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COMP3106A

Assignment 2

1. This agent is a model based reflex agent. This uses a model based on mean and standard deviation for features in each class based on past observed data and uses it to make decisions.
2. 
    a. Partially observable: the agent can only see past data and the patient's temperature and heart rate to make its prediction. It can't use other data such as visuals to make its prediction.
    b. Single agent: this agent is the only agent in the environment. It makes predictions by itself.
    c. Stochastic: this agent uses probability based off of previous data to make its prediction.
    d. Episodic: the agent's current action will not affect its future actions (however it's prediction given current and past data, will affect the "past data" for future predictions).
    e. Static: we can assume that the patient's measurements will remain constant throughout the prediction as it is given to us.
    f. Discrete: there are only 2 possible predictions the agent can make, healthy and diseased
    g. Known: the agent is provided with prior data and calculates probabilities for each class. Therefore, the agent knows the potential outcomes for each combination of features.
3. Since this is a binary classification problem, we can use accuracy to measure its performance.

$$accuracy = \frac{\#correct\ predictions}{\#\ predictions}$$

4. For an instance where the data is very imbalanced, it is better to use equal prior probabilities rather than computing prior probabilities from the data.
   For example, if there was 80% healthy patients and 20% diseased patients, prior probabilities would be

$$P(healthy) = 0.8$$
$$P(diseased) = 0.2$$

However, our current patient's measurements indicate he's more likely to be diseased. For example, let's say the likelihoods are

$$P(features|healthy) = 0.3$$
$$P(features|diseased) = 0.6$$

If we calculate posterior probabilities using computed prior probabilities:

$$P(healthy|features) = \frac{0.3 * 0.8}{(0.3 * 0.8) + (0.6 * 0.2)} = 0.67$$
$$P(diseased|features) = \frac{0.6 * 0.2}{(0.3 * 0.8) + (0.6 * 0.2)} = 0.33$$

Because 0.67 > 0.33, the patient would be classified as healthy

If we use equal priors for each class (0.5):

$$P(healthy|features) = \frac{0.3 * 0.5}{(0.3 * 0.5) + (0.6 * 0.5)} = 0.33$$
$$P(diseased|features) = \frac{0.6 * 0.5}{(0.3 * 0.5) + (0.6 * 0.5)} = 0.67$$

Using equal priors, the patient would be classified as diseased.

5. Fuzzy rules:
    a. IF temperature is low AND heart rate is low THEN patient is healthy
    b. IF temperature is high OR heart rate is high THEN patient is diseased

Temperature Low: a = 0, b = 0, c = 36, d = 38
Temperature High: a = 37, b = 39, c = 100, d = 100
Heart rate Low: a = 0, b = 0, c = 70, d = 90
Heart rate High: a = 80, b = 100, c = 220, d = 220

a. Temperature = 37.5, Heart Rate = 85

   Temperature membership values

   Low: a = 0, b = 0, c = 36, d = 38

$$= \frac{d - x}{d - c} = \frac{38 - 37.5}{38 - 36} = 0.25$$

   High: a = 37, b = 39, c = 100, d = 100

$$= \frac{x - a}{b - a} = \frac{37.5 - 37}{39 - 37} = 0.25$$

Heart rate membership values

Low: a = 0, b = 0, c = 70, d = 90

$$= \frac{d - x}{d - c} = \frac{90 - 85}{90 - 70} = 0.25$$

High: a = 80, b = 100, c = 220, d = 220

$$= \frac{x - a}{b - a} = \frac{85 - 80}{100 - 80} = 0.25$$

Healthy: minimum of temperature low 0.25 and heart rate low 0.25 = 0.25

Diseased: maximum of temperature high 0.25 and heart rate high 0.25 = 0.25

b. Temperature = 37.8, Heart rate = 88

Temperature membership values

Low: a = 0, b = 0, c = 36, d = 38

$$= \frac{d - x}{d - c} = \frac{38 - 37.8}{38 - 36} = 0.1$$

High: a = 37, b = 39, c = 100, d = 100

$$= \frac{x - a}{b - a} = \frac{37.8 - 37}{39 - 37} = 0.4$$

Heart rate membership values

Low: a = 0, b = 0, c = 70, d = 90

$$= \frac{d - x}{d - c} = \frac{90 - 88}{90 - 70} = 0.1$$

High: a = 80, b = 100, c = 220, d = 220

$$= \frac{x - a}{b - a} = \frac{88 - 80}{100 - 80} = 0.4$$

Healthy: minimum of temperature low 0.1 and heart rate low 0.1 = 0.1

Diseased: maximum of temperature high 0.4 and heart rate high 0.4 = 0.4

Predicted class: diseased 0.4

c. Temperature = 37.2, Heart rate = 82

Temperature membership values

Low: a = 0, b = 0, c = 36, d = 38

$$= \frac{d - x}{d - c} = \frac{38 - 37.2}{38 - 36} = 0.4$$

High: a = 37, b = 39, c = 100, d = 100

$$= \frac{x - a}{b - a} = \frac{37.2 - 37}{39 - 37} = 0.1$$

Heart rate membership values

Low: a = 0, b = 0, c = 70, d = 90

$$= \frac{d - x}{d - c} = \frac{90 - 82}{90 - 70} = 0.4$$

High: a = 80, b = 100, c = 220, d = 220

$$= \frac{x - a}{b - a} = \frac{82 - 80}{100 - 80} = 0.1$$

Healthy: minimum of temperature low 0.4 and heart rate low 0.4 = 0.4

Diseased: maximum of temperature high 0.1 and heart rate high 0.1 = 0.1

Predicted class: healthy 0.4

d. Temperature = 37.7, Heart rate = 83

Temperature membership values

Low: a = 0, b = 0, c = 36, d = 38

$$= \frac{d - x}{d - c} = \frac{38 - 37.7}{38 - 36} = 0.15$$

High: a = 37, b = 39, c = 100, d = 100

$$= \frac{x - a}{b - a} = \frac{37.7 - 37}{39 - 37} = 0.35$$

Heart rate membership values

Low: a = 0, b = 0, c = 70, d = 90

$$= \frac{d - x}{d - c} = \frac{90 - 83}{90 - 70} = 0.35$$

High: a = 80, b = 100, c = 220, d = 220

$$= \frac{x - a}{b - a} = \frac{83 - 80}{100 - 80} = 0.15$$

Healthy: minimum of temperature low 0.15 and heart rate low 0.35 = 0.15
Diseased: maximum of temperature high 0.35 and heart rate high 0.15 = 0.35
Predicted class: diseased 0.35

6. The fuzzy rule-based system and naïve Bayes classifier use different methods to predict. Fuzzy uses rules and membership functions and predicts based on how well the data fits into each category. Naïve Bayes classifier uses probability based on data given, prior probability and likelihood to make a prediction. If a patient's measurements are clearly healthy or diseased, then its very likely both Fuzzy and Bayes will predict the same class. If a patient's data is not very clearly healthy or diseased, then Fuzzy and Bayes are more likely to predict different classes. Bayes might predict the class that has a higher prior probability.