DOMAIN 1: AI, Automation, Robotics & Drone Technology

PS-1.1: City-Scale AI-Driven Urban Risk Intelligence System

Problem Description

Modern urban environments face compound and cascading risks such as flooding, heatwaves, and air pollution due to climate change, rapid urbanization, and aging infrastructure. These risks are spatio-temporal, uncertain, and interdependent, making traditional rule-based systems ineffective.

Participants are required to design an AI-driven early warning and decision-support system that integrates real-time IoT data, satellite imagery, historical climate data, and urban infrastructure information to predict risks and support informed decision-making by city administrators.

Objectives

- Predict and monitor urban flooding, heatwaves, and air pollution events
- Fuse heterogeneous real-time and historical data sources
- Provide explainable insights for policymakers
- Support scenario-based policy simulations

Constraints

- Incomplete, noisy, or missing sensor data
- Real-time or near-real-time processing requirements
- Scalability from local (ward) to city level
- Explainability for non-technical stakeholders

Expected Deliverables

- AI/ML models for risk prediction
- Interactive decision-support dashboard
- Explainability and uncertainty visualization
- System architecture and technical documentation

PS-1.2: Explainable Multi-Modal AI Framework for Medical Diagnosis

Problem Description

Healthcare AI solutions often fail in resource-constrained hospitals due to data silos, lack of interpretability, and fairness concerns. There is a need for a clinically reliable and explainable AI system that can integrate diverse medical data while adhering to ethical and regulatory requirements.

Participants must design a multi-modal diagnostic AI framework integrating medical images, EHRs, lab reports, and wearable data.

Objectives

- Enable accurate multi-modal medical diagnosis
- Ensure model explainability and trust
- Detect and mitigate demographic bias
- Enable deployment in low-resource settings

Constraints

- Limited computational and storage resources
- Regulatory and privacy constraints
- Trade-off between accuracy and interpretability

- Integration with existing clinical workflows

Expected Deliverables

- Multi-modal AI diagnostic model
- Explainability module (visual/textual)
- Bias and fairness evaluation report
- Deployment feasibility analysis
- Demonstration prototype

PS-1.3: Multi-Agent Reinforcement Learning for Traffic Intelligence

Problem Description

Urban traffic systems are dynamic, adversarial, and multi-agent. Traditional traffic signal control systems fail to adapt to real-time changes, leading to congestion and delayed emergency response.

Participants must develop a multi-agent reinforcement learning (MARL) system to optimize traffic signals, predict accidents, and prioritize emergency vehicles.

Objectives

- Optimize traffic signal timings dynamically
- Predict accident-prone scenarios
- Enable emergency vehicle prioritization
- Balance local and global traffic objectives

Constraints

- Partial observability and sensor failures
- Strict real-time decision latency
- Non-stationary traffic behavior
- Safety-critical decision requirements

Expected Deliverables

- MARL-based traffic control model
- Simulation results and performance metrics
- Emergency handling logic
- Visualization dashboard
- Technical documentation

PS-1.4: Cross-Platform Misinformation Intelligence System

Problem Description

Misinformation spreads rapidly across platforms using text, images, videos, and coordinated networks. Manual moderation is insufficient to detect such campaigns.

Participants must develop a cross-platform misinformation detection system capable of identifying fake news, deepfakes, and coordinated disinformation campaigns.

Objectives

- Detect fake news and manipulated media
- Identify coordinated disinformation networks
- Track content provenance

- Support explainable moderation decisions

Constraints

- Multi-lingual and multi-modal data
- Concept drift in evolving narratives
- Free-speech and ethical considerations
- Platform interoperability

Expected Deliverables

- NLP and vision-language detection models
- Network analysis and visualization
- Provenance tracking module
- Explainability report
- Functional demo

PS-1.5: Autonomous Infrastructure Monitoring via Drones

Problem Statement

Manual inspection of infrastructure is costly, slow, and unsafe. Cities require autonomous drone-based inspection systems for early detection of structural anomalies.

Objectives

- Perform automated visual inspection.
- Detect cracks, corrosion, and deformation.
- Predict maintenance needs.
- Reduce inspection time and risk.

Constraints / Challenges

- Weather-induced vision degradation.
- Limited flight time.
- Structural anomaly class imbalance.
- Regulatory flight constraints.

Expected Deliverables

- Drone-based vision model.
- Structural anomaly detection pipeline.
- Predictive maintenance analytics.
- Inspection report generation system.

PS-1.6: AI-Enabled Disaster Response and Search-and-Rescue Robotics

Problem Description

Natural and man-made disasters such as earthquakes, floods, fires, and industrial accidents require rapid and coordinated search-and-rescue (SAR) operations. Human responders face high risk, limited visibility, and time-critical constraints.

Participants must design an AI-powered robotic and drone-assisted SAR system that autonomously explores disaster zones, detects survivors, and supports rescue planning.

Objectives

- Detect human presence using vision, thermal, and audio data
- Enable autonomous navigation in unstructured environments
- Prioritize rescue tasks based on risk and survivability
- Provide real-time situational awareness to rescue teams

Constraints

- Limited communication connectivity
- Harsh and dynamic environments
- Battery and payload limitations
- Safety and reliability requirements

Expected Deliverables

- AI-based survivor detection models
- Autonomous navigation and exploration logic
- SAR coordination dashboard
- Simulation or field-test results

PS-1.7: Intelligent Robotic Automation for Smart Warehousing

Problem Description

Modern warehouses require high efficiency, accuracy, and adaptability to dynamic demand. Traditional automation systems lack intelligence, flexibility, and real-time optimization.

Participants must develop an AI-driven robotic warehouse automation system for inventory handling, order picking, and logistics optimization.

Objectives

- Optimize robot task allocation and path planning
- Enable vision-based object recognition and picking
- Predict demand and optimize inventory placement
- Improve throughput and energy efficiency

Constraints

- Multi-robot coordination challenges
- Dynamic obstacles and layout changes
- Real-time decision-making requirements
- Integration with legacy warehouse systems

Expected Deliverables

- Robotic control and coordination algorithms
- Vision-based object detection and grasping model
- Warehouse simulation and performance metrics
- System architecture documentation

PS-1.8: AI-Driven Precision Agriculture using Autonomous Drones and Robots

Problem Description

Agriculture faces challenges such as water scarcity, crop diseases, and inefficient resource usage. Precision agriculture using AI and robotics can significantly improve productivity and sustainability.

Participants must design an autonomous system using drones and ground robots for crop monitoring, disease detection, and targeted intervention.

Objectives

- Monitor crop health using multi-spectral imagery
- Detect pests, diseases, and nutrient deficiencies
- Enable targeted spraying and irrigation
- Improve yield while reducing resource wastage

Constraints

- Variability in crop types and field conditions
- Limited rural connectivity
- Environmental and weather uncertainty
- Cost constraints for small-scale farmers

Expected Deliverables

- AI models for crop health analysis
- Drone/robot navigation and task execution logic
- Precision intervention strategy

- Farmer-friendly dashboard or mobile app

PS-1.9: Autonomous Surveillance and Threat Detection System

Problem Description

Critical infrastructure such as airports, borders, power plants, and campuses require continuous surveillance to detect intrusions and anomalous activities.

Participants must develop an AI-enabled autonomous surveillance system using drones, cameras, and sensors for real-time threat detection and response.

Objectives

- Detect unauthorized intrusions and suspicious behavior
- Perform real-time video analytics
- Enable autonomous patrol planning
- Provide explainable alerts to security operators

Constraints

- High false-alarm sensitivity
- Privacy and ethical considerations
- Adverse lighting and weather conditions
- Scalability across large areas

Expected Deliverables

- Vision-based anomaly detection models
- Autonomous patrol and coverage algorithms
- Alerting and visualization system
- Evaluation on simulated or real datasets

PS-1.10: Human-Robot Collaboration System for Industrial Safety

Problem Description

In industrial environments, close collaboration between humans and robots increases productivity but introduces safety risks if not properly managed.

Participants must design an AI-powered human–robot collaboration system that ensures safety, adaptability, and efficiency in smart manufacturing setups.

Objectives

- Detect human presence and intent in real time
- Enable adaptive robot behavior for safe collaboration
- Predict and prevent potential accidents
- Optimize task sharing between humans and robots

Constraints

- Strict industrial safety standards
- Low-latency perception and control
- Occlusions and sensor noise
- Diverse human behavior patterns

Expected Deliverables

- Human intention and activity recognition models
- Safe robot control and motion-planning algorithms
- Risk assessment and mitigation module
- Demonstration prototype or simulation