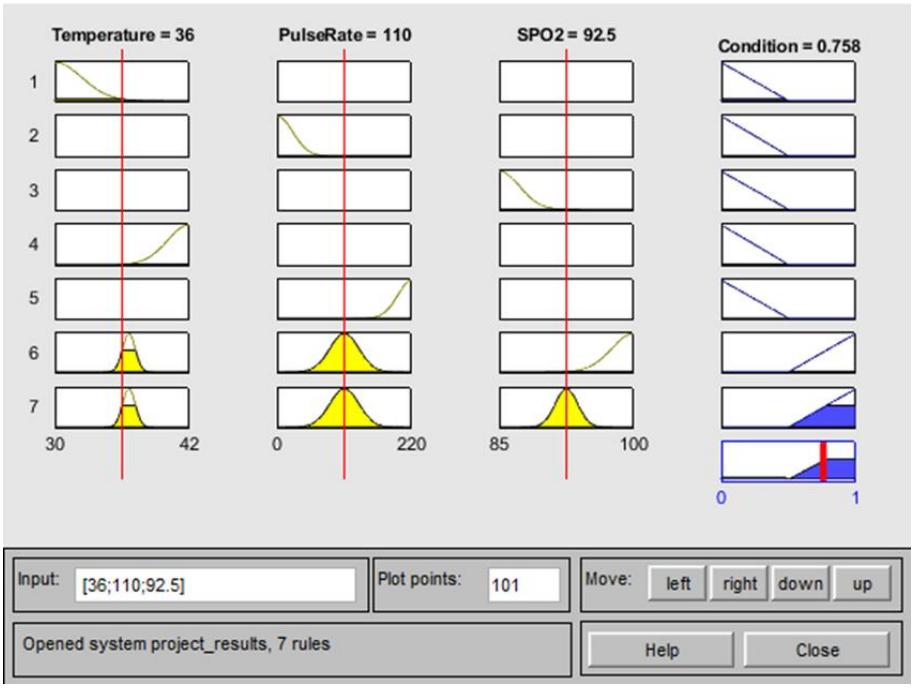

Fig. 9. Output as a Rule Viewer

6. Discussion and Conclusion

Supervised machine algorithms work accurately if the labelled dataset used is accurate. We can see the body parameters have different ranges for different age groups. To have appropriate results, dataset used for prediction about particular entity need to belong to the same age group. It is impossible to capture the body parameters of a person in critical condition, but we can do negative testing and avoid the pattern of other natural conditions like tiredness, rest, and exertion. So, the ranges used are as per the expert's opinion.

It is difficult for the fearful woman to take precautionary action and ask for help by clicking/taping some device/application or by making phone call. Technology like AI-ML can change the scenario and identify the critical conditions based on observed change in body parameter values. According to experts' opinion body parameters can be used as a base for identifying the situation. Algorithms like Fuzzy logic can feed to the smart devices (which also have GPS and GSM facility) and outcome can be used by such device. If the outcome predicts the critical condition, device will send alerts to nearby/concern people. To avoid the false alert user can have a provision to stop the alerts.

Author contributions

Ratnmala Bhimanpallewar: Conceptualization and methodology **Suruchi Dedgaonkar:** software, resources and data creation, **Nilesh P. Sable:** writing- original draft preparation **Priya Shelke:** field study **Jayashri V. Bagade:** writing- review and editing

Conflicts of interest

The authors declare no conflicts of interest.

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