FACULTY OF COMPUTING

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SECJ3553 – ARTIFICIAL INTELLIGENCE

SECTION 3

ASSIGNMENT 1: SMART URBAN APPLICATION

THEME: SMART CITY

LECTURER: DR. NORSHAM BINTI IDRIS

GROUP 7

NAME OF STUDENTS	MATRIC NO.
TAN ZHI MING	A23CS0189
CHUA JIA LIN	A23CS0069
NAZMI HAIKAL BIN KHAIRUL	A23CS0145
POH LOK YEE	A23CS0262

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Knowledge Representation

1. Environmental Data Collection (IoT Sensor Layer)

This KR defines how the Iot sensor capture and organize the environmental variables such as rainfall intensity , humidity and river water level. This ensure the sensor data can keep continuously be collected , verified and formatted for downstream AI analysis, providing the reliable real-time environmental awareness for the flood prediction

- IF rainfall_intensity is HIGH THEN flood_risk INCREASES
- IF river_level > safety_limit THEN flood_warning_status = ACTIVE
- IF sensor_status = OFFLINE THEN data_collection = PAUSED

Explanation:

This supplies the real-time environmental input required for the AI system to identify early indicators of KR flooding. Without accurate and continuous data input, prediction models cannot be trusted. Thus, this KR guarantees raw input integrity, which is essential for reliable flood risk analysis and timely early warning notification.

First Order Logic:

- ∀x (Sensor(x) → Collects(x, data(x)))
- ∀x (Collects(x, data(x)) ∧ HighRainfall(data(x)) → Increase(FloodRisk))
- ∀x (Collects(x, data(x)) ∧ AboveThreshold(RiverLevel(data(x))) → Activate(FloodWarning))
- ∀x (SensorOffline(x) → Pause(DataCollection))

For every entity x, if x is a sensor, then x collects its corresponding data.

For every entity x, if x collects its data and that data indicates high rainfall, then the system should increase the flood risk level.

For every entity x, if x collects its data and the river-level information in that data exceeds a safe threshold, then a flood warning is activated.

For every entity x, if x is offline, then data collection is paused.

2. Flood Prediction Model

This flood prediction model is a crucial tool used to analyse and predict the flood events. It deconstructs several environmental elements such as rainfall intensity, water level in river, humidity and drainage performance in algorithms. This model identifies the patterns and forecasts the possible flood events using both historical and current data. It is a systematic way of interpreting the complex data patterns that enable the system to effectively predict the floods and forms the foundation of precise forecasting the floods.

- *IF (rainfall_intensity = high AND river_level = rising) OR (rainfall_intensity = moderate AND drainage_status = blocked) THEN flood_risk = high*
- *IF (humidity = high AND rainfall_intensity = high) OR (past_flood_pattern = similar_current_conditions) THEN predict_flood_event = true*
- *IF (flood_risk = high OR predict_flood_event = true) THEN send_alert = on*

Explanation:

Flood prediction model enables the system to identify trends and forecast possible floods in advance. It forecasts the future by predicting the existence of indicators and analysing previous and current data through machine learning algorithms, therefore, providing early warnings to residents and authorities. It assists in making prompt decision, being better prepared and reducing the effects of floods, which directly corresponds to the mission of the AI system to increase the possibility to predict, monitor, and react accordingly.

First Order Logic:

- $\forall x\ [((HighRainfall(x) \land RisingRiver(x)) \lor (ModerateRainfall(x) \land BlockedDrainage(x))) \rightarrow HighFloodRisk(x)]$
- $\forall x\ [((HighHumidity(x) \land HighRainfall(x)) \lor SimilarPattern(x)) \rightarrow PredictFlood(x)]$
- $\forall x\ [(HighFloodRisk(x) \lor PredictFlood(x)) \rightarrow SendAlert(x)]$

For every location x, if x records high rainfall and rising river levels, or moderate rainfall combined with blocked drainage, then the flood risk for that area is considered high.

For every location x, if x records both high humidity and high rainfall, or if the current environmental conditions are similar to past flood patterns, then the system predicts a flood event.

For every location x, if there is a high flood risk or a predicted flood event, then the system sends an alert to the authorities and residents for that area

3. **Alert and Communication System**

This system enables real-time communication among all users. Once high flood risk is detected, flood alerts will be sent to the residents, city planners, and emergency rescue teams. This makes sure that every user can prepare early for the flood.

- *IF (water_level = high OR is_clogged = true) AND raining = true THEN predicted_flood_risk = high*
- *IF predicted_flood_risk = high THEN send_alert = residents, city_planners, emergency_teams*
- *IF alert_received = residents THEN activate_preventive_measures = true*
- *IF alert_received = city_planners THEN prepare_response_measures = true*
- *IF alert_received = emergency_teams THEN standby_rescue_teams = true*
- *IF alert_received = residents OR alert_received = city_planners OR alert_received = emergency_teams THEN communication_channel = on*

Explanation:

This system estimates the possibility of flooding and notifies all users. When water levels are high or the drainage is clogged, and it is raining, the AI system will predict a high flood risk and will automatically send alerts to residents, city planners, and emergency teams. Besides, each user group's response is also defined. This enables real-time communication and coordination to response towards flood effectively.

First Order Logic:

- ∀ *x (((water_level(x)* ∧ *high(x))* ∨ is_clogged(x)) ∧ *raining(x))* → *predicted_flood_risk(high)*
- ∀ *r; c, e predicted_flood_risk(high)* → *(send_alert(r)* ∧ *send_alert(c)* ∧ *send_alert(e))*
- ∀ *r alert_received(r)* → *activate_preventive_measures(r)*
- ∀ *c alert_received(c)* → *prepare_response_measures(c)*
- ∀ *e alert_received(e)* → *standby_rescue_teams(e)*
- ∀ *r, c, e(alert_received(r)* ∨ *alert_received(c)* ∨ *alert_received(e))* → *communication_channel(on)*

For every location x, if the water level is high or the drainage is clogged, and it is also raining, then high flood risk is detected.

For every resident r, city planner c, and emergency rescue team e, if the flood risk prediction is high, then an alert will be sent to them.

For every resident r, if they receive the alert, then they will activate preventive measures.

For every city planner c, if they receive the alert, then they will prepare response measures.

For every emergency team e, if they receive the alert, then rescue teams will standby to rescue the residents.

For every resident r, city planner c, and emergency team e, if any of them receive the alert, then the temporary communication channel will be turned on for coordination and quick response.

4. **Geographic Information System and Decision Support System**

This Knowledge Representation (KR) determines how flood prediction data, sensor readings, and alert information are able to be visualized and represented through the system's dashboard using Geographic Information System (GIS).

- *IF flood_risk = high THEN map_indicator = red_zone*
- *IF flood_risk = moderate THEN map_indicator = yellow_zone*
- *IF flood_risk = low THEN map_indicator = green_zone*
- *IF new_sensor_data_received = true THEN update_dashboard = true*
- *IF dashboard_updated = true THEN decision_support = enabled*

Explanation:

By converting the system's analytical outputs into understandable information for users, this KR helps the suggested AI solution. All flood-related data, such as risk levels, rainfall intensity, and impacted areas, are presented in an easy-to-use format by GIS. It directly contributes to the project's objective of improving flood response, monitoring, and prediction. Residents can understand where areas are at risk and take the appropriate preparations, city planners and emergency personnel can make quicker and better decisions all thanks to a centralized real-time software. Additionally, by displaying historical data and patterns, this KR aids in long-term flood control by enabling official entities to plan drainage system upgrades and lessen the effects of upcoming floods.

First Order Logic (FOL):

- $\forall x\ (HighFloodRisk(x) \rightarrow MapIndicator(x,\ RedZone))$
- $\forall x\ (ModerateFloodRisk(x) \rightarrow MapIndicator(x,\ YellowZone))$
- $\forall x\ (LowFloodRisk(x) \rightarrow MapIndicator(x,\ GreenZone))$
- $\forall x\ (NewSensorData(x) \rightarrow UpdateDashboard(x))$
- $\forall x\ (DashboardUpdated(x) \rightarrow EnableDecisionSupport(x))$

Explanation of FOL:
For every location x, if the flood risk is high, it is marked as a red zone on the map; if moderate, a yellow zone; if low, a green zone. The dashboard changes in response to new sensor data, triggering the decision support system that helps users understand and effectively address flood hazards.

5. **Drainage Situation Analysis and Management**

It will detect the condition of the drainage and will send maintenance alerts if necessary. After maintenance is done, it will update the drainage condition.

- *IF is_clogged = true THEN send_maintenance_alert = city planner*
- *IF maintenance_alert_received = true THEN maintenance = true*
- *IF maintenance_completed = true THEN is_clogged = false*
- *IF (water_level = high OR is_clogged = true) AND raining = true THEN predicted_flood_risk = high*

Explanation:

It detects, reports, and updates the drainage conditions. If a clog is detected in the drainage, the system will send a maintenance alert and will update the drainage condition after the maintenance is completed. Besides, it will also estimate flood risk based on the drainage condition. This will ease the drainage monitoring and detect flood risk at early stage.

First Order Logic:

- *∀x is_clogged(x) → send_maintenance_alert(city_planners)*
- *∀x maintenance_alert_received(city_planners) → maintenance(x)*
- *∀x maintenance_completed(x) → ¬ is_clogged(x)*
- *∀ x (((water_level(x) ∧ high(x)) ∨ is_clogged(x)) ∧ raining(x)) → predicted_flood_risk(high)*

For all drainage systems x, if a clog in drainage is detected in the drainage, then a maintenance alert will be sent to the city planners.

For all drainage systems x, if the city planners receive the maintenance alert, then they will start doing the maintenance.

For all drainage systems x, if the maintenance is done, then the drainage is not clogged anymore.

For every location x, if the water level is high or the drainage is clogged, and it is also raining, then high flood risk is detected.

Knowledge Representation Involved to Achieve Goals

The proposed AI-flood management system integrates five KRs , which work together to provide accurate prediction, timely alert, and the correct decision making. First, the environmental data acquisition of KR ensures that real-time sensor inputs such as precipitation, humidity, and river water levels can be reliably acquired. This forms the basic knowledge necessary for all subsequent arguments. Without reliable input, the prediction and analyst would not be accurate.

Next, data processing and machine learning knowledge rules transform the raw data into meaningful patterns and predictive insights by analyzing historical and real-time information. This helps the system to predict the potential flood incident, recognize the risk trends, and send early warnings, helping authorities and communities prepare for the flood. The logical knowledge-based supports the goal by defining the environmental signal and the relationship between the signal and related system responses. When the sensor detects the rise of water level or blockage occur, the system will increase the flood risk and trigger the related alarm or alert. These rules ensure the automated reasoning and emergency response correspond to the actual situation.

The proposed AI flood management system integrates five KRs which work together to provide accurate prediction, timely warning, and wise decision. First, the environmental data acquisition of KR ensures that real-time sensor inputs such as precipitation, humidity, and river water levels can be reliably acquired. This forms the basic knowledge for all subsequent arguments. Without reliable input, the prediction and analysist would not be accurate.

Next, the data processing and machine learning transform the raw data into meaning models and predictive insights by analyzing historical and real time information. This helps the system in predicting the flood incident, identifying the risk trend and issue early warnings, helping the authorities and communities prepare for the flood.

This will be achieved by the logical knowledge base, which outlines the relationships between environmental signals and the associated system responses. For example, when indications of rising water levels and/or blocked drainage are received, the system will deduce a rise in flood risk and trigger mechanisms for setting alarms. These parameters will ensure that emergency responses and automated reasoning correspond to what is taking place.

Apart from that, KR also uses visualization and insight tools like dashboards and GIS maps to transform the results of analysis into an understandable format. This improves response efficiency, enabling citizens, officials, and emergency personnel to instantly determine the degree of risk, the areas affected, and the recommended actions.

Finally, maintenance and monitoring of the drainage system guarantee continuous risk management, by monitoring drainage conditions and automatically clearing blockages.