ARTIFICIAL INTELLIGENCE (AI)
FUZZY LOGIC

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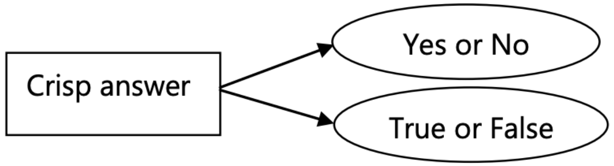
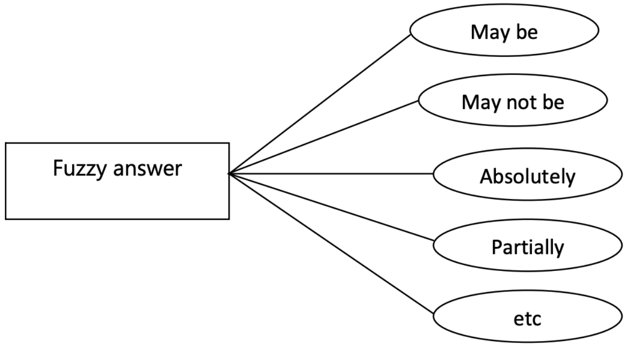
FUZZY LOGIC

- Dictionary meaning of fuzzy is not clear, noisy etc
  - Example: Is the picture on this slide is fuzzy?

FUZZY LOGIC





Our world is better described with “Fuzzily”!

MEMBERSHIP FUNCTION

- Imagine you want to describe how **hot** a day is.
- Classical logic: Yes|No. Fuzzy logic: allows us to say how **hot** the day is on a scale from 0 to 1.

  - If the temperature is **10°C or below**, it's **not hot** at all, so the membership value is 0.
  - If the temperature is **30°C or above**, it's **definitely hot**, so the membership value is 1.
  - For temperatures between **10°C and 30°C**, it's somewhere in between:For 20°C, it might be **0.5** hot (partially hot).
  - For 25°C, it might be **0.75** hot.

RULES FOR EVALUATING COMPLEX STATEMENTS

- AND condition.
  - Imagine you are deciding whether to go for a walk. You want to go if it is **warm AND not raining**.
  - If it is **70% warm** and **40% not raining**, how comfortable would you feel about going for a walk?
  - *You would feel **only 40% comfortable** because even though it's somewhat warm, there's a bigger chance of rain.*
  - *the strength of this "truth" depends on the **weaker** condition, because both have to be satisfied.*

RULES FOR EVALUATING COMPLEX STATEMENTS

- OR condition.
  - You want to decide whether to relax. You will relax if it is either **sunny OR** you have **free time**. If it is **80% sunny** and you have **30% free time**, how much would you relax?
  - *You would likely relax **80%** because it's mostly sunny, even though you have little free time.*
  - *the strength of this "truth" depends on the stronger condition.*

Example: Cardiac Health Management

Fuzzy Rules

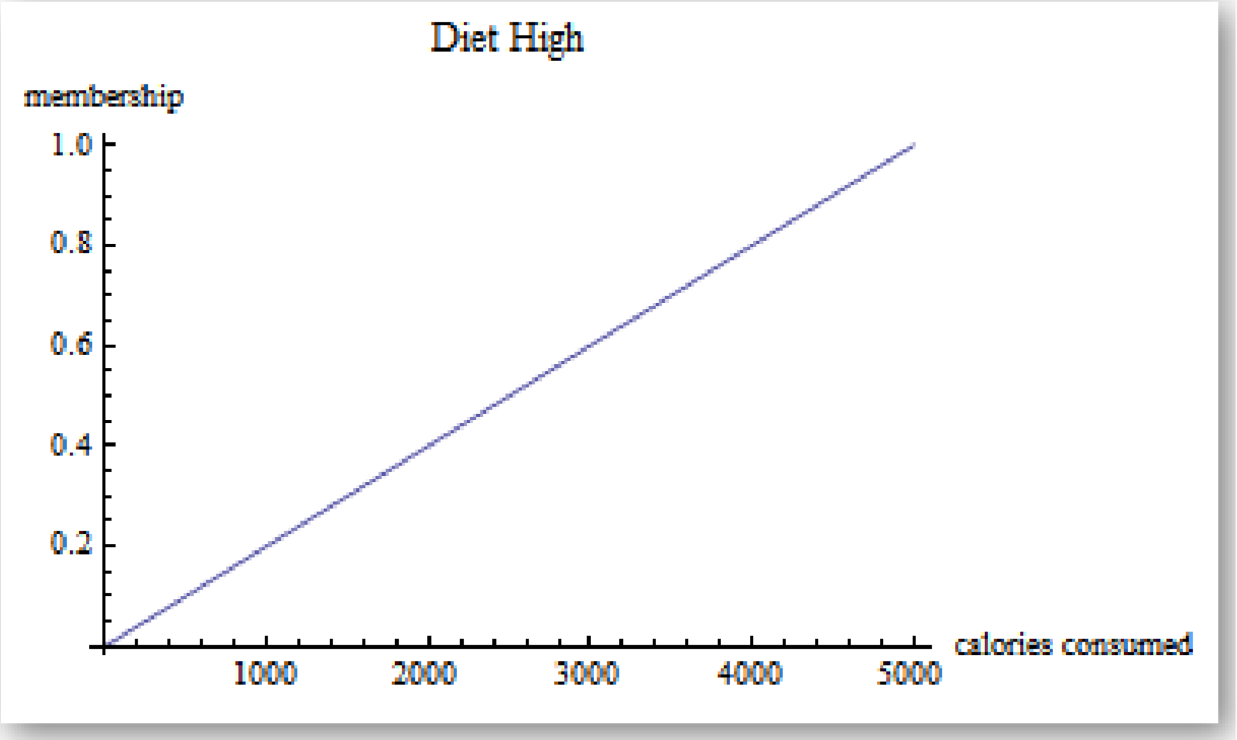
1. Diet is low AND Exercise is high $\Rightarrow$ Balanced
2. Diet is high OR Exercise is low $\Rightarrow$ Unbalanced
3. Balanced $\Rightarrow$ Risk is low
4. Unbalanced $\Rightarrow$ Risk is high

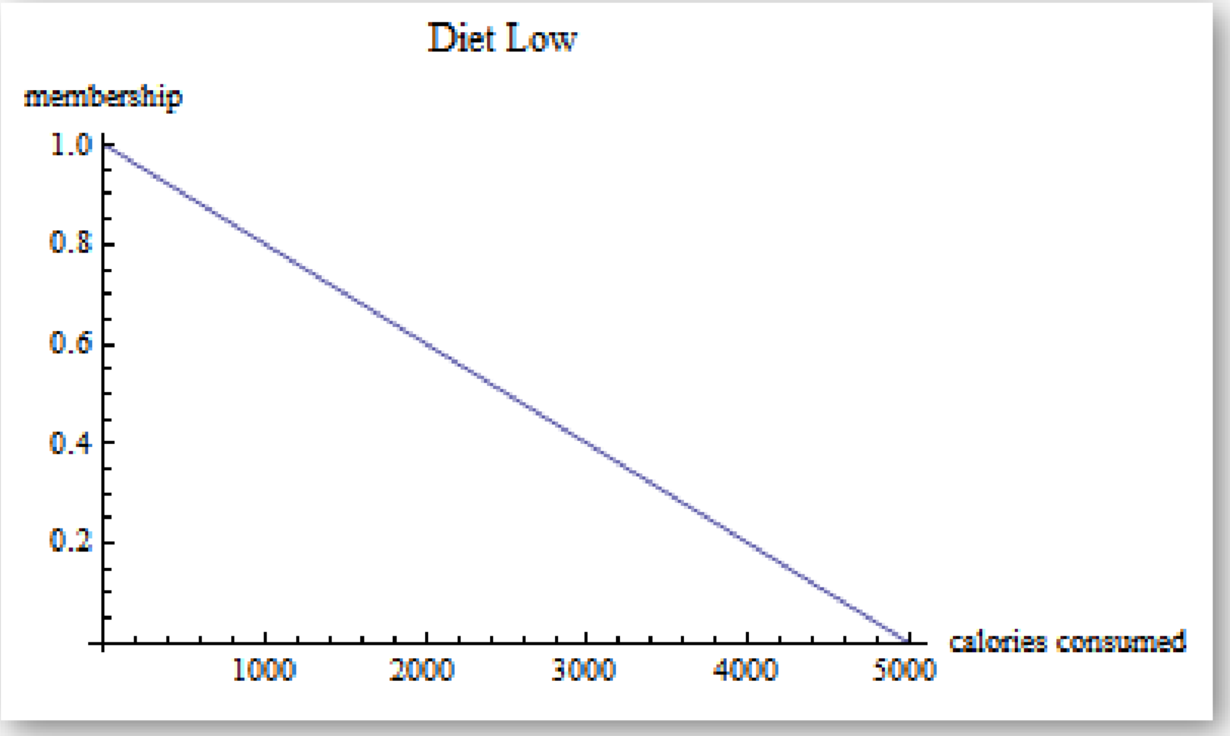
For a person it is given that:

- Diet = 3000 calories per day
- Exercise = burning 1000 calories per day

What is the risk of heart disease?

Membership Functions

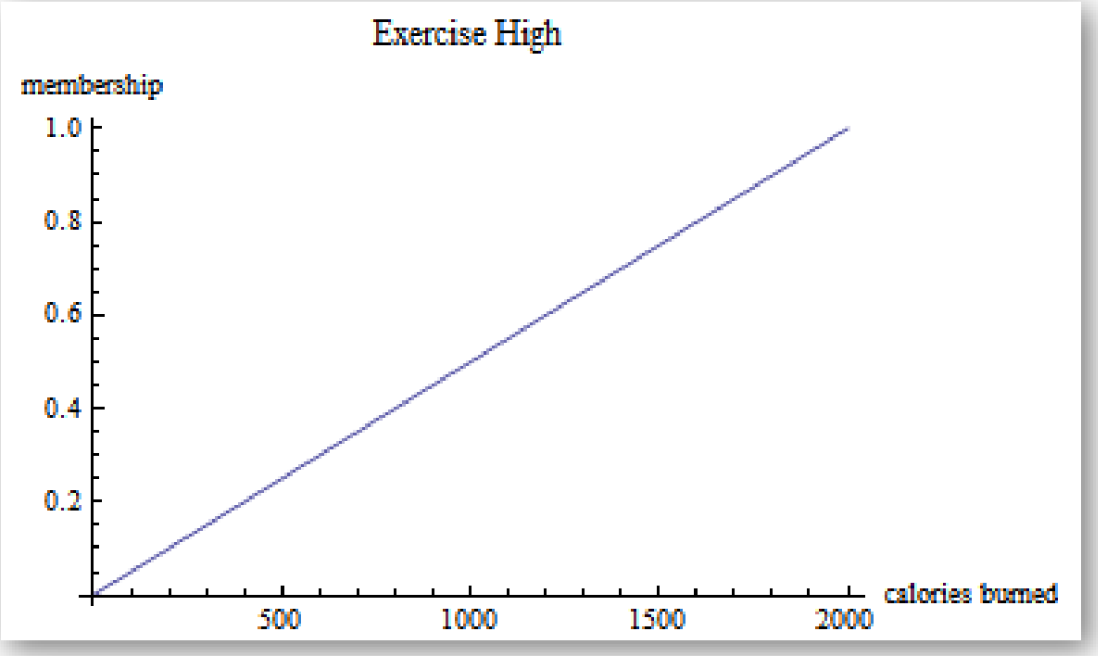


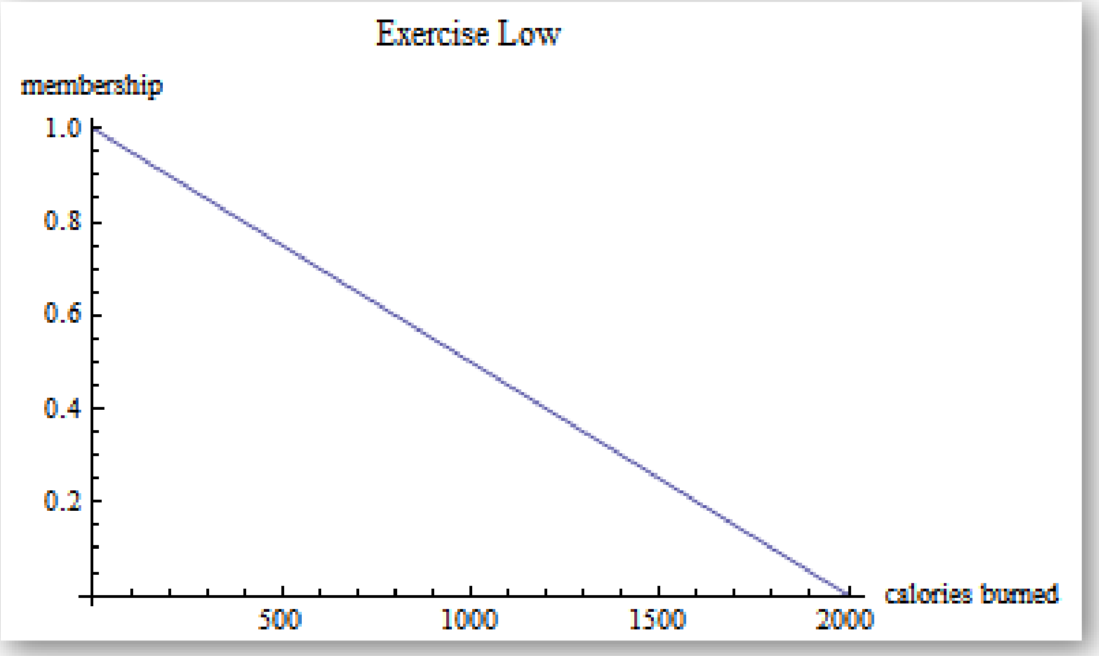


$$f_{diet\ high}(x) = \frac{1}{5000}x$$

$$f_{diet\ low}(x) = 1 - \frac{1}{5000}x$$

Membership Functions





$$f_{exercise\ high}(x) = \frac{1}{2000}x$$

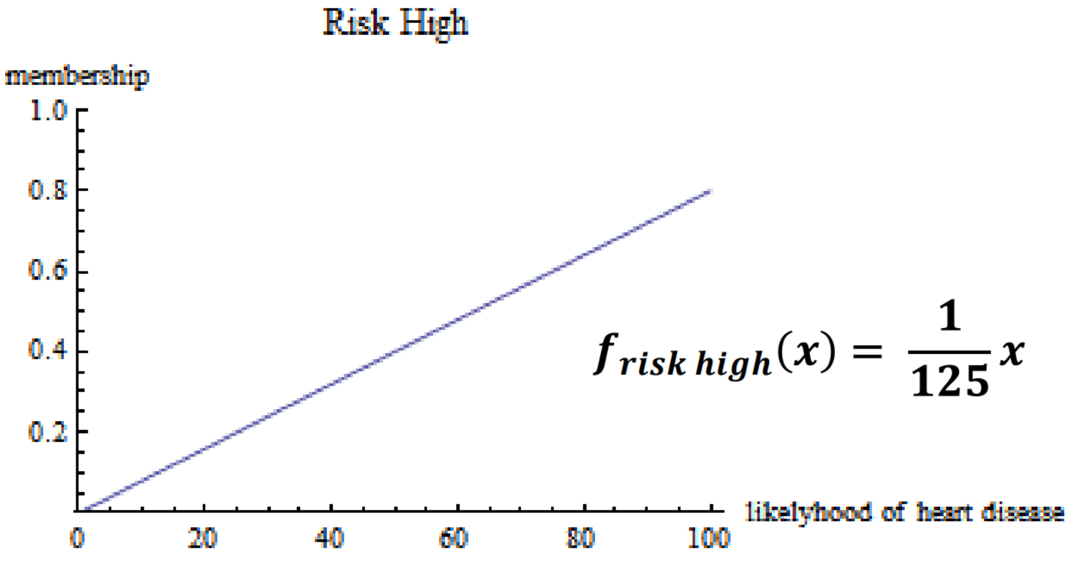
$$f_{exercise\ low}(x) = 1 - \frac{1}{2000}x$$

RULE EVALUATION

Fuzzy Rules

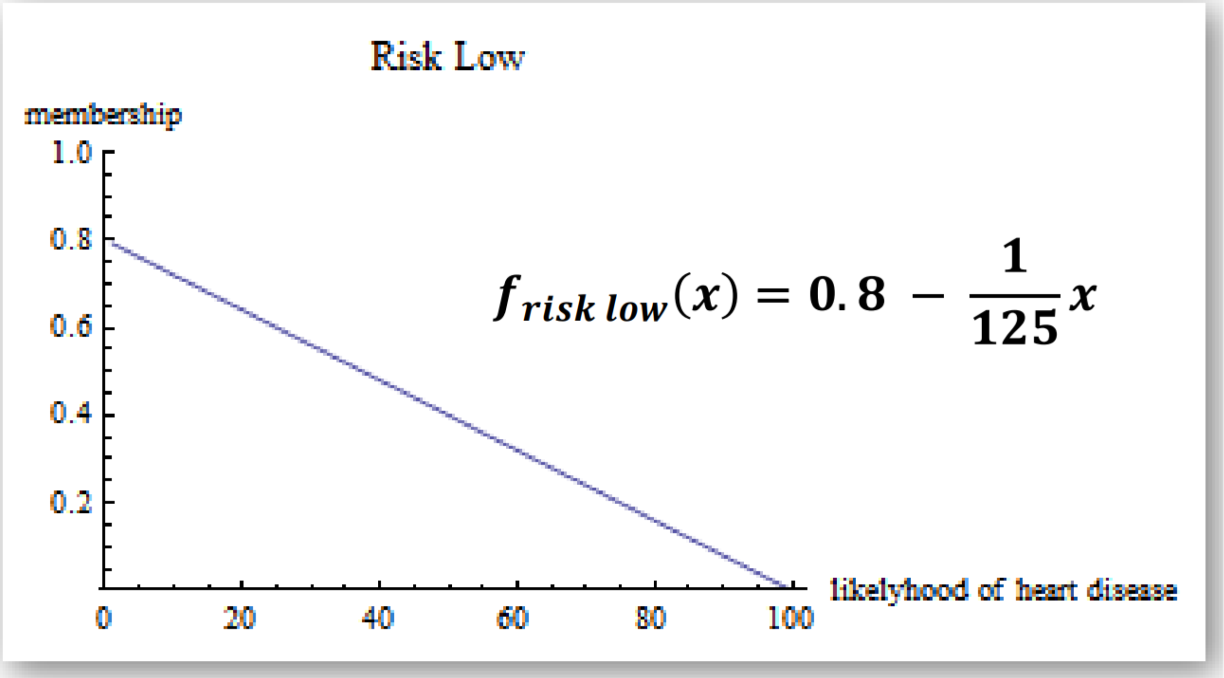
1. **Diet is low AND Exercise is high $\Rightarrow$ Balanced**
2. **Diet is high OR Exercise is low $\Rightarrow$ Unbalanced**
3. **Balanced $\Rightarrow$ Risk is low**
4. **Unbalanced $\Rightarrow$ Risk is high**

Risk-High Evaluation



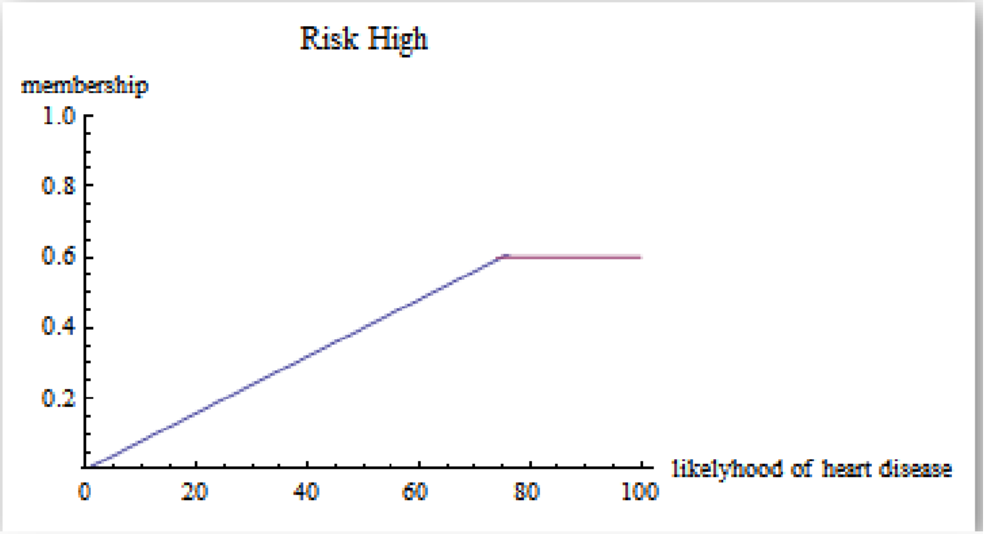
$$f_{risk\ high}(x) = \frac{1}{125}x$$

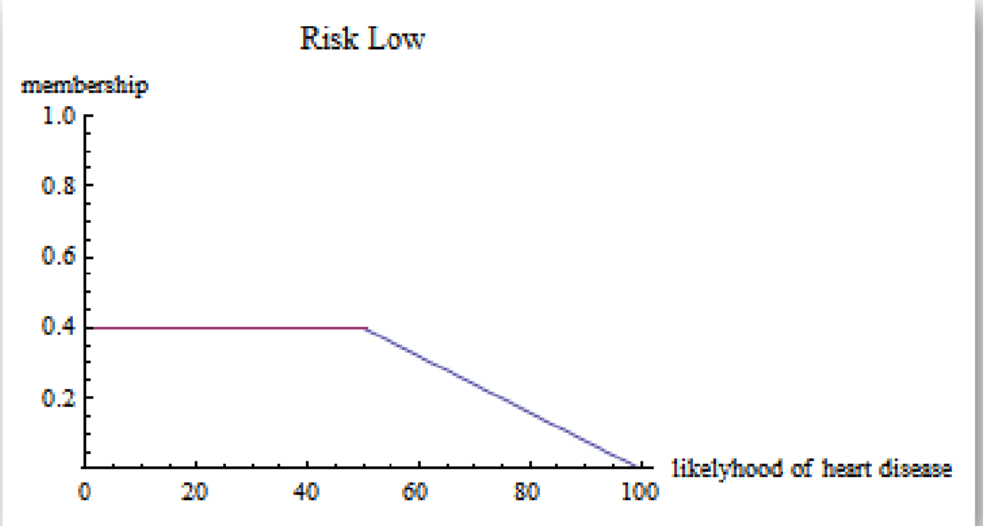
Risk-Low Evaluation



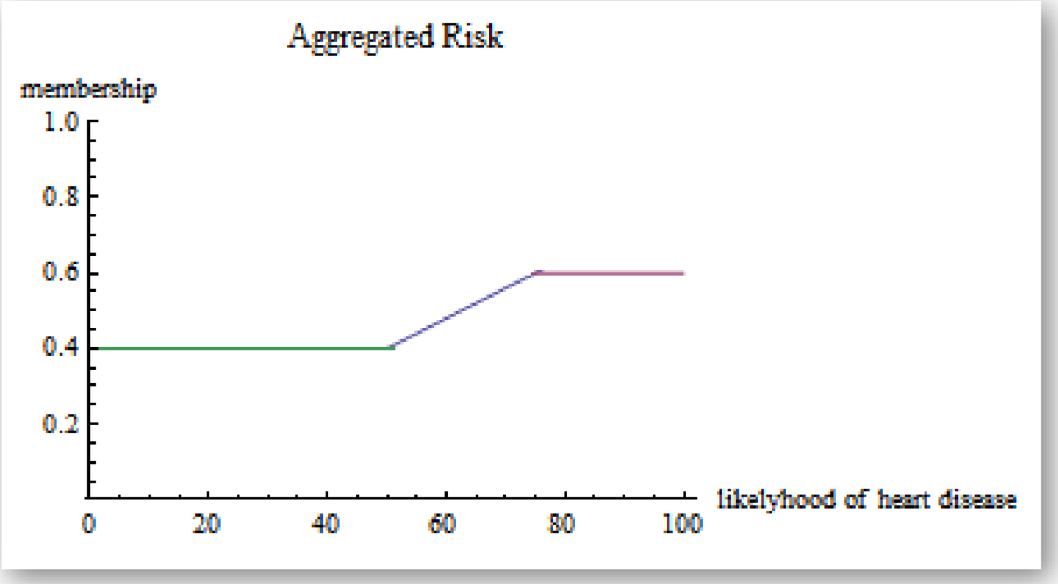
$$f_{risk\ low}(x) = 0.8 - \frac{1}{125}x$$

Aggregated Risk Function



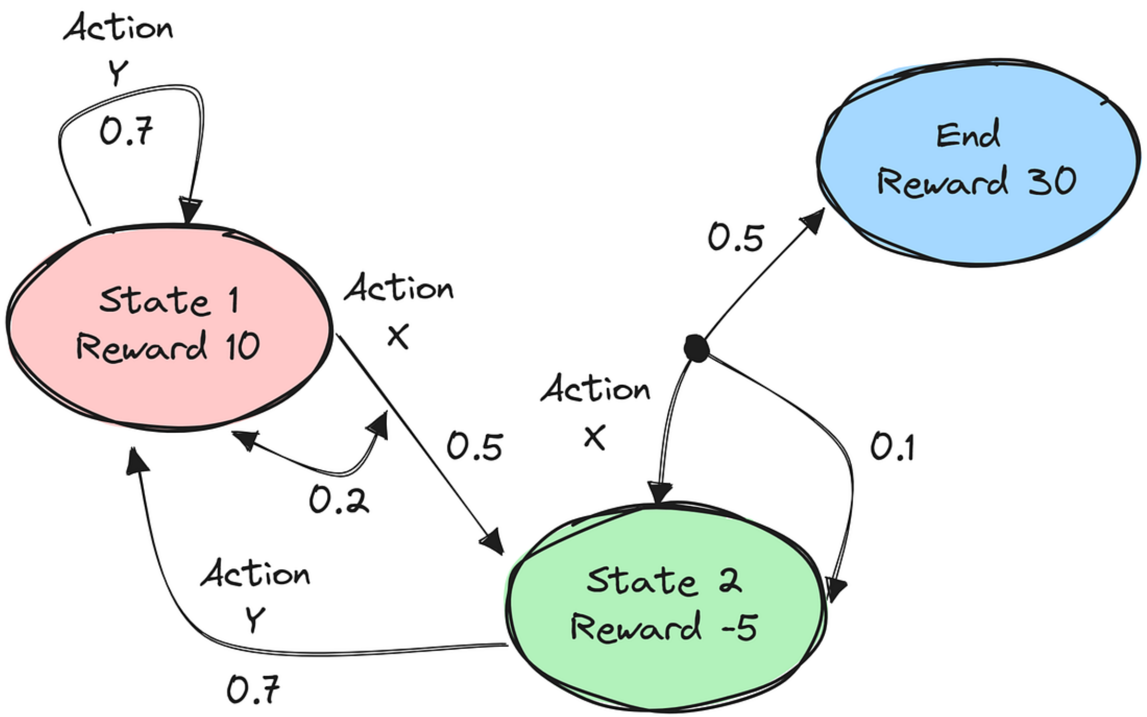


Defuzzification



WHAT NEXT?

- **Probabilistic reasoning in State Machines (Markov Chains)**
- Bayesian Optimization
- Bayesian Learning for Classifiers
  - Classifier should separate out "Lack of Knowledge"



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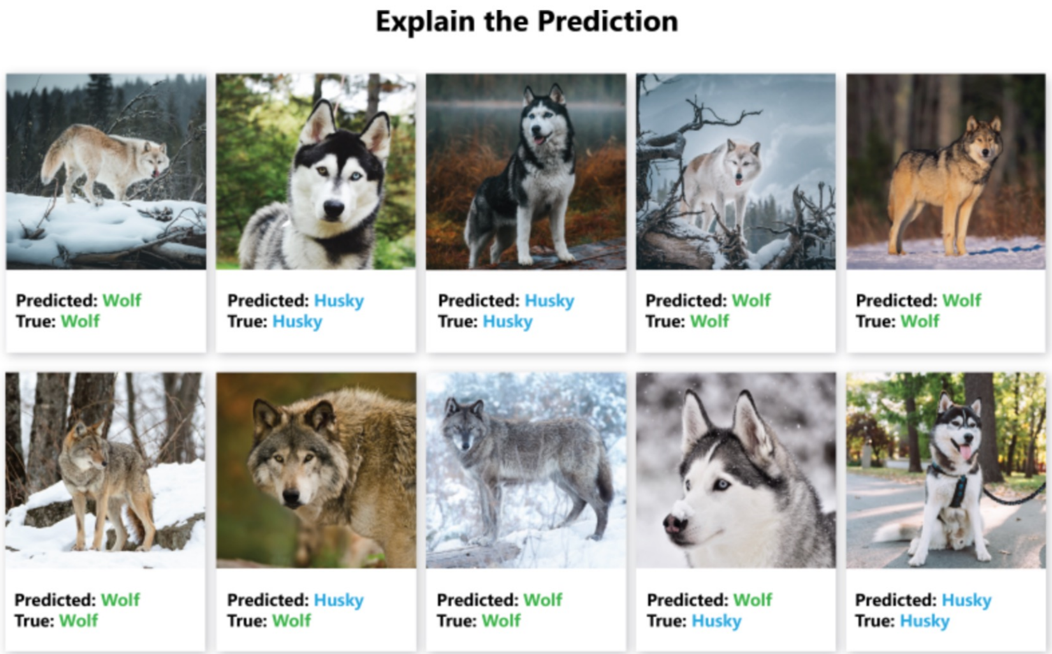

WHAT NEXT?

- Probabilistic reasoning in State Machines (Markov Chains)
- Bayesian Optimization
- **Bayesian Learning for Classifiers**
  - **Classifier should separate out "Lack of Knowledge"**
  - **Uncertainties | Belief/ confidence about a prediction**

To measure the misinformation score effectively by deploying a temporal embargo strategy, we are interested to capture the model's degree of certainty (or belief) about its own predictions. In the context of neural networks, this can be interpreted as the entropy of the predictive distribution (Gal and Ghahramani 2016). The entropy of a probability distribution provides a measure of the uncertainty associated with the distribution. We used the softmax model output to quantify its predictive uncertainty. A lower entropy corresponds to a higher confidence level, as the model predictions are more concentrated on certain classes. This confidenc
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represent the softmax c
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x. Then, the entropy of t

$$E_S(x) = -\sum_i P_S(x;\theta_S)_i \log P_S(x;\theta_S)_i \tag{11}$$

$$E_N(x) = -\sum_i P_N(x;\theta_N)_i \log P_N(x;\theta_N)_i \tag{12}$$

Here, the summations are over all classes i. To convert these entropy measures into confidence levels, we first normalize them to the range [0, 1] by dividing by $\log K$, where K is the number of classes. Then, we subtract the normalized entropy from 1:

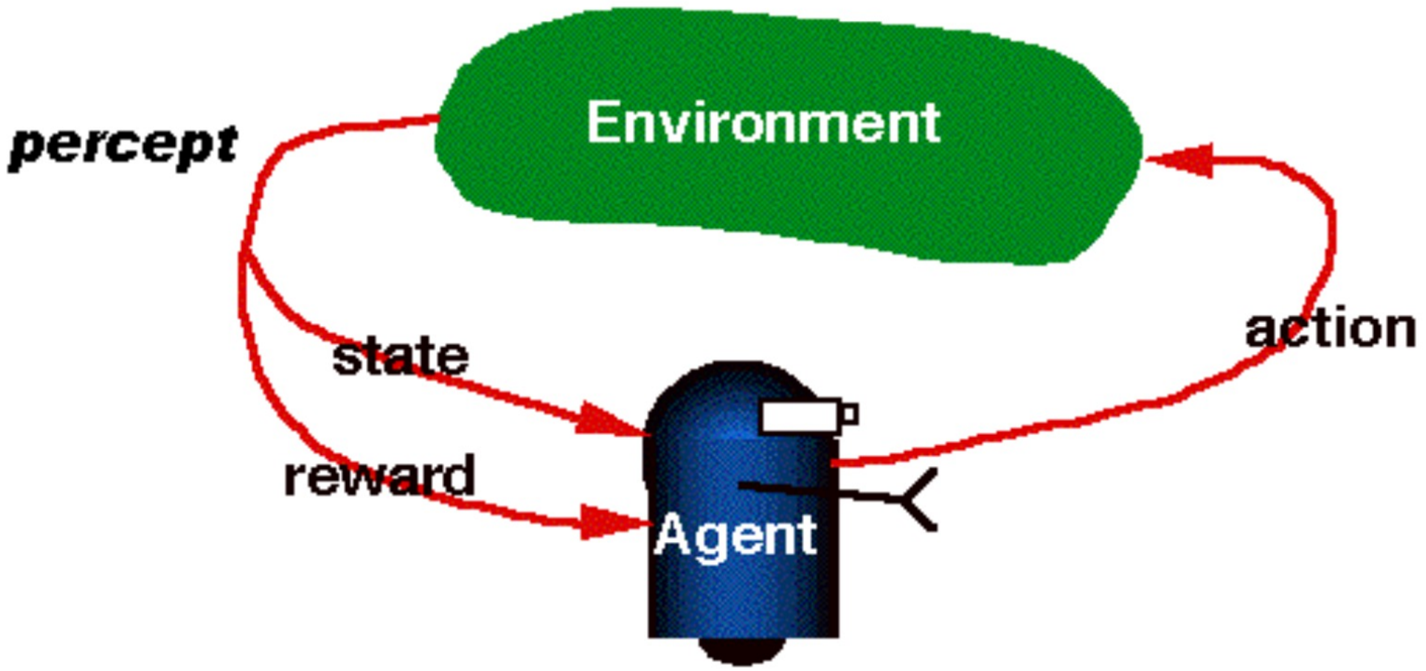
$$C_S(x) = 1 - \frac{E_S(x)}{\log K} \tag{13}$$

$$C_N(x) = 1 - \frac{E_N(x)}{\log K} \tag{14}$$

Ref:
Ghosh, Shreya, Prasenjit Mitra, and Preslav Nakov. "Clock against Chaos: Dynamic Assessment and Temporal Intervention in Reducing Misinformation Propagation." *Proceedings of the International AAAI Conference on Web and Social Media*. Vol. 18. 2024.

MDP AND RL

RL is learning from interaction



Examples of Reinforcement Learning

- How should a robot behave so as to optimize its "performance"? (Robotics)

- How to automate the motion of a helicopter? (Control Theory)

- How to make a good chess-playing program? (Artificial Intelligence)

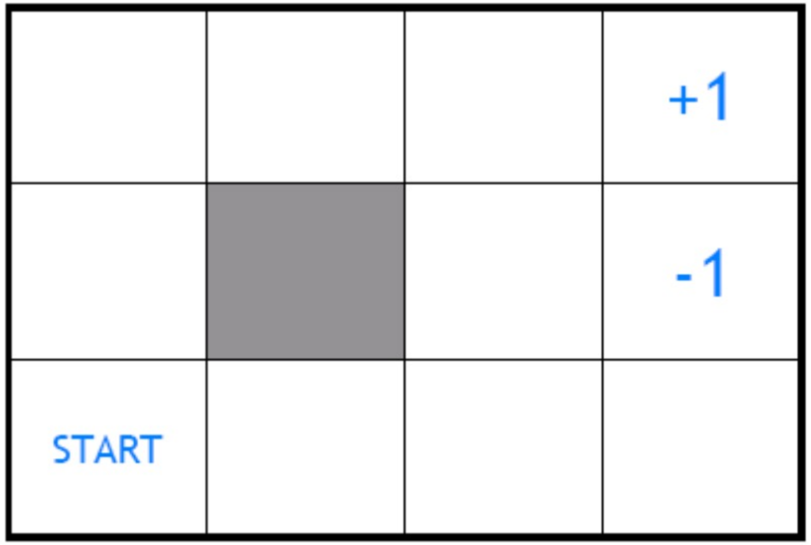
SUPERVISED LEARNING VS RL

- Supervised learning

$$f : X \rightarrow Y$$

  - X: inputs
  - Y: outputs
  - The predicted outputs can be evaluated immediately by the teacher
  - f evaluated with loss function

Robot in a room



actions: UP, DOWN, LEFT, RIGHT

UP

80%	move UP
10%	move LEFT
10%	move RIGHT

- reward +1 at [4,3], -1 at [4,2]
- reward -0.04 for each step

- what's the strategy to achieve max reward?
- what if the actions were NOT deterministic?