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Deep Learning 2024-25

Assignment 1

Q1: Environmental Monitoring and Hazard Detection

Scenario:

A sensor-based system monitors environmental conditions to detect potential hazards (e.g., flooding, storms). Sensors provide binary input:

- x1=1 – High temperature detected.
- x2=0 – No wind activity.
- x3=0 – Low humidity.
- x4=1 – Rain detected.

Weights reflect the impact of each factor on the risk level. For instance:

- High temperature (w1=0.2) slightly increases hazard risk.
- W2=-0.3
- W3=0.5
- Rain (w4=−0.4) might reduce risk in fire-prone areas but increase it for floods.

The system activates an alarm (output 1) if the combined risk exceeds a threshold (e.g., t=0.1)

Real-World Application:

- Wildfire detection systems use similar neural networks, balancing factors like heat, wind, and humidity.
- Flood detection models assess rainfall, ground saturation, and temperature to trigger early warnings.

Task:

1. Calculate the output of the neuron based on the given inputs and weights.
2. Explain how each input influences the final decision.
3. Discuss how changing the weight of x4 (e.g., from -0.4 to -0.1) might alter the neuron's behavior.

Q2: Autonomous Vehicle Decision-Making

Scenario:

An autonomous vehicle must decide whether to proceed or stop at an intersection. The system evaluates two key factors:

- x1– Obstacle detected (1 = Yes, 0 = No).

- x2 – Traffic light is red (1 = Red, 0 = Green).

Weights reflect their importance:

- Obstacle (w1=0.7) has more influence on stopping.
- Red light (w2=0.3) is less critical but still considered.

The vehicle stops (output 1) if the weighted sum exceeds t=0.5.

Task:

1. Construct a truth table showing the neuron's output for all possible input combinations (x1,x2)
2. Analyze the table to explain under what conditions the neuron activates.
3. Reflect on how a slight decrease in w1 or an increase in w2 could impact the output.

Real-World Application:

- Self-driving cars use neural models to integrate sensor data and traffic signals.
- The model balances pedestrian detection, light signals, and surrounding vehicle positions to make driving decisions.

Q3: Predictive Maintenance in Industrial Equipment

Scenario:

A manufacturing plant uses sensor data to predict equipment failures. Four sensors measure machine conditions:

- X=[2,1,−2,−1] – Temperature, vibration, pressure deviation, and fluid levels.

Weights represent the sensitivity of the system to these factors:

- w=[−0.1,1,1,0.1] – Vibration and pressure deviations are more critical for failure prediction.

The ReLU activation ensures that only significant deviations trigger alerts (ignoring negative or minor inputs).

Task:

1. Calculate the initial output of the neuron using the ReLU activation function.
2. If the output is zero, explain how the network responds to this situation during training.

Real-World Application:

- Predictive maintenance systems analyze sensor data to prevent costly machine downtime.
- Neural networks learn from historical failures to adjust weights, improving accuracy over time.