CSE140-W2025: Introduction to Intelligent Systems
Quiz-4 - Rubric

Date: 22/04/2025 **Total Time:** 45 mins **Total Marks:** 10 Marks

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Instructions

- Attempt all questions.
- MCQs have a single correct option.
- State any assumptions you have made clearly.
- Standard institute plagiarism policy holds.
- No evaluations without suitable justifications.

Multiple Choice Questions

Q1. *"Without AI-powered analytics, IoT devices and the data they produce throughout the network would have limited value. Similarly, AI systems would struggle to be relevant in business settings without the IoT-generated data pouring in. However, the powerful combination of AI and IoT can transform industries and help them make more intelligent decisions from the explosive growth of data every day. IoT is like the body, and AI the brains..." – Maciej Kranz, Vice President, Cisco*

Which of the following **best captures** the implication of the AI + IoT integration?

A. AI systems can replace IoT devices by analyzing external datasets, eliminating the need for real-time sensing.

B. IoT systems can independently generate value through sensing and connectivity, while AI is optional.

C. AI and IoT are mutually dependent; AI gives meaning to IoT data, while IoT provides the real-world grounding that AI needs.

D. The primary benefit of combining AI and IoT is reducing hardware costs through centralized analytics.

1 Mark

Answer: (C) AI and IoT are mutually dependent; AI gives meaning to IoT data, while IoT provides the real-world grounding that AI needs.

Explanation:

- **Option A** is incorrect because AI cannot replace real-world data acquisition—it needs input from sensors to be contextually relevant.
- **Option B** is incorrect because, as the quote states, IoT data would have "limited value" without AI analytics.
- **Option D** focuses on cost optimization, which is not the main point of the quote.
- **Option C** correctly captures the symbiotic relationship described—IoT as the "body" (sensing/actuation layer) and AI as the "brains" (analytics/decision layer), with each amplifying the value of the other.

Marking:

- Correct answer with proper explanation: 1 mark
- Incorrect answer: 0 marks

Q2. Scenario: IoT sensors embedded across a smart city continuously capture real-time data such as vehicle density, speed, and congestion levels. An AI system uses this data to dynamically control traffic lights, suggest alternate routes, and predict congestion patterns before they occur.

Assertion (A): Integrating AI with IoT enables smart cities to proactively manage and reduce traffic congestion.

Reason (R): AI systems can learn from real-time sensor data to make adaptive decisions, which static rule-based systems cannot.

A. Both A and R are true, and R is the correct explanation of A.
B. Both A and R are true, but R is not the correct explanation of A.
C. A is true, but R is false.
D. A is false, but R is true.

1 Mark

Answer: (A) Both A and R are true, and R is the correct explanation of A.

Explanation:

- **Assertion is true:** AI+IoT integration allows the city to respond to real-time traffic patterns and predict future congestion, not just react passively. This enables proactive management of traffic.
- **Reason is true:** AI models (e.g., reinforcement learning, time-series prediction) can adapt to dynamic patterns in ways that traditional hardcoded signal logic cannot.
- **R explains A:** The adaptive, learned behavior of AI directly enables the proactive traffic management described in A. Without AI's ability to learn from real-time data, the system would be limited to reactive or scheduled responses.

Marking:

- Correct answer with proper explanation: 1 mark
- Incorrect answer: 0 marks

Q3. Assertion (A): Mid-level fusion architectures offer a better trade-off between performance and interpretability compared to early and late fusion in complex multi-sensor systems.

Reason (R): In mid-level fusion, features are extracted independently from each sensor stream and then combined, allowing the system to learn intermodal relationships while preserving sensor-specific processing.

A. Both A and R are true, and R is the correct explanation of A.
B. Both A and R are true, but R is not the correct explanation of A.
C. A is true, but R is false.
D. A is false, but R is true.

1 Mark

Answer: (A) Both A and R are true, and R is the correct explanation of A.

Explanation:

- **Assertion is true:** Mid-level fusion is widely used in modern systems (e.g., autonomous vehicles, multimodal medical diagnosis) because it balances the raw correlation richness of early fusion with the modularity and robustness of late fusion. It allows joint learning while retaining some interpretability.
- **Reason is true:** By independently encoding sensor streams before fusion, the model retains modality-specific semantics (e.g., time for audio, texture for vision), and still enables cross-modal learning through joint feature layers.
- **R explains A:** The ability to separately extract then combine features enables both better performance (through learned interaction) and clearer architecture design (versus early fusion's black-box concatenation). This is precisely why mid-level fusion offers the described trade-off between performance and interpretability.

Marking:

- Correct answer with proper explanation: 1 mark
- Incorrect answer: 0 marks

Q4. In a smart agriculture setup, soil moisture sensors collect data and send it to a remote server via LoRaWAN. The system then analyzes the data and automatically triggers irrigation if needed.

Which of the following **correctly maps the functionality** described to the standard layers of an IoT architecture?

A.
- **Perception Layer:** Analyzes soil data
- **Network Layer:** Stores irrigation rules
- **Application Layer:** Collects data from sensors

B.
- **Perception Layer:** Collects soil moisture readings
- **Network Layer:** Transmits data via LoRaWAN
- **Application Layer:** Analyzes data and triggers irrigation

C.
- **Perception Layer:** Executes irrigation decisions
- **Network Layer:** Connects pumps to power supply
- **Application Layer:** Handles sensor calibration

D.
- **Perception Layer:** Uploads data to the cloud
- **Network Layer:** Computes decisions based on sensor inputs
- **Application Layer:** Encodes sensor IDs and MAC addresses

1 Mark

Answer: (B)
- **Perception Layer:** Collects soil moisture readings
- **Network Layer:** Transmits data via LoRaWAN
- **Application Layer:** Analyzes data and triggers irrigation

Explanation:
- The **Perception Layer** handles the sensing and physical environment interaction (e.g., soil moisture sensor readings).
- The **Network Layer** manages data transmission protocols and connectivity (e.g., LoRaWAN, MQTT, Wi-Fi).
- The **Application Layer** performs data analytics and decision logic, visible to end users (e.g., analyzing moisture data and triggering irrigation).
- **Option A** is incorrect because the Application layer does analysis, not the Perception layer.
- **Option C** is incorrect because execution (actuation) is typically handled by the Application layer's commands, and calibration is often part of Perception layer setup.
- **Option D** is incorrect because cloud upload is handled by the Network layer, not the Perception layer, and computing decisions is done by the Application layer.

Marking:
- Correct answer with proper explanation: 1 mark
- Incorrect answer: 0 marks

Q5. Assertion: Active sensing systems can operate reliably even in complete darkness or low-light environments.

Reason: Active sensors emit their own signal (e.g., light, sound, or radio waves) and measure the reflected response, unlike passive sensors which rely solely on ambient energy.

A. Both A and R are true, and R is the correct explanation of A.
B. Both A and R are true, but R is not the correct explanation of A.
C. A is true, but R is false.

D. A is false, but R is true.

1 Mark

Answer: (A) Both A and R are true, and R is the correct explanation of A.

Explanation:

- **Assertion (A)** is **true** because active sensors like radar, ultrasound, and LiDAR emit their own signals, enabling them to operate in conditions where ambient light is insufficient or absent (e.g., in complete darkness).
- **Reason (R)** is **true** because it accurately describes how active sensors work. Active sensors generate their own energy (like light or sound waves) and rely on the reflection of these signals to detect objects, unlike passive sensors that depend on external energy sources like visible light or heat.
- **R explains A** because the operation of active sensors (emitting their own signals) allows them to function in dark or low-light conditions, which is what the assertion is describing.

Marking:

- Correct answer with proper explanation: 1 mark
- Incorrect answer: 0 marks

Short Answer Questions

Q6. A battlefield AI system uses three sensor modalities to detect a potential threat:

- **Sensor A (Drone Vision)**: Image classifier
- **Sensor B (RF Signal Analysis)**: Signal strength analyzer
- **Sensor C (Seismic Sensor)**: Ground vibration detector

Each sensor outputs a confidence score for the binary class "Threat Present".

Sensor Readings for One Event

Sensor	Prediction	Historical Reliability (Weight)
A	0.90	0.6
B	0.30	0.9
C	0.55	0.3

[**A**] If you apply reliability-weighted late fusion, defined as:

$$\text{Final Threat Confidence} = \frac{(A_{\text{prediction}} \times A_{\text{weight}}) + (B_{\text{prediction}} \times B_{\text{weight}}) + (C_{\text{prediction}} \times C_{\text{weight}})}{A_{\text{weight}} + B_{\text{weight}} + C_{\text{weight}}}$$

What is the final threat confidence score? (Answer to 2 decimal places) **1 Mark**

Answer: 0.54

Calculation:

$$\text{Final Threat Confidence} = \frac{(0.90 \times 0.6) + (0.30 \times 0.9) + (0.55 \times 0.3)}{0.6 + 0.9 + 0.3}$$

$$= \frac{0.54 + 0.27 + 0.165}{1.8} = \frac{0.975}{1.8} = 0.54$$

Marking:

- Correct calculation with answer 0.54: 1 mark
- No partial marking

[**B**] Given the computed **0.54**, and a decision threshold of **0.65**, will the system raise a threat alert?
1 Mark

Answer: No, the threat alert will not be triggered since the final confidence score (0.54) is below the threshold of 0.65.

Marking:

- For answering "No" to raising the alert: 0.5 marks
- For correct inference using part (a) result: 0.5 marks

[**C**] Explain why early or mid fusion strategies might perform better or worse than this late fusion approach in this scenario. Your answer should consider:

- Sensor disagreement
- Cross-modal feature correlation
- Robustness to sensor bias

1 Mark

Answer:

Early Fusion:

- **Pros:** Can directly capture low-level cross-modal correlations (e.g., specific visual patterns that correlate with particular RF signatures).
- **Cons:** Sensitive to sensor biases and scaling differences; one modality may dominate others.
- In this scenario: Would likely be confused by the strong disagreement between sensors A and B.

Mid Fusion:

- **Pros:** Extracts meaningful features from each modality before fusion, allowing better cross-modal pattern recognition.
- **Cons:** More complex architecture, requires more training data.
- In this scenario: Could learn that when A shows high confidence but B shows low confidence, certain features from C become particularly important.

Late Fusion (Current Approach):

- **Pros:** Simple, interpretable, handles different reliabilities explicitly.
- **Cons:** Cannot model interactions between sensor outputs, treats each prediction independently.
- In this scenario: The weighted averaging handles basic reliability differences but misses potential complex relationships between sensors.

Best Approach: Mid fusion would likely perform best here as it can learn context-specific relationships between modalities while still maintaining some modality-specific processing.

Marking:

- For identifying that mid or early fusion would perform better: 0.5 marks
- For proper justification: 0.5 marks

Q7. A smart building uses 15 temperature sensors (0.3W each), 10 light sensors (0.2W each), and 5 motion sensors (0.5W each). Calculate the total daily power consumption if all sensors operate continuously. How much power could be saved annually by implementing a system that turns off light sensors at night (8 hours per day)? **2 Marks**

Answer:

Total power consumption:

- 15 temperature sensors $\times$ 0.3W = 4.5W
- 10 light sensors $\times$ 0.2W = 2.0W
- 5 motion sensors $\times$ 0.5W = 2.5W
- Total: 9.0W

Daily consumption with continuous operation:

- 9.0W $\times$ 24 hours = 216 Watt-hours per day

With light sensors off for 8 hours:

- Light sensors off: (15 $\times$ 0.3W + 5 $\times$ 0.5W) $\times$ 8 hours = (4.5W + 2.5W) $\times$ 8 hours = 56 Watt-hours
- Light sensors on: 9.0W $\times$ 16 hours = 144 Watt-hours
- Total: 200 Watt-hours per day

Daily savings: 216 - 200 = 16 Watt-hours per day

Annual savings: 16 Watt-hours $\times$ 365 days = 5,840 Watt-hours = 5.84 kWh per year

Marking:

- (a) Correct calculation of total power: 1 marks
- (b) Correct calculation of savings with light sensors off: 0.5 marks
- Correct calculation of annual savings: 0.5 marks