Faculty of Computing

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SECJ3553 Artificial Intelligence

Section 07

Task 2 Assignment 1

Project Theme:

**Smart City - Traffic & Parking Advisor Application (Parkora.ai)**

Team: TriSpark Tech

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## 6.0 Knowledge Representation (KR)

## 6.1 Overview of Knowledge Representation in Parkora.ai

Knowledge Representation (KR) is a crucial component of artificial intelligence that focuses on how information about the world can be formally structured, stored and processed by machines to perform reasoning and decision-making. In Parkora.ai, KR enables the system to represent essential knowledge about parking areas, roads, vehicles, time, and user preferences in a machine-understandable form.

KR serves as the "knowledge backbone" of Parkora.ai, allowing the AI algorithms to reason intelligently about real-time and historical data gathered from multiple sources. This knowledge is derived from:

- IoT-enabled parking sensors (to detect space occupancy),
- Traffic and navigation APIs such as Google Maps (to access live road data),
- Historical parking datasets (to support predictive modeling).

The system employs a hybrid KR approach that combines structured data representation, semantic networks and First Order Logic (FOL) to model relationships between different entities such as:

- Parking spaces and their occupancy status
- Roads and their congestion levels
- Routes connecting locations
- User preferences for proximity and cost
- Temporal knowledge for predicting parking availability

Through this logical framework, Parkora.ai is capable of reasoning, inferring and predicting optimal actions for the user. Logical rules allow the system to not only identify available parking spots but also infer future availability, choose the best route, and avoid congested areas, all in real time.

## 6.2 Logical Representations of Knowledge (FOL)

This section defines at least five (5) logical representations that are essential for Parkora.ai's AI-driven decision-making. Each KR is represented using First Order Logic (FOL) with appropriate logical connectives and quantifiers.

- ParkingLot(p) defines the entity as a parking area.
- Space(s) represents an individual parking space.
- In(s, p) indicates that the space s belongs to the parking lot p.
- ¬Occupied(s) means that the space is currently free.

**KR 1: Parking Availability Representation**

The system must know which parking lots currently have free spaces. This is the foundational knowledge for real-time decision-making. IoT sensors installed in parking lots continuously transmit data on whether a parking space is occupied or vacant.

FOL Representation:

$$\forall p\ (ParkingLot(p) \rightarrow (Available(p) \leftrightarrow \exists s\ (Space(s) \land In(s, p) \land \neg Occupied(s))))$$

This formula states that for every parking lot p, it is considered available if and only if there exists at least one parking space s that is part of p and is not occupied.

This knowledge representation (KR) directly supports Parkora.ai's main objective which is helping users find available parking efficiently, reducing the time and fuel wasted when searching for empty spots.

**KR 2: Optimal Route Selection**

The AI must determine the most efficient route that connects a user's location to a parking space, considering both traffic congestion and distance.

FOL Representation:

$\forall r\ \forall p\ ((Route(r) \land Connects(r, UserLocation, p) \land Available(p) \land LeastCost(r)) \rightarrow OptimalRoute(r))$

This statement means that for all routes r and parking lots p, if route r connects the user's current location to parking lot p, and p is available, and r has the least travel cost (time, congestion or distance), then r is the optimal route.

The AI uses search algorithms such as Dijkstra's algorithm or A* to find the route with the minimal cumulative cost, represented by LeastCost(r). Cost factors include distance, congestion and estimated travel time.

This KR enables intelligent route optimisation, helping users reach available parking quickly while reducing congestion and fuel consumption. In addition, it supports the system's broader goals of promoting sustainability and enhancing overall travel efficiency.

**KR 3: Time-Based Parking Prediction**

The AI system should predict parking availability at different times of the day based on historical occupancy patterns.

FOL Representation:

$\forall p\ \forall t\ ((ParkingLot(p) \land HighOccupancy(p, time\_past)) \rightarrow LikelyUnavailable(p, time\_now))$

This representation means that if a parking lot p has historically experienced high occupancy at a certain time interval *time_past*, it is likely to be unavailable at a similar time *time_now*.

The AI model uses machine learning to learn occupancy patterns such as peak hours on weekdays. Using this knowledge, Parkora.ai predicts future availability and notifies users before they reach their destination.

This predictive capability reduces user frustration by avoiding full lots before arrival and promotes proactive planning, aligning with the goal of minimising stress and improving convenience.

**KR 4: User Preference and Proximity Rule**

The AI system should consider user preferences when recommending parking, such as proximity to the destination, safety or pricing.

FOL Representation:

$\forall p\ ((\text{Available}(p) \land \text{Near}(p, \text{Destination})) \rightarrow \text{Preferred}(p))$

This logical rule states that a parking lot p becomes preferred if it is both available and near the user's destination. Additional parameters such as pricing or security level, can also be integrated into the reasoning process using extended predicates.

This representation allows Parkora.ai to tailor parking suggestions according to personalised user profiles and contextual information, enhancing user satisfaction.

By aligning parking recommendations with user preferences, this KR ensures a user-centred experience to support the goal of improving convenience and comfort in daily driving.

**KR 5: Traffic Congestion Reasoning**

The system needs to recognise congested roads and use this information to reroute drivers.

FOL Representation:

$\forall r\ ((\text{Road}(r) \land \text{VehicleDensity}(r) > \text{Threshold}) \rightarrow \text{Congested}(r))$

This logical statement means that a road segment r is marked as congested if the number of vehicles per unit distance exceeds a pre-defined threshold. Data for VehicleDensity(r) can be obtained through API inputs or traffic cameras. Once identified, these congested routes are deprioritised in route computation, guiding users through alternative, faster paths.

By dynamically avoiding congested roads, this KR directly contributes to reducing travel time and traffic buildup, promoting smoother traffic flow and efficient navigation.

### 6.3 How KR Supports the AI Solution

The Parking Availability KR is important in Parkora.ai. It uses real-time data from IoT parking sensors to see which lots have free spaces. This helps the system know which spots are occupied or empty. With this information, users can find parking faster and avoid circling. This supports the goal of showing available parking in real time.

The Optimal Route Selection KR finds the best routes to available parking. It uses algorithms like Dijkstra or A* and looks at travel time, congestion, and distance. This helps users reach parking quickly and reduces traffic. It supports smoother and more efficient driving.

The Time-Based Prediction KR predicts future parking availability. It uses past data to learn trends, like peak hours or busy events. This helps users plan ahead and avoid full lots. It gives the system a way to predict instead of just react.

The User Preference Rule KR adds user choices to parking suggestions. It considers distance, cost, safety, or walking distance. This makes the recommendations more useful and convenient. It improves user satisfaction and creates a stress-free parking experience.

The Traffic Congestion Rule KR checks road traffic levels. If a road is too busy, the system avoids it and suggests a better route. This reduces delays and helps traffic flow, making travel faster and more reliable.