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Smart Transportation Systems using AI and IOT

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Abstract

The transportation systems we have now can be pretty bad. They get congested. It is hard to manage the routes. This means we use fuel than we need to and it takes a long time to get help in an emergency. We also do not know what is happening on the roads in time. This research is about a Smart Transportation System that uses artificial intelligence. It is meant to make our roads safer. It is meant to make it easier for people to get around cities. The people who made this system used React.js to create the part that users see Spring Boot to make the backend work and MySQL to store the data safely. This means the system can handle a lot of users and work well. The Smart Transportation System uses intelligence and Internet of Things technology. This helps the system look at traffic in time find the best routes, track vehicles and know when the roads will be congested. The artificial intelligence looks at how the traffic's moving and how the vehicles are moving. This helps make the traffic flow better and makes our trips shorter. The system also tells us away if there is an accident if the road is congested or if we need to take a different route.

The Smart Transportation System is very important. We need to make our roads better and safer. The system uses intelligence, Internet of Things technology and other things, like React.js, Spring Boot and MySQL to make this happen.

Keywords: Smart Transportation System, intelligence, Internet of Things, traffic management, route optimization, React.js, Spring Boot, MySQL, intelligent transportation, urban mobility.

1. Introduction

Around the world cities are getting really crowded and this is causing big problems for the roads. The old ways of managing traffic are not working well because of all the cars on the road people are not working together ambulances are getting stuck in traffic and we are not keeping a close eye on the roads. This is wasting a lot of time and fuel. It is also making the air dirty and causing accidents.

The AI-Integrated Smart Transportation System is an idea that can help solve these problems. This system uses computers to keep an eye on the traffic and make sure everything runs smoothly. The AI-Integrated Smart Transportation System is built using React.js, Spring Boot and MySQL which're like building blocks that help make a strong and safe website for transportation. This means that people who use the roads the people, in charge of the roads and the people who manage the traffic can all talk to each other easily and work together. The AI-Integrated Smart Transportation System is a solution because it helps everyone communicate and makes the roads safer and more efficient.

The new system is really cool because it uses Artificial Intelligence and Internet of Things together to make transportation smarter. The Artificial Intelligence part looks at how busy the roadsre where accidents happen what the weather is like and what the traffic was like before to find the best routes figure out where traffic will be bad and make the traffic lights work better. The Internet of Things sensors and GPS devices collect information about the traffic and the cars in time so the system can change what it does when the roads change.

The main thing we want to do with this study is make a transportation system that's good for cities helps people get around easier reduces traffic jams and makes the roads safer. We also want to send people messages and give them real-time updates so they know what is going on and can get where they are going faster. The system makes traditional transportation better by getting rid of things that do not work well and helps people use transportation that's smarter, safer and better, for the planet. Artificial Intelligence and Internet of Things are used together to make this happen and improve transportation services.

2. Literature Review

The number of people living in cities is growing fast and more people are using roads to get around. This has made researchers and governments want to put money into transportation technologies. Smart Transportation Systems use things, like intelligence and the internet to make transportation better, safer and more environmentally friendly. In this part we will look at how this systemiser being developed and what people are doing to make them work.

2.1 Existing Systems Study

The way we manage transportation has changed a lot from watching traffic to using really smart systems that can do a lot of things on their own. Smart Transportation Systems are getting better and better. We will look at Smart Transportation Systems. See what they can do.

- **Intelligent Traffic Monitoring Systems:**

Today we have traffic management systems that use cameras, GPS devices and road sensors to keep an eye on traffic and see how cars are moving. These systems can get information about how fast carsre going how many cars are on the road how long it takes to get somewhere and if the road is crowded. In smart cities the people in charge of transportation have a central place where they can watch what is happening on the roads and make decisions about how to run things.

A lot of these systems are more about watching what is happening than trying to figure out what will happen next. Even though we can see what is happening on the roads now most systems do not change how they work based on what is happening or help us find the best way to get somewhere. Smart Traffic Monitoring Systems are supposed to make our lives easier, by helping us deal with traffic so Smart Traffic Monitoring Systems should be able to do more than just watch what is happening.

- **Cloud-Based Transportation Platforms**

These days transportation systems are changing to use the cloud so they can handle people and be easier to use. The cloud helps people in charge of transportation store. Look at the big amounts of traffic data that come from sensors and GPS devices. They use Cloud-Based Logistics Platforms to make this happen. Cloud-Based Logistics Platforms are important for this. We have a tool that help us build the backend of these systems. For example, we use Spring Boot and Node.js because they can handle a lot of users and are easy to work with. Cloud-Based Logistics Platforms use these tools to be more efficient. We also have tools that help us build the frontend, which's what people see when they use the system. React.js and Angular are two examples. They help us make transportation dashboards that're easy to use and look good for both regular people and the people in charge. Cloud-Based Logistics Platforms are getting better, with these tools.

- **IoT in Smart Transportation**

The Internet of Things is playing a role in how we travel these days. We have sensors and cameras and GPS trackers and all sorts of Internet of Things devices that are always collecting information about transportation. This information gets sent to computers in the cloud, where special programs look at it and figure out what it means. The Internet of Things is used in a lot of ways to make transportation better such as:

- We can track vehicles in real time with the Internet of Things.
- The Internet of Things helps us manage parking in a smart way.
- The Internet of Things coordinates traffic signals.
- The Internet of Things can detect crashes.
- The Internet of Things monitors the condition of roads
- The Internet of Things helps control transportation.

The Internet of Things has really improved the way transportation systems work. Now they can respond quickly to changes, in traffic.

• AI-Based Transportation Systems:
Artificial Intelligence is really important for making transportation smarter. Artificial Intelligence looks at things like how traffic moves what the weather is like how people commute and when accidents happen to make the system work better. Artificial Intelligence uses ways of learning, like machine learning and deep learning for lots of things including:

- Figuring out when traffic will be bad.
- Finding the best routes.
- Watching how vehicles move.
- Making traffic signals smarter.
- Finding out when accidents might happen.
- Creating cars that can drive themselves.

Some studies have found that using Artificial Intelligence to manage traffic can really help reduce traffic jams, save fuel and cut down on time wasted compared to the old ways of managing traffic. Artificial Intelligence can make a difference, in how we travel.

2.2 Limitations of Current Systems

We still have a lot of problems with transportation systems with all the tech advancements.

- **Limited Real-Time Decision-Making:** Most transportation systems can collect data in time but they can't respond quickly to sudden changes like accidents, roadblocks or natural disasters. This means commuters still get stuck in traffic delays.

- **Traffic Congestion and Fuel Consumption:**
Cities have a problem with too many cars on the road because of growing populations. This causes fuel to be used and more pollution, in the environment. Traffic congestion is an issue and traffic congestion causes a lot of problems. Traffic congestion and fuel consumption are concerns.

- **Data Fragmentation:**
The transportation related data is often stored in different systems that are not connected to each other and are managed by different people. This makes it hard for traffic control people to work together. It makes the studies on transportation not very good.

- **High Cost of Infrastructure:**
To use Internet of Things sensors and smart traffic lights and GPS and artificial intelligence it will cost a lot of money. This can be a problem for countries that're not very rich and for areas that are far from cities.

- **Security Problems:**
Smart transportation systems have information about where people are and where they are going and what they are driving. If the security is not good then these systems can be attacked by hackers and people's information can be stolen.

- **User Adoption:**
Many transportation systems are not made for people who do not know a lot about technology. Older people and people who are not used to technology might have trouble using these systems. Transportation systems like these can be hard for people to use if they are not familiar with transportation systems, like these.

2.3 Role of Security and Reliability

Security and reliability are really crucial for any transportation system. These systems are always talking to each vehicle, sensors, cloud servers and the people using them. So, it is very important that we keep the data safe when it is being sent around. The Smart Transportation System we have made includes these things:

- We make sure users are who they say they are with something called Secure JWT.
- We control what people can do based on their role.
- We make sure the data is safe when it goes from devices to servers.
- We store transportation data in a place in the cloud.

Security and reliability of the system are equally important because transportation systems are always running and need to work in real time. If something goes wrong. Is slow it can affect how traffic is coordinated and it can be bad for the people commuting. Security and reliability are key, to making sure everything works smoothly.

2.4Research Gap

There is a problem with transportation systems right now. Lots of people have done research. Come up with smart ways to make transportation better. We still need a transportation platform that uses artificial intelligence and internet of things technology to make things work together smoothly. We need a platform that can do lots of things like look at traffic help, in emergencies and provide services to commuters all in one place. So, in this study we made a solution that tries to fix this problem. The transportation platform we propose is designed to put intelligence and internet of things technology together in one place.

3. Techniques Used

The AI-Integrated Smart Transportation System is developed using a modern technology stack that supports scalability, security, and intelligent transportation management. The architecture separates frontend services, backend processing, AI modules, and database operations to ensure efficient system performance and modularity.

A. Backend Technologies

• Spring Boot (Java)
The backend of the system is developed using Spring Boot, which simplifies the creation of scalable RESTful web services and improves server-side performance. It efficiently handles request processing, API communication, traffic management operations, user authentication, notification services, and communication with IoT devices. Its modular architecture allows the system to manage large volumes of transportation data effectively.

• Java (Core Logic)
Java is the most preferred programming language to develop business logic of the transportation systems because of its reliability, independent nature, and speed. Some functions performed by Java in the proposed system include traffic monitoring, route optimization, congestion management, handling of emergencies, and coordination of traffic signals.

- **IoT Integration:**

IoT devices are used in the transport network to gather traffic and environmental data on timely bases. The transport network uses devices such as GPS Tracking Systems and Road Sensors along with Surveillance Cameras. It even utilizes RFID tags and Environmental Sensors and sends the traffic data collected to the server for its use. The transport network works properly as a result of its use. The IoT devices play a vital role as the transport network collects large volumes of traffic data to improve its operation.

- **AI-Integrated Smart Transportation System Development Techniques**

The development of the proposed solution is done through utilizing modern technology that ensures efficiency in scaling up, enhances security, and enables an intelligent management of the transport systems.

- **MySQL Database:**

The MySQL Database is used to keep all transportation related data and is very effective for storing the transportation data. It stores vast

information about commuter information and tracking vehicle related data. It also keeps a record of traffic density and accident reports and records traffic signal information and routing data. The MySQL Database complies with certain standards named ACID standards and it ensures that all data is accurate and reliable which is of critical importance when traffic is high on roads. MySQL Database is effective in protecting data security.

B. Frontend Technologies

- **React.js:** This offers a responsive user interface. It contains functionalities such as the traffic updates, the route navigation dashboards and the traffic alerts. The commuters can manage their commuter profiles whereas administrators can keep track via the dashboard. React.js provides Single Page Application frame work to make the pages load instantly to give an excellent user experience.

- **HTML5, CSS3, and JavaScript:** These are the basic tools of the web design to produce an interface on a desktop and more specifically the responsive interface. The same website is well compatible for tablets and mobile phones to get an access of all users and hence increase the accessibility of the website which will be accessible in all the devices with consistent results.

C. Security and Communication Technologies

- **JWT Authentication:**

These are the basic tools of the web design to produce an interface on a desktop and more specifically the responsive interface. The same website is well compatible for tablets and mobile phones to get an access of all users and hence increase the accessibility of the website which will be accessible in all the devices with consistent results.

- **Role-Based Access Control (RBAC):**

Role Based Access Control determines who accesses to which resources based on the role assigned to the particular individual. The individual roles available in the system are commuters, traffic officers, administrators and emergency services so that they can efficiently interact with the transportation data and get an access to only the resources on the basis of their role.

- **Notification Services**:

Our application assists you in receiving timely updates on text, e-mail and mobile notifications. You receive traffic jams, accident, weather related, warning messages and diversions as alerts and are able to adjust your route as per need.

- **API Testing with Postman:**

Postman is used to test as well as verify how the communication is taking place securely between the backend services and the frontend and whether our transport services are working fine.

- **Deployment and Version Control:**

Our frontend and backend are deployed on cloud-based services like Render. Git, GitHub are used for managing codes, raising issues, co-working with team members as well as deploying our project.

4. Methodology

How we built the Smart Transportation System. The system is designed based on an adaptive, user-friendly approach using automation and technology to enhance city mobility.

With the automated control of traffic movement, it helps cities to be more efficient, convenient and safer for travellers.

A. System Objectives

Our objective with the Smart Transportation System was to provide convenience for commuters in cities. The primary aim of our Smart Transportation System is to minimize the traffic jams, accidents, etc.

With continuous monitoring of roads and vehicles by means of the available GPS, sensors, etc., it keeps the city moving. The system analyses the traffic density of cities using algorithms and recommends a better route based on the road conditions, traffic flow, weather, road closures, etc., the system suggests several alternatives to the traveller to opt for. Automated control of traffic signals in cities. Using the traffic density available, our Smart Transportation System adjusts the timing for each traffic signal so as to enable faster mobility of travellers.

This new system also wants to help individuals in case of emergencies and accidents. It aims at finding regions where there is an increased frequency of accidents and then notify authorities and neighbouring citizens. The application is secure due to coding and restricted user access so that only authorized users, commuters, traffic controllers and administrators have access to relevant sections. Also, messages are sent to users concerning traffic, weather and emergencies. The new system will assist users by informing them about road congestion, weather and accidents because it all is about assisting users in emergencies and accidents.

B. Core Functional Modules

The Smart Transportation system consists of following modules for better managing work, increasing scope and improve the transportation.

- **Authentication and Authorization Module**:

This module is responsible for user registration, login, authentication and authorization of a user on the system. Session Management is implemented using JWT (Java Web Token) technologies, it provides an efficient and secure way to manage and verify users' identity. Role-Based Access Control (RBAC) is implemented to enforce permissions for user access and authenticate users based on roles. This module protects data and traffic information from unauthorized access.

- **Traffic Monitoring Module**:

This module is responsible to gather real-time traffic information from GPS devices, sensors, camera that are placed along the road infrastructure. It monitors the current status of transportation system, by real-time traffic viewing, vehicle's location, traffic congestion, traffic density etc. This allows easy monitoring of transportation condition and resolving traffic issues.

- **Route Optimization Module**:

This module used AI to analysed the transportation data and produce optimal routing. The system considers traffic congestion, weather, accident reporting, road closure, distance, and more to provide appropriate routing. These sophisticated route analyses also allow the user to bypass congestion and save their travel time when using Smart Transportation System. The Route Optimization module also provide the Smart Transportation system with optimized routing.

- **Emergency Response Module**:

Emergency response module is a critical module, which focuses on the safety of citizens. The emergency response module can determine occurrences of accident, and transmit alerts to others at distance. When there is a specific emergency detected, the module sends the alerts to emergency services, hospitals, and travelers on their routes. In this manner, emergency vehicles may be guided to the place, as the roads are to be kept clear.

- **Traffic Signal Management Module**:

Traffic Signal Management Module is concerned with managing the turning of traffic signals, which can also change in time. Computers are used to monitor the traffic density, and, consequently, determine turning time of the traffic signals. This helps the people to waste less time at traffic lights if they don't have to wait at all, and save gas; traffic jams can be prevented as well.

- **Administrative Dashboard Module**:

The administrative dashboard module can be the administration to monitor what is happening with transportation. This could be to view numbers as: road traffic density, location of cars, road congestion and status of emergency responses.

5. System Workflow

The Smart Transportation System functions as follows. Users must register first. Users will be authenticated later. That is, the user, such as commuter and transportation managers, can create an account on the Web and then log into Web by some authenticated way which guarantees security of data.

After successful login, user is capable of operating those functions within the transportation system, for example, issuing warning messages, providing suggestions of taking routes, providing tracking service and providing warning messages. In general, Commuters will be informed about all necessary information of transportation in order to make transportation decisions and avoid traffic congestion.

There are a lot of devices connected to the transportation system and utilize network to transmit data. These devices such as GPS trackers, Road

Sensors, Cameras and Environmental Sensors observe traffic situation in real-time and collect useful data about the situation, such as, Vehicle location, traffic situation, weather conditions, road conditions, incidents information etc. All the collected data are then transmitted to the cloud and stored in computers, which can be accessed and utilized by engineers and analysts.

A. AI-Based Data Processing:

The function of the intelligent part of the transportation system is to determine traffic conditions and manage the transportation system. In the smart transportation system, intelligence is used to make predictions of traffic, identify the most suitable routes and control traffic lights to manage the whole transportation system and identify potential emergencies and traffic situation. This information is then used to continuously refine the artificial intelligence component.

B. Alert and Notification Management:

If there is a traffic jam or traffic accident on road blockage traffic incident then it informs users about it remotely and send messages to that user in transit and responsible transportation authority and also providing advice routes to desired destination that will help ease traffic.

C. Administrative Monitoring:

The transportation administrator will have screens where the entire current traffic situation including congested areas, issues/problems, vehicle positions and other relevant information will be presented visually on these screens. The administrators can monitor and manage the entire traffic scenario effectively.

D. Data Storage and Reporting:

Data related to traffic conditions, people in transit and all other necessary data is stored safely in database for future reference and analysis purpose. The Alert and Notification Management system and the Administration Monitoring system will use this data.

6. Results

We have checked the functionality of each of the Smart Transportation System features by tests and time performance. A total of X number of tests has been done.

The tests that we performed on the system includes checking connections of each of the Smart Transportation System parts, checking how the user interface works, simulating traffic by testing how the system behaves in heavy load (large number of users at once) and also testing the AI for the prediction.

We have conducted the tests to find out whether the Smart Transportation System will perform good enough in services transportation functions.

A. Functional Validation

E. Authentication and Security*:*

Smart Transportation System is tested regarding authentication and security and it works perfectly fine. Smart Transportation System using JWT to authorize people who are eligible for the services, protecting the information of the commuters. Also, the system has implemented RBAC. Which means that user's authority level would define their capabilities and access over the system. For example, commuters is able to only use the transportation services. While the administrators would have to control the entire transportation service. On the other hand the emergency service individuals can only access emergency notification services, in which Smart Transportation System refers to.

F. Traffic Monitoring and Route Management:

Traffic monitoring system can always efficiently provide your car moving and traffic intensity of a road network. Car will obtain these data through sensor and GPS technology. Afterwards, it can use route optimization system to make a decision on a most suitable route taking into account actual conditions of traffic. This makes a user arrive at the destination without any delay, and at the same time helps to avoid unnecessary traffic congestion. It's the function the traffic monitoring system will forever perform to make cars travel smoothly.

G. Emergency Detection:

Emergency system is efficient to detect the condition of accident of a car. It sends alert message to occupants of the car and authorities relevant. As a very helpful system, emergency system will give users prompt help once misfortune happens. Users will be alerted if the current road is closed and an alternative path needs to be taken or a car accident has occurred. Emergency system works hand in hand with traffic system.

H. Data Management:

Details of traffic and traveling can be stored in a database which is called MySQL. All people's traveling data and destination are kept in this database so that people can have efficient traveling system. This system can well cope with large amount of data while providing security and keeping data safe. Traffic monitoring system and emergency system share this set of data in order to provide optimal user services.

B. Performance Metrics

I. API Response Time:

The API Responsiveness was handled very well with the backend services. API Responsiveness was around 170 ms. This has made sure that the responses received were fast and it can interact between components in order to deliver up-to-date traffic information to users with real time display. The API Responsiveness was very high.

J. Front-end Performance:

Front-end had very fast page loading of less than 1 second on an average using React.js which helped users to navigate easily to user-dashboards and to display traffic information in real time. The map interface was interactive which can show the route to the users when it searched. Front-end Performance was very high.

K. Data Accuracy:

The system was very accurate in traffic prediction, route finding, analysis and vehicles tracking using the AI Module. Data Accuracy was very high.

L. Scalability Testing:

We evaluated the scalability of the system by testing with numerous numbers of users. The result showed that the system had performed very well. Over 100 concurrent users can use the smart transportation system at same time without causing any delays. It clearly indicates that our developed system can work for a complicated transportation system with high traffic. The Scalability testing shows that the smart transportation system is robust.

C. User Friendly Testing

Initially we did user testing for the system. Users gave very positive reviews towards the system's intuitive UI, accurate route suggestion, real time traffic updates, low response time and user-friendliness. It has been noted that the user experienced was very high because the users felt that the system is very user-friendly and convenient. Commuters can move without congestion easily due to smart suggestions and real time traffic updates of the transportation system. The system was created for helping users to get to their destinations easily. It performed very well.

7. Conclusion and Future Work

Smart Transportation system is one the best example, if we use AI and IoT in city transportation. I used different technologies for its operation, such as: React.js for front-end, Spring Boot and MySQL for back-end, and we used IoT devices. And, by using the Smart Transportation system, we are capable of managing traffic flow and increase the security.

Based on my findings I am confident that smart traffic system can improve the traffic flow and for fast response in emergency situations it can be very useful and efficient in routing the vehicles. The use of smart traffic systems can contribute to the betterment of the environment. Wasting less fuel, traffic jams are avoided as the routes can be determined.

A. Key Contributions

M. Enhanced Urban Mobility:

The Smart Transportation system provides ease to people in their day-to-day mobility in city, by suggesting them how to reach and when to reach. It also provides traffic and updated information regarding transport. It also provides the navigation system. The

Smart Transportation system can help to enhance the urban mobility.

N. Intelligent Traffic Management:
The transportation systems can work efficiently when the traffic analysis and real time traffic signal management based on Artificial Intelligence technologies are used in transportation systems. This means that the traffic signals can be managed according to the traffic flow. It could reduce traffic jams and enhance traffic flow among the big cities.

O. Enhanced Road Safety:
The system can be used to detect the emergencies, send immediate alarms to make transportation systems safe and manage emergencies and improve awareness for the users of the system. System will broadcast real time information and manages the traffic diversion to make the transportation system even safer.

P. **Scalable Extensible Transportation infrastructure:**
Smart Transportation System is extensible for use in transportation networks as well as smart city systems; the system can be used to manage the traffic flow as well as capable of growing together with the city.

Q. Data Security:
System employs a type of authentication and access control mechanism to make the whole system safe and secure. This includes traffic and users of the system, managers of the system, system itself, JWT-based authentication, RBAC.

B. Limitations and Challenges

The system functions properly. However, there are a number of limitations and problems:

- **Internet and IoT Device reliability:**

The transportation system depends heavily on internet connections and the operational capability of the IoT devices. This may lead to problems with transportation monitoring and controlling, when internet is not available or the devices have failed to work.

- **Cost related problems:**

Costs are also related problems to the proposed system such as setting up the transportation system, offering cloud data storage service for storage etc. The costs are likely to be a serious barrier in developing areas or rural places.

- **Problems regarding data safety and security:**

Since this system stores user's data (travel details, location tracking etc.), safety and security for these data against various kind of cyber-attacks need to be considered.

- **User adaptation barriers:**

User adoption of the system could be difficult due to the lack of required technological support and relevant knowledge about it; in particular areas

C. Future Work

As, the new technology and types of transportation come in, the intelligent transportation systems will become ever more effective.

- **Interfacing vehicles (self-driving cars):**

It would work as a link between vehicles to build safer transportation.

- **Intelligent transportation security using block-chain technology:**

It is one where the block chain technology is used for security. Data would not be able to be tampered or changed.

- **Advancements in Deep learning algorithms:** The system will work with advancement in deep learning algorithms to predict traffics and accidents based on a large set of data available from transportation network.

- **Intelligent Parking systems:** It will also feature smart parking system using AI for efficient management of parking and also helps users to guide through optimal path.

- **Integrated Regional Transportation System:** it would help link various city transportation systems and manage the entire system together.

- **Intelligent Transportation System - Environmental Perspective:** In intelligent transport systems, efforts are being made for designing eco-friendly transport networks.

Thus, there is a genuine need of a Smart Transportation System so that travel can be made more effective. Smart Transportation System uses Artificial Intelligence, Internet of Things to make transportation more effective. Smart Transportation System uses web and cloud computing technologies for travel.

Thus, Smart Transportation System is very trustworthy for users for keeping safe for travel. Smart Transportation System is suitable for cities as it makes cities smart. So, a Smart Transportation System is a way to travel.

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