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BBAX: AN INTEGRATION OF BLACKBOARD ARCHITECTURE AND EXPLAINABLE AI FOR SMART URBAN MOBILITY

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Summary: The increasing complexity of urban mobility systems demands advanced decision-making frameworks capable of integrating real-time data, adapting to changing conditions, and improving transport efficiency. The Blackboard Architecture (BBA), an AI-driven knowledge-based system and an extension of expert systems, provides a robust solution for facilitating intelligent problem-solving in dynamic environments.

BBA operates on a shared knowledge space where multiple knowledge sources (KSs) contribute to solving a complex problem collaboratively and opportunistically. This architecture can be particularly well-suited for urban mobility applications, where diverse data streams, such as traffic congestion, public transport schedules, pedestrian flows, and weather conditions, must be processed and synthesized efficiently.

This study introduces BBAX, an extended BBA integrated with an explanation engine to enhance transparency and trust in decision-making processes. This module is commonly used in expert systems but rarely implemented in a BBA due to its complexity. Explainable AI (XAI) acts as an intermediary between the inference mechanism and end-users, providing real-time justifications for the proposed solutions.

Traditional AI models often function as black boxes, making it challenging to interpret their decisions. Therefore, XAI is commonly used to enhance the transparency of AI prediction models. On the other hand, our approach extends its application to a complex AI architecture, the blackboard system. By integrating XAI into a BBAX, we ensure interpretability not only at the prediction level but also within the collaborative decision-making process of the architecture. This allows stakeholders to validate, understand, and trust the system's outcomes, fostering greater confidence in its real-time transport optimization solutions.

In this study, interpretability is specifically applied within the context of urban mobility. As intelligent transport systems increasingly rely on machine learning and heuristic decision-making models, users and stakeholders require transparent insights into the decision-making process.

Furthermore, the architecture incorporates dynamic feedback, allowing users, such as transport operators, to interact with and refine the decision-making process. This adaptability enhances the efficiency of transport management, fostering a more resilient and user-centric mobility ecosystem.

The validation of this architecture was performed through a simulation that was developed to optimize schedules already planned for trains and buses according to the meteorological conditions at Ermesinde Station (Porto, Portugal). The simulated scenarios encompass various time slots, ensuring adaptability to different operational hours while dynamically adjusting to real-time weather conditions.

The findings of this research contribute to the growing field of AI-driven smart mobility solutions by showcasing how BBAX can be leveraged for real-time transport optimization. Additionally, the integration of an explanation module (XAI) addresses a fundamental limitation in AI systems, lack of transparency, thereby fostering greater trust and acceptance of automated decision-support frameworks in urban mobility planning.

Future work will explore more simulation scenarios integrating additional factors such as environmental sustainability. By expanding the capabilities of BBAX in urban mobility contexts, this research paves the way for more intelligent, dynamic, adaptive, and explainable transport systems, ultimately contributing to more sustainable and efficient urban mobility networks.