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CMPE 491 - Project Specifications Report

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SCHEDULE OPTIMIZATION FOR PUBLIC TRANSPORTATION SYSTEMS

1. Introduction

1.1 Description

As students ourselves, we actively use public transportation systems in our daily lives and we depend on it to sustain our transportation needs. Due to this regular usage, we faced certain issues related to these systems. After gathering opinions from other regular users, the issues seemed to be originating mainly from these problems:

1. **Irregular Schedules and Delays:** Uncertain schedules and frequent delays result in extended wait times, which negatively impact the customer experience overall.
2. **Overcrowding and Underutilization:** Inefficient resource allocation that does not effectively satisfy passenger demand is shown in the gap between underutilized services on certain routes and high crowding on others.
3. **Limited Adaptability to Usage Patterns:** The system's limited ability to adapt to both peak and off-peak usage is caused by the fact that current schedules are not altered in response to past passenger demand patterns.

Being a group of computer engineering undergraduates, we used brainstorming to see if a more efficient way could be developed that minimized these problems. After that, we decided to work on this project.

By using innovative AI-driven optimization strategies that are appropriate for the requirements of Ankara's public transportation system, this project aims to address these problems. Our AI-based system will automatically modify transport schedules to better match passenger demand patterns by utilizing data analysis and predictive modeling. The goals of this adaptive scheduling strategy are to increase resource efficiency, decrease crowding, and shorten wait times.

Our objective is to improve the operational reliability and sustainability of the public transportation system while offering Ankara citizens a more seamless and effective experience. In partnership with the Ankara Metropolitan Municipality, this project aims to create a responsive, intelligent transportation system that enhances passenger experiences while advancing the creation of more intelligent urban planning.

1.2 Constraints

- **Economic Constraints**: Without any sponsorship, the budget is very limited and impacts every aspect of development, from data collection and processing to AI model training and maintenance. The cost of high-performance hardware, data storage, and server infrastructure for real-time analytics could be significant. Our budget and sponsors will influence the scale at which we can deploy and test the AI system, potentially limiting the number of routes initially included or the extent of predictive accuracy achievable.

- **Environmental Constraints**: One of the project's core values is environmental sustainability. Reducing greenhouse gas emissions by optimizing bus usage is critical. An efficient public transport system also encourages more people to opt for public transit over private vehicles, indirectly contributing to reduced pollution and improved air quality.
- **Social Constraints**: User acceptance is crucial to the success of this AI-driven system. Public trust, usability, and accessibility are essential to ensure widespread adoption and use. Additionally, feedback mechanisms will be embedded to gauge public perception and willingness to integrate AI-driven transport solutions.
- **Political Constraints**: Policies governing public transportation, data privacy, and technology in public sectors may limit system implementation.
- **Ethical Constraints**: Addressing privacy issues is essential as the project relies on real-time data; data must be managed responsibly.
- **Health and Safety Constraints**: Health and safety of passengers should be protected by making sure there is minimal overcrowding in public transportation systems.
- **Manufacturability Constraints**: Creating a system capable of being adapted and scaled to various transport networks may have technological limitations.
- **Sustainability Constraints**: Emphasize the long-term viability and environmental sustainability of the optimization methods used.

1.3 Professional and Ethical Issues

- **Data Privacy**: Following ACM and IEEE standards, ensure the system respects user data privacy and is transparent about data collection. Also, a violation of KVKK (General Data Protection Regulations) should be avoided and might limit the usage of data.
- **Transparency**: Users should understand how their data is used to create optimized routes.
- **Equity and Accessibility**: Ensure the system serves all community members fairly, without bias towards specific neighborhoods or demographics.

2. Requirements

System Requirements

1. Functional Requirements

1.1 Public Transportation Schedule Optimization

- The system should use AI algorithms to understand and analyze data.
- The system should generate optimal schedules to minimize waiting time.
- The system should decrease the density of public transportation.
- The system should adapt schedules based on changing conditions.
- The system should add additional trips according to the usage percentages from previous data.
- The system should generate feedback reports on transportation efficiency.

2. Non-Functional Requirements

2.1 Performance Requirements

- Access time for a data point should not exceed 1 second.
- The system must be able to handle large volumes of data.
- The system should be able to process different numbers of lines simultaneously to produce schedules.

2.2 Reliability and Availability

- The passenger data should be reliable and available at all times for the model to continuously produce schedules in given intervals.
- The system should have a high availability to ensure continuous model training.

2.3 Security Requirements

- All the data used should be anonymized and should be in accordance with the laws where applicable.
- The system shall restrict access to authorized personnel for maintenance and monitoring to prevent unauthorized access and data manipulation.

2.4 Usability Requirements

- The system should provide easily visible and understandable new schedules.

3. Technical Requirements

3.1 Hardware Requirements

- A computing system with high GPU power shall be used that enables large scale data analysis and AI model creation.
- A networking system shall be used for data transmission and retrieval.

3.2 Software Requirements

- An AI model shall be developed to provide schedules based on the data it is given.
- An interface for users to interact with the model and retrieve data shall be created.

4. Data Requirements

- The system shall use stored data to analyze crowd information, to enable scheduling predictions.
- Alignment with the Ankara Metropolitan Municipality Guidelines shall be ensured with local regulations and policies on data privacy, safety, and public infrastructure modifications.

5: Operational Requirements

5.1 Maintenance and Support

- Regular maintenance checks for all hardware and software systems shall be performed to ensure optimal performance and accuracy.

5.2 Monitoring and Reporting

- Regular controls of accuracy of crowd detection and user satisfaction rates shall be performed to ensure ongoing optimization and improvement.

3. References

- IEEE. IEEE Code of Ethics. https://www.ieee.org/about/corporate/governance/p7-8.html
- *6698 Sayılı Kişisel Verilerin Korunması Kanunu (KVKK)*, www.mevzuat.gov.tr/mevzuat?MevzuatNo=6698&MevzuatTur=1&MevzuatTertip=5. Accessed 25 Oct. 2024.
- Sjøberg, Dag, et al. Software Constraints for Large Application Systems, Oct. 1997, www.researchgate.net/publication/220459741_Software_Constraints_for_Large_Application_Systems.