An Ethical-Aware Intelligent Patrol Allocation Agent for Dynamic Risk Zones

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1 Introduction

Urban safety management requires allocating limited patrol resources across multiple regions while responding to dynamically changing risk levels. Traditional static patrol schedules are inefficient and fail to adapt to temporal patterns in incident data. Additionally, naive automation risks over-concentration of resources in specific regions, raising ethical concerns.

This project proposes an **intelligent decision-support agent** that predicts abstract *risk intensity* levels for city zones and allocates patrol units rationally while enforcing fairness constraints. The system is designed to assist human decision-makers rather than operate autonomously.

2 Intelligent Agent Design

The proposed system is a **learning, model-based rational agent**. It maintains an internal model of zone risks and patrol locations and selects actions that maximize a defined performance measure.

Task Environment Analysis

- **Observability**: Partially observable (risk inferred from data)
- **Dynamics**: Static per decision cycle
- **State Space**: Discrete (zones and patrol units)
- **Determinism**: Deterministic planning phase

PEAS Framework

- **Performance Measure**: High-risk coverage, patrol distance cost, fairness violations
- **Environment**: Simulated city grid divided into zones
- **Actuators**: Patrol allocation actions
- **Sensors**: Historical incident data and temporal features

3 Proposed AI Techniques

3.1 Statistical Learning for Risk Prediction

A supervised learning model classifies each zone into *Low*, *Medium*, or *High* risk.

- **Model**: Random Forest (with Logistic Regression baseline)
- **Features**: Time of day, day of week, historical incident density
- **Justification**: Models non-linear patterns, robust to noise, and generalizes better than a single decision tree
- **Evaluation**: Accuracy, Precision, Recall, and F1-score

3.2 Search-Based Planning for Patrol Allocation

Using predicted risk levels, the agent allocates patrol units to zones.

- **State**: Patrol locations and zone risk levels
- **Actions**: Assign patrol unit to zone
- **Objective**: Maximize high-risk coverage while minimizing travel cost
- **Algorithm**: A* search or constrained greedy planning

Correctness and Efficiency

- **Completeness**: A* guarantees a solution if one exists
- **Optimality**: Optimal under admissible heuristics
- **Time Complexity**: Exponential in the worst case
- **Space Complexity**: Stores explored states

4 Ethical Considerations

To mitigate ethical risks such as bias amplification and over-policing, the agent enforces a fairness constraint: no zone may receive continuous patrol assignments beyond a predefined threshold unless its predicted risk exceeds a specified limit. This embeds ethical reasoning directly into the agent's decision-making process.

5 Evaluation Strategy

The learning component is evaluated using classification metrics, while agent behavior is evaluated using:

- Percentage of high-risk zones covered
- Average patrol distance
- Fairness constraint violations

Results are compared against random and risk-only baseline strategies.

6 Conclusion

This project integrates statistical learning and search-based planning to design a rational, ethical-aware intelligent agent. The system demonstrates core artificial intelligence principles including agent rationality, model selection, and algorithmic correctness while addressing societal concerns.