

CS 514 - Applied Artificial Intelligence
Project -2 Fuzzy Rule Based System (fuzzy JESS)
Health Monitor System

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Problem Specification: To simulate the Health monitoring System that records readings and recommends the action.

Abstract:

The fuzzy rule-based system is designed using fuzzy JESS Rule Engine and can diagnose/identify the health condition of the user and recommends the corresponding action. This system can be considered as a simulation of a Health Monitoring System that can be used to monitor a patient in a hospital which can also be linked to an interface for two-way communication between a patient and a doctor or it can be a wearable device for personal monitoring of health. This Health Monitoring system can be used as a replacement for manual patients readings in hospitals and can also send warning messages to doctors in case of any emergency or critical conditions. It is also a motivating system which is very useful for the people who want to monitor their health regularly.

In this system, the parameters used for monitoring each user/patient are - Name, Age, Gender, Blood Pressure Systolic, Blood Pressure Diastolic, Heart Rate, Body Temperature. I have considered these variables, as they are the basic details that are monitored to know the health condition of a person. The Health Monitoring System would record the readings of Blood Pressure, Heart Rate and Body Temperature through some sensors, but in this simulation system the user is asked to input the readings.

The system uses fuzzy rule based approach to diagnose the patient's condition (hypertension, hypotension, fever, hypothermia, bradycardia or tachycardia) by processing the readings and firing the corresponding fuzzy rules and check if they are within the normal range or not.

Scope:

The system is designed to accept age (in years) as a number between (0-120), gender as a text whose value should be from the list {MALE, FEMALE, NOTSPECIFIED}, Blood Pressure Systolic (in mmHg) is an integer between (80-250), Blood Pressure Diastolic (in mmHg) is an integer between (40-150), Heart Rate (in BPM) is an integer between (20-200), Body Temperature (in Fahrenheit) is a number between (90-120). The above given ranges are the acceptable value ranges for the inputs.

The readings are considered normal if they are within these given ranges:

Blood Pressure Systolic (90-140) mmHg), Blood Pressure Diastolic ((60-90) mmHg), Heart Rate ((60-100) BPM), Body Temperature ((97-99) Fahrenheit).

Structure of the system – The system is designed to interact with the user by allowing the user to enter the required details. It then identifies the health condition of the user/patient and recommends corresponding action. The input values requested from the user are:

- Age (in years (0-120))
- Gender (MALE, FEMALE, NOTSPECIFIED)
- Blood Pressure Systolic (in mmHg (80-250))
- Blood Pressure Diastolic (in mmHg (40-150))
- Heart Rate (in BPM (20-200))
- Body Temperature (in Fahrenheit (90-120))

Once we get all the required information from the user, we run the rule engine, which has rules corresponding to all the possible combinations of values for these given variables. It identifies the health condition of the user/patient based on the values of all these variables and gives the recommendation.

Knowledge Base: The knowledge base of this system is composed of the following components.

Templates:

1. User template: This template corresponds to all the information of the user/patient which includes name, age, gender, Blood Pressure Systolic, Blood Pressure Diastolic, Heart Rate and Body Temperature.

```
(deftemplate User
  (slot name)
  (slot age (type INTEGER))
  (slot gender)
  (slot BloodPressureSys)
  (slot BloodPressureDys)
  (slot HeartRate)
  (slot BodyTemperature))
```

2. Question template: This template corresponds to the questions asked by the system to the user.

```
(deftemplate question (slot text) (slot type) (slot ident))
```

3. Answer template: This template corresponds to the answers received from the user.

(deftemplate answer (slot ident) (slot text))

Questions Facts: This consists of a list of questions where each question has an id to distinguish from one another and a type, which corresponds to the type of answer the rule system is expecting. The questions I have included are:

1. Age of the user/patient : "What is the user's/patient's age in years (0-120) ? "
2. Gender of the user/patient : "What is the gender of the user/patient (MALE/FEMALE/NOTSPECIFIED) ? "
3. Systolic Blood Pressure : "What is recorded Systolic Blood Pressure of the user/patient (80-250) ? "
4. Diastolic Blood Pressure : "What is recorded Diastolic Blood Pressure of the user/patient (40-150) ? "
5. Heart Rate : "What is recorded Heart Rate of the user/patient (20-200) ? "
6. Body Temperature : "What is recorded Body Temperature of the user/patient (90-120) ? "

Rules:

1. initial-terms : This rule is used to initialize the global variables (fuzzy variables) - BloodPressureSysVar, BloodPressureDysVar, HeartRateVar, BodyTemperatureVar and divide them into various fuzzy categories by defining the fuzzy terms to describe the concepts of the fuzzy variable.

Example :

```
(defglobal ?*BloodPressureSysVar* = (new FuzzyVariable "BloodPressure" 80 250 "mmHg"))
```

```
(?*BloodPressureSysVar* addTerm "low" (new ZFuzzySet 80 100))
```

```
(?*BloodPressureSysVar* addTerm "moderate" (new TrapezoidFuzzySet 80 100 140 150))
```

```
(?*BloodPressureSysVar* addTerm "high" (new SFuzzySet 140 200))
```

2. welcome-user : This rule is used to welcome the user with welcome message.

3. assert-answers : This rule is used to get the inputs from the user and create an instance of the User template by asserting the facts.

4. generate-fuzzysset : This rule is used to pass the user input values into the initialized fuzzy variables to generate the fuzzy values using fuzzy sets. I have used SingletonFuzzySet for fuzzification.

Example : (assert(BloodPressureSys_data
 (new FuzzyValue ?*BloodPressureSysVar*
 (new SingletonFuzzySet
 ?User.BloodPressureSys))))

5. Fuzzy rules : the rules corresponding to different combinations of these fuzzy values are created to diagnose a health condition.

Test Cases:

- 1) Valid scenario: All the inputs are correct and the readings are within normal ranges.

```
Jess> (batch HealthMonitorSystemTest.clp)

*****Welcome to Health Monitor System*****
Type the name of the user/patient and press Enter> abc
Let us begin the health monitoring for abc.
Please provide the required details that would be recorded by the system and
the system will tell the health status of the user/patient.

What is the user's/patient's age in years (0-120) ? 25
What is the gender of the user/patient (MALE/FEMALE/NOTSPECIFIED) ? MALE
What is recorded Systolic Blood Pressure of the user/patient in mmHg (80-250) ? 100
What is recorded Diastolic Blood Pressure of the user/patient in mmHg (40-150) ? 90
What is recorded Heart Rate of the user/patient in BPM (20-200) ? 80
What is recorded Body Temperature of the user/patient in Fahrenheit (90-120) ? 98.5
*****
The Heart Rate, Blood Pressure and the Body Temperature are Normal.
*****
```

- 2) Error scenario: The input 'value' for gender is incorrect and the system asks to reenter the gender.

```

Jess> (batch HealthMonitorSystemTest.clp)

*****Welcome to Health Monitor System*****
Type the name of the user/patient and press Enter> abc
Let us begin the health monitoring for abc.
Please provide the required details that would be recorded by the system and
the system will tell the health status of the user/patient.

What is the user's/patient's age in years (0-120) ? 21
What is the gender of the user/patient (MALE/FEMALE/NOTSPECIFIED) ? m
|The answer to the question is invalid. Please enter the answer in the correct expected format.
What is the gender of the user/patient (MALE/FEMALE/NOTSPECIFIED) ?

```

- 3) Error scenario: The input 'value' of heart rate is incorrect and the system asks to re enter the heart rate.

```

Jess> (batch HealthMonitorSystemTest.clp)

*****Welcome to Health Monitor System*****
Type the name of the user/patient and press Enter> abc
Let us begin the health monitoring for abc.
Please provide the required details that would be recorded by the system and
the system will tell the health status of the user/patient.

What is the user's/patient's age in years (0-120) ? 77
What is the gender of the user/patient (MALE/FEMALE/NOTSPECIFIED) ? FEMALE
What is recorded Systolic Blood Pressure of the user/patient in mmHg (80-250) ? 100
What is recorded Diastolic Blood Pressure of the user/patient in mmHg (40-150) ? 80
What is recorded Heart Rate of the user/patient in BPM (20-200) ? 0
What is recorded Body Temperature of the user/patient in Fahrenheit (90-120) ? 98

The heart rate value entered is not logically correct with respect to this system. Please enter a value between (20-200).

```

- 4) Error scenario: The input 'type' of blood pressure is invalid and the system asks to re enter the blood pressure.

```

Jess> (batch HealthMonitorSystemTest.clp)

*****Welcome to Health Monitor System*****
Type the name of the user/patient and press Enter> abc
Let us begin the health monitoring for abc.
Please provide the required details that would be recorded by the system and
the system will tell the health status of the user/patient.

What is the user's/patient's age in years (0-120) ? 66
What is the gender of the user/patient (MALE/FEMALE/NOTSPECIFIED) ? NOTSPECIFIED
What is recorded Systolic Blood Pressure of the user/patient in mmHg (80-250) ? qw
|The answer to the question is invalid. Please enter the answer in the correct expected format.
What is recorded Systolic Blood Pressure of the user/patient in mmHg (80-250) ?

```

- 5) High Body Temperature scenario: All the inputs are correct and the readings indicate fever.

```
Jess> (batch HealthMonitorSystemTest.clp)

*****Welcome to Health Monitor System*****
Type the name of the user/patient and press Enter> abc
Let us begin the health monitoring for abc.
Please provide the required details that would be recorded by the system and
the system will tell the health status of the user/patient.

What is the user's/patient's age in years (0-120) ? 30
What is the gender of the user/patient (MALE/FEMALE/NOTSPECIFIED) ? MALE
What is recorded Systolic Blood Pressure of the user/patient in mmHg (80-250) ? 100
What is recorded Diastolic Blood Pressure of the user/patient in mmHg (40-150) ? 70
What is recorded Heart Rate of the user/patient in BPM (20-200) ? 90
What is recorded Body Temperature of the user/patient in Fahrenheit (90-120) ? 99.5
*****
The readings indicate a Warning for Fever.
Please consult the doctor to get the treatment for Fever (high body temperature)
*****
```

- 6) Low Heart Rate and High BP: All the inputs are correct and the readings indicate bradycardia and hypertension.

```
Jess> (batch HealthMonitorSystemTest.clp)

*****Welcome to Health Monitor System*****
Type the name of the user/patient and press Enter> abc
Let us begin the health monitoring for abc.
Please provide the required details that would be recorded by the system and
the system will tell the health status of the user/patient.

What is the user's/patient's age in years (0-120) ? 40
What is the gender of the user/patient (MALE/FEMALE/NOTSPECIFIED) ? FEMALE
What is recorded Systolic Blood Pressure of the user/patient in mmHg (80-250) ? 160
What is recorded Diastolic Blood Pressure of the user/patient in mmHg (40-150) ? 90
What is recorded Heart Rate of the user/patient in BPM (20-200) ? 50
What is recorded Body Temperature of the user/patient in Fahrenheit (90-120) ? 98
*****
The readings indicate a Warning for Bradycardia.
Please consult the doctor to get the treatment for Bradycardia (low heart rate)
*****
*****
The readings indicate a Warning for Hypertension.
Please consult the doctor to get the treatment for Hypertension (high Blood Pressure)
*****
```

Valid cases:

- Works for all the cases where age has a value between (0-120) years, gender has a value from the list {MALE, FEMALE, NOTSPECIFIED}, Blood Pressure Systolic has an integer value between (80-250) mmHg, Blood Pressure Diastolic has an integer value between (40-150) mmHg, Heart Rate has an integer value between (20-200) BPM and Body Temperature has a value between (90-120) Fahrenheit.
- If the type of expected answer to a question is incorrect, the system asks to reenter the answer again in the correct expected format.

Expected Output:

The system would give a health condition and the recommendation for a user/patient.

If all the readings are within normal ranges as below,

BloodPressureSystolic >= 90 mmHg and BloodPressureSystolic <= 140 mmHg

BloodPressureDiastolic >= 60 mmHg and BloodPressureDiastolic <= 90 mmHg

HeartRate >= 60 BPM and HeartRate <= 100 BPM

BloodPressureSystolic >= 97 F and BodyTemperature <= 99 F

then a message is displayed saying all the readings are normal.

The condition can be a “Warning for Fever” if the Body Temperature is high (> 99 F), a “Warning for Hypothermia” if the Body Temperature is low (< 97 F), a “Warning for Bradycardia” if the Heart Rate is low (< 60 BPM), “Warning for Tachycardia” if the Heart Rate is high (> 100 BPM), a “Warning for Hypertension” if the Blood Pressure is high (Systolic > 140 mmHg, Diastolic > 90 mmHg), a “Warning for Hypotension” if the Blood Pressure is low (Systolic < 90 mmHg, Diastolic < 60 mmHg).

Possible extensions:

- Additional parameters/variables can be added corresponding to additional details that can be recorded.
- Additional criteria can be added based on age and gender as the conditions may slightly vary based on age and gender.
- The enlarged system can be used in hospitals for monitoring patients instead of taking the readings from time to time and also by any person for their personal health monitoring.