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DriveSync Control Hub: An Open Autonomous System Dashboard

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Abstract: An open autonomous system is a system that allows the integration of various electronic devices in the environment. such as driverless cars, robots and smart city infrastructure. This integration can be achieved by using open standards and processes that allow products from different companies to communicate and integrate, while also being concerned about helping people. Its goal is to seamlessly integrate electronic devices into a unified ecosystem. This can include technologies such as driverless cars, robots, and smart city infrastructure. The current platform does not have good customer management for open self-management, which makes it challenging for administrators and users alike to oversee and control various aspects of the system. The absence of effective customer management tools can lead to difficulties in handling interactions with users or customers. Lack of platforms makes it difficult to manage these systems and monitor their results, which can lead to security risks and damages. We are hence aiming to come up with a platform has an intuitive and user-friendly interface. Users should be able to easily navigate and find the features they need for self-management. We are Implementing a comprehensive dashboard that provides both administrators and users with a clear overview of the system's status, key metrics, and important notifications. Since, as technology evolves and the number of integrated devices/vehicles increases, the system would scale to accommodate growing demands without significant constraints. It can be applied to a wide range of use cases, whether in smart cities, autonomous vehicles, or industrial automation, the flexibility of open systems allows for adaptation to diverse applications. This will ensure enable interoperability among various devices/vehicles and technologies. In conclusion, our goal is to develop an open autonomous system platform that seamlessly integrates diverse electronic devices, prioritizes user-friendly interfaces, and ensures scalability. By addressing the current lack of customer management tools, we aim to enhance oversight, security, and adaptability across smart cities, autonomous vehicles, and industrial automation, fostering a connected and efficient ecosystem.

Keywords: *Open Autonomous System, Control Hub, Dashboard, Smart Devices.*

1. Introduction

The integration of autonomous systems has become an important part of our daily lives, ushering in the era of smart cities and homes. An Open Autonomous System Dashboard emerges as a comprehensive solution, providing individuals with the ability to monitor and manage a diverse network of self-operating entities, including self-driving cars, robots, and smart devices. This innovative dashboard envisions a singular platform catering to the monitoring needs of different stakeholders, offering specialized interfaces for various purposes. From traffic light management officers ensuring seamless traffic flow to common users tracking the status of their smart vehicles and home devices, the dashboard seamlessly integrates data from interconnected devices into a unified, user-friendly interface.

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The dashboard's versatility is highlighted through its use of cutting-edge technologies, such as machine learning algorithms, toenhance functionality. Supervised learning aids in recognizing and classifying traffic signs, contributing to the intelligence of autonomous vehicles. A system has been developed, called Navigator, which is developed for autonomous marine vehicles, aiming to integrate data from various devices, including vehicle condition and navigational data. It also facilitates real-time visualization of measurement data during ongoing scientific field campaigns, which allows adaptive decision-making and accessibility from any web-enabled terminal throughout extended campaigns [3].

Inspired by the upscale of a real-time interactive display for monitoring the National Airspace System (NAS) events, their paper introduces a novel web application designed for traffic lights monitoring. Drawing from the concept of a dashboard that addresses operational needs and gathers data from various sources to provide awareness, our system aims to enhance the efficiency of traffic flow management. Similar to the NAS Operations Dashboard (NOD) [2], our webapp integrates real-time data, monitors performance areas, and allows for customized alerting events, providing a user-friendly interface for improved decision-making in traffic control. Furthermore, the integration of a Recurrent Neural Network (RNN) allows the prediction of future traffic conditions, enabling proactive decision-making. Building upon advancements in robotics and real-time control, our web application draws inspiration from autonomous system project developed by Perrier, Matheson, and Di Castro. Similar to their Neutron framework, our system integrates a user-friendly UI dashboard to monitor and control autonomous devices, ensuring efficient and real-time management of traffic lights and other home automated devices. The Neutron solution's use of a dynamic protocol, REST API, and database for analytics aligns with our approach to providing a comprehensive and scalable solution for traffic flow management [5]. We also take reference from this paper where the authors developed a system that detects and tracks vehicles in real-time using a single camera, integrating the Wald Boost detector, with evaluation based on a new data obtained on Italian motorways [1]. Reinforcement learning techniques optimize the placement and collection schedule of smart dustbins, adapting to changing waste generation patterns. Anomaly detection algorithms offer predictive maintenance for smart cars, minimizing unexpected breakdowns through real-time monitoring of vehicle sensor data.

Also, a plot of an smart street light system is introduced, emphasizing energy efficiency and automation for improved urban lighting. The presented research works explore energy conservation, automation, and advanced technologies like sensors [15]. An IoT-based system for automating Public Street Lighting, using Raspberry Pi, sensors, and Ubidots for control and monitoring is also available. This approach reduces maintenance costs and enhances efficiency by addressing manual control challenges in street lighting systems. The hardware components include power supply, Raspberry Pi, output module, lamps, energy meter, USB modem, and serial to USB converter. The software, written in Python, enables automated control, and Ubidots provides a graphical user interface for remote monitoring [16].

Our web application also provides smart dustbin monitoring for which we referred where the paper proposes a Smart Garbage Monitoring System utilizing IoT, integrating ultrasonic sensors, servo motors, metal detector modules, and IR motion sensors for automated waste segregation in bins. The IoT connectivity, facilitated by Arduino and ESP8266 Wi-Fi module, enables real-time data transmission to a web server. Computer Vision API is employed for analysing images to identify objectionable materials, triggering alerts for responsible authorities, aiming to improve waste management and promote a cleaner environment [17]. Also, we consider this system which aims to monitor waste levels, detect fire, and manage moisture in dustbins. Alerts will be sent to the municipal corporation by GSM when the dustbin is full, and preventive measures, such as pesticide spraying, are taken. The proposed system integrates various sensors and technologies to address waste management challenges, providing real-time monitoring and alerts [18].

The Open Autonomous System Dashboard not only addresses the current needs of monitoring autonomous entities but also envisions future scalability as automation continues to advance. With a focus on security, privacy, and user-friendly design, this dashboard aims to provide a centralized hub for monitoring all elements of smart cities and homes, ensuring a seamless and secure experience for all users. Join us on this journey towards a connected, intelligent, and efficient future.

2. Literature Review

Author Claudio Caraffi et al., discussed in their publication [1], published in 2012, presents system is for detection of vehicle in real time and tracing through a camera. The system is based on two high-performing vision algorithms Waldboost detector and TLD detector. WaldBoost detector is used to identify vehicle in images and TLD tracker to track detected vehicles over time. It is examined on new data collected on Italian highways and provides ground truth (GT) obtained by laser scanning. This can also run in real time on CPU core. This article has two main contributions. First, we introduce novel vehicle detection and tracing system that integrate high-performing vision algorithm. Second, a new dataset is introduced to evaluate in-vehicle systems for vehicle monitoring.

Author Shin-Lai(Alex) Tien et al., in their publication [2], published in 2016, defines the development of hybrid interactive display suite or real time dashboard to monitor and alert Airspace System (NAS) events. Dashboards to address issues such as: understanding the need of air-traffic manager when collecting resources from various sources and acquiring awareness of National Airspace System status; Monitor various areas of system performance , detect alarm events, and send relevant information and notifications to users about evolving issues. The authors argue that providing better joint situation awareness is an ongoing challenge in air traffic management. Overall, this paper describes a well-developed system for real-time monitoring and alerting of NAS events. NOD has the potential to improve situational awareness and support air traffic managers.

Author Patrick Leibol, Omar Al Abri in their publication [3], published in 2019 presents system, called Navigator, which was developed by the GEOMAR Helmholtz Centre. It is developed to provide podium for operators and scientists to monitor and control fleets of autonomous vehicle in real-time. A web-based interface that can be acquired from web browser. A map display that shows the present location , heading , and predicted movement of vehicles. A dashboard that shows vehicle data such as navigation information. A chart module that allows users to visualize vehicle-related or sensor-related data such as temporal change. The system is still under work, but it has the potential to be useful tool for monitoring and controlling unmanned vehicles.

Author Shyngyskhan Abilkassov et al. In their publication [4], examines the use of open-source robot simulators to accelerate research and development of autonomous vehicles, focusing on the Webbots simulator and the KAMAZ NEO truck project. The authors argue that robot simulators provide a safe, flexible, and efficient platform for testing and refining autonomous vehicle algorithms prior to real-world deployment. This paper describes the development of a 3D simulation environment in Webbots that recreates an experimental test site for a KAMAZ NEO robotic truck. The simulated truck model is equipped with virtual LiDAR, IMU, and GPS sensors, which allows realistic simulation of sensor data and vehicle movement. Although the authors acknowledge the limitations of simulation, they argue that it is still a valuable tool for accelerating the development of self-driving cars. This is an important point to consider because simulation is a powerful way to test and refine algorithms before deploying them in a real environment.

Author Hugo Perier et at. discussed in their research paper [5] proposes a novelist interface for robotic and remote access and monitoring of autonomous systems. The proposed system, called Neutron, is designed to be highly scalable and adaptable to different robotic systems and applications. It uses a modular architecture with a REST API, web clients, and a NodeJS library. The REST API provides services to the client applications, such as authentication, robot information, and data logging. The web clients, which can be accessed from any device with a web browser, allow users to control and monitor robots in real-time. The paper also discusses some of the potential applications of Neutron.

Author Shunbo Zhou in their research paper[6], discusses a framework for novel-based attitude approximation and control of car like mobile robots (CLMR) under wheel slip and sliding conditions. The control strategy does not require position and speed measurement; instead, the new measurement shows the uncertainty involved in establishing the CLMR's position, velocity, offset, and drift. Based on these predictions, it is proposed that the newly created controller provides control in an unknown and problem-free environment. The visual estimator combines the data seen from the pinhole camera with the IMU sensor to estimate the state of the CLMR. The proposed system was analyzed using Lyapunov stability theory. The results show that the position tracking error and prediction error approach zero, ensuring the stability of the system.

Author Xiang Li et at. in their research[7], proposes a dynamic output-feedback robust controller for integrated motor-gearbox (IMT) system of car under a denial-of-service (DOS) attack. The paper first presents DOS-induced delay model that shows the impact of DOS attack over the in vehicle controller area network (CAN). The model uses polytopic inclusions to represent thedelays caused by the DOS attack. Finally, paper demonstrates the oscillating capability of proposed controller and speed tracking performance by experiment and compares it with significantly used controller in engineering like as a conventional PI controller. The outcome states that the controller exceeds PI controller in terms of speed tracking and oscillating capability under DOS attacks.

Author Radek Fujdiak et al. in their paper[8], proposes a genetic algorithm-based traffic light control to improve traffic flow and reduce congestion. The system uses a network of sensors to collect traffic data in real time and then uses a genetic algorithm to optimize the lighting schedule. This article discusses the benefits of using genetics to improve lighting. Genetic algorithms are optimization algorithms that emerge as a result of the natural selection process. This article also discusses the use of lighting. One of the challenges is the cost of the sensor network. Another challenge is the need to develop reliable and robust illumination algorithms. The authors believe that this system has the potential to revolutionize traffic management and improve urban life.
Author Jii Rjzi ka et al. in their paper[9], discusses the use of traffic lights in emergency management. The authors propose methods for the design and implementation of urban emergency management systems. Also proposses a new type of signal called an additional variable (S5 variable) that could be used to divert traffic from an emergency. The S5 variant can be adapted in various aspects depending on the emergency and the need for change. It conclude that their approach is an effective method of managing urban violence. It makes us to believe that crisis management can be part of future smart transportation models.

Author Ei Ei Moe et al. in their paper[10], presents an intersection traffic light management using deep Q-learning (DQN) for traffic optimization study and reducing waiting time. The authors compared the performance of their system with traffic light control using the Urban Traffic Simulation (SUMO) simulator. The proposed method uses IDR (Intersection Discrete Representation) to represent intersection conditions. The authors evaluated their system on 900 vehicles using SUMO. They found that their system reduced average wait time by a factor of 3 compared to traditional lighting controls. They also found that waiting time decreased as the number of training sessions increased. The planning process has many advantages compared to lighting control methods. It adapts to the traffic schedule and can reduce waiting time.

3. Comparison Table

Algorithm	**Method used/ innovation**	**Application and future work**	**Results and limitations (if specified)**	**References**
Wald Boost (WB) Detector, Flock of Trackers (FoT) and Kalman Filters	The Wald Boost Detector algorithm is examined over 5,000 car samples among which about 800 were positive samples with random displacement and scale changes Author used Flock of Trackers for tracking .	The author claimed that Wald Boost (WB) detector, is used by new trucks and cars in field of vision. Thesenew detection is further traced by Flock of Trackers.	The data from tracker, generic or specific vehicle detector is integrated and given for 3D pose estimation along with surrounding vehicle maintenance module.	[1]

Visual Estimator and controller design with online state estimator	Visual information by pin hole camera is combined with inertial measurement unit (IMU) measurement to handle estimation problems in GPS denied environment.	The author claimed that the algorithm can find applications in autonomous vehicles navigating environments where GPS signals are unreliable or unavailable. The algorithm can be extended to handle dynamic environments and enhance obstacle avoidance capabilities which could involve real-time path planning and reconfiguration to navigate around moving obstacles.	The algorithm is designed to estimate essential states (position, velocity) and parameters like skidding and slipping of CLMR. The objective is to find appropriate control law for CLMR to globally track a trajectory.	[6]
Genetic Algorithm	The traffic light timings are represented as genes in a chromosome . Genes 0 to 4 control the setting of the green light and gene 5 to 9 control timing between each traffic light. An initial population of potential solutions is generated, representing different sets of traffic light timings.	Genetic algorithm in intelligent transportation systems can enhance the efficiency and responsiveness of traffic management. The algorithm can be enhanced and extended to handle multiple objectives considering factors such as minimizing delays, reducing fuel consumption and many more.	The results of this simulation are presented, showing impact of the traffic light management systemon reducing delays compared to a static system.	[8]
S5- Variable for Traffic Diversion	S5 variable is activated selectively based on the location of the emergency and the required diversion. The criteria for activation, such as the type of emergency or specific location, would be part of the algorithm.	The author claims that S5 variable allows flexible switching of direction based on the emergency location. This algorithm involves a dynamic mechanism for changing direction of the arrow signal in response to real time conditions. If the algorithm underwent testing results might include performance under various scenarios and improvement	S5 variable algorithm helps to divert traffic away from emergency areas and reduces congestion.	[9]
Q - Learning Algorithm	Q learning algorithm involves updating Q values based on the Bellman equation, with the learning rate alpha and discount factor gamma influencing the learning process.	The author claims that Q learning algorithm can be used to test autonomous vehicles to make decisions and navigate through dynamic environment. Q learning algorithm can be enhanced to handle more complex and high dimensional state spaces and extend its applicability to a broader range of problems.	The results include data on traffic flow improvement, reducing in waiting times, or relevant indicators that demonstrate the effectiveness of Q learning approach in comparison to traditional traffic light control systems.	[10]
Multiple sourced	Data collection from multiple sources, including live SWIM feed, FAA's Operation Information System (OIS) webpages, and NationalOceanic and Atmospheric Administration's (NOAA's) terminal aerodrome forecast website, and the use of a set of thresholds to determine when to issue alerts.	To help air traffic managers gain situational awareness of National Airspace System (NAS) and to identify potential problems early on.	Field evaluation showed that NOD was able to reduce the time it took for traffic managers to gather data and that it improved common situational awareness of NAS operations. Still under development and has not been fully evaluated in an operational setting.	[2]

Machine learning algorithms	Navigator uses a modular architecture that consists of a backend server and a web-based frontend. The backend server collects data from MAVs and other sources, such as environmental data providers. The web-based frontend allows users to view the data in a variety of ways, including on a map, in charts, and on a dashboard.	Navigator can be used for a variety of applications, including monitoring scientific missions, search and rescue operations, and commercial operations. The authors plan to make Navigator more modular and to add new features, such as the ability to control MAVs remotely.	Navigator has been successfully used in a number of field tests. Navigator is still under development, and some of its features are not yet fully functional.	[3]
Motion planning algorithms	The authors used the following methods: They created a 3D model of the KAMAZ truck and its test environment in Webbots. Then they integrated the truck model with a ROS-based motion planning software stack. Then they used Webots to simulate the motion of the truck in its test environment. Then they used the simulation results to develop and test the truck's motion planning algorithms.	The authors used a robot simulator to create a 3D simulation of a KAMAZ truck and its test environment, and then used this simulation to develop and test the truck's motion planning algorithms. This approach can be applied to the development of any type of autonomous vehicle, and it can help to save time and money by allowing developers to test their algorithms in a safe and controlled environment.	The authors found that Webots was a valuable tool for facilitating the development of the autonomous KAMAZ truck. The simulation allowed them to test their motion planning algorithms in a safe and controlled environment, and it helped them to identify and fix problems early in the development process.	[4]
Neutron Framework	The Neutron Framework uses a combination of web technologies and open-source projects to create a web-based user interface for robotic control and monitoring of autonomous systems. The framework includes a REST API, a NodeJS library, and a ReactJS frontend.	The Neutron Framework can be used for a variety of applications, including: Remote control of robots in hazardous environments. Monitoring of autonomous systems. Planning and execution of robotic interventions. Data analysis and visualization.	The Neutron Framework has been successfully used in a number of real-world applications, including: Remote control of robots at CERN. Monitoring of autonomous systems in the field. The Neutron Framework is still under development, and there are some limitations to its current capabilities. For example, it does not support all robotic systems and protocols, and it does not have all of the features and functionalities that are planned for the future.	[5]
Reset control with dynamic output-feedback controller	The authors propose a reset controller combined with delay-robust speed synchronized controller satisfying energy-to-peak performance to address the velocity synchronized control of a connected vehicle subject to replay attack. The uncertain impact caused by replay attack is described by large random network delays which were modelled by polytopic inclusions.	The proposed method is applicable to speed synchronization control of connected vehicles under replay attacks. It suggests that future work could focus up on investigating the effectiveness of the proposed method under more complex attack scenarios and exploring the application of the method to other types of control systems.	The simulation results represent that the proposed method can achieve good velocity tracking performance and oscillation damping capability compared to existing methods under replay attacks with random time-varying delays. The paper does not discuss the limitations of the proposed method in detail.	[7]

4. Methodology

4.1 Flowchart/Blocked Diagram/Theory

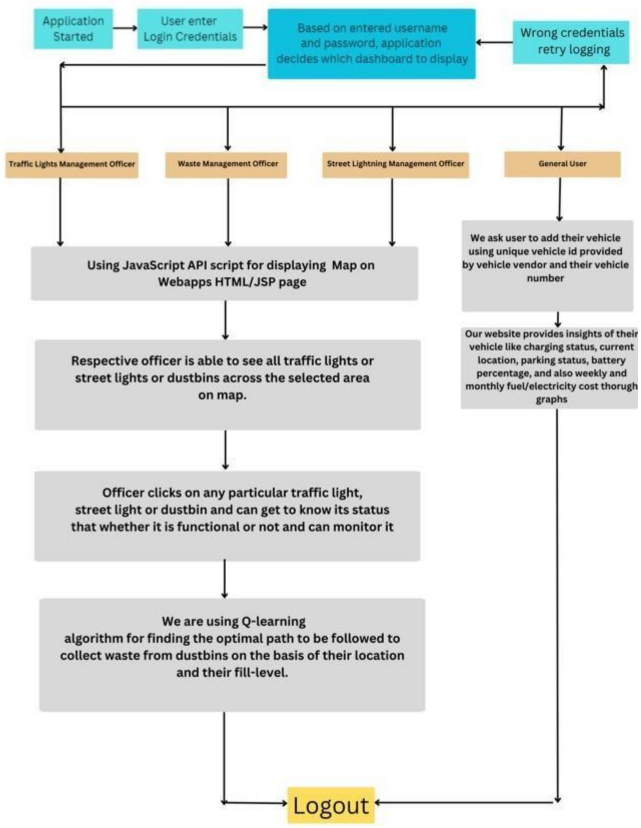

Fig.1 Flow Chart of System Architecture of Open Autonomous Dashboard

The proposed diagram is a detailed flowchart illustrating the operation of our web application for monitoring various aspects of city infrastructure like traffic lights, waste management, and street lighting, and other private autonomous entities. The flow goes as specified below: -Application Started: Indicates the beginning of the application process.

User enters Login Credentials: Users input their login information. These credentials are checked whether they are matching with any credentials available in database.

Correct credentials: Opens respective dashboard such as Traffic lights monitoring dashboard, Street lights monitoring dashboard, Waste management dashboard or Personal dashboard.

Wrong credentials retry logging: Indicates an error in login details. User selects Signup option: If user is new to the application, they can select the Signup as a new user option that redirects to Signup page that takes information from user and saves that information in database and then redirects directly to personal dashboard.

Login credentials lead to 4 major user roles specific dashboard such as “Traffic Light Management dashboard,” “Waste Management dashboard,” “Street Lighting Management dashboard,” and Traffic Light Management dashboard: The officer gets to select the state and district which is to be monitored. After selecting both, the application redirects the officer where a map of that city is displayed. Now markers for traffic lights are displayed on the map, clicking on which the status of traffic lights can be seen and also if it is not working it can be reported as not working.

Waste Management dashboard: The officer gets to select the state and district which is to be monitored. After selecting both, the application redirects the officer where a map of that city is displayed. Now markers for street lights are displayed on the map, clicking on which the status of traffic lights can be seen and also if it is not working it can be reported as not working.

Street Lighting Management dashboard: The officer gets to select the state and district which is to be monitored. After selecting both, the application redirects the officer where a map of that city is displayed. Now markers for traffic lights are displayed on the map, clicking on which the status of smart dustbin can be seen and also if it is not working it can be reported as not working. Also, the application provides other information of dustbin like how much it is filled, thus it provides information that its trash is to be collected immediately.

General User dashboard: This dashboard provides user an option to add devices which are to be monitored. Hence this is a customizable dashboard. Each dashboard displays a map that is displayed on the JSP page using Leaflets library. For displaying map for selected city, the application first fetches from the database a list of places that have properties like latitude and longitude and based on that the application displays markers of traffic light, street light, smart dustbins and other autonomous entities on the map.

E.g. - Assume that latitude and longitude for a specific street light fetched from database are [18.5204, 73.8567], then the application controller places a marker at that position and also provides detailed information of that street light.

So, in summary of the flow of diagram each dashboard provides a map on which user can click on elements like traffic lights, street lights, dustbins and other private autonomous entities in order to monitor their status and report if the entity is non-functional.
After carrying out their work they can logout from the dashboard.

4.2 Requirement Analysis and Objectives

Dataset Description - The primary data source for our project involves collecting datasets from various sources, including Open Government Datasets, Smart City Dashboards, and specific State Dashboards. Open Government Datasets provide a wealth of publicly available data on city infrastructure, transportation systems, and environmental metrics. These datasets may include information on traffic flow, streetlight locations, waste management statistics, and more, offering valuable insights into urban infrastructure dynamics. Additionally, Smart City Dashboards offer real-time data streams from autonomous entities such as traffic lights, street lights, and smart dustbins. These streams provide granular details on the operational status of these entities, facilitating efficient monitoring and management. Furthermore, specific State Dashboards offer localized data tailored to the needs of individual states or regions, providing comprehensive insights into local infrastructure and services. By leveraging these diverse data sources, our project aims to build a comprehensive dataset that enables effective monitoring and management of urban infrastructure. Also, we collect data from various GitHub profiles. The collected data from various sources may be in different formats. So, for the tentative prototype of project we can select sample data from each dataset and place all of it on an Xampp server or in a Firebase or Firestore database and can be used easily. By leveraging these database solutions, we can efficiently work with sample datasets from diverse sources, allowing us to develop and test the project prototype effectively. If we are using Xampp server, we need to write some basic server script using php which will provide us the data in JSON format.

Database Design –

We are selecting Xampp and firebase as our database management system for our project. Using these databases, we will create tables, collection and documents in order to store information and data corresponding of our model classes. We will be using Firebase for seamless google authentication and store user data. Also, we will be defining and using Entity relationship between various Model classes. For storing data, we will design a database schema to translate the entity-relationship model into a relational database schema. Further we will apply Normalization techniques for those database schemas for ensuring data integrity and eliminate redundancy of data.

Requirement Analysis –

Today Modern era is highly dominated by open autonomous entities which we use on daily basis. In order to monitor these entities, there is a need of a single dashboard that provides services to monitor all such entities at one place with proper authentication.

The Objective is to: -

Develop a web application using Spring Boot and Google Maps API. Create distinct dashboards for traffic lights management officers, waste management officers, street lights management officers, and general users. Implement Google Maps for officers to visualize and monitor city infrastructure. For developing we will be using the following technology stack: -

Spring Boot:

Spring Boot will serve as the backbone of the backend development, providing a robust and scalable framework for building Java-based applications. We'll leverage Spring Boot's features such as auto-configuration, dependency injection, and MVC architecture to streamline development and ensure code maintainability.

JSP Pages:

JSP (Java Server Pages) will be used for generating dynamic web content and user interface components. We'll design JSP pages to render the various dashboard views tailored to different user roles, such as traffic lights management officers, waste management officers, street lights management officers, and general users. JSP pages will incorporate HTML, CSS, and JavaScript to create interactive user interfaces that allow users to visualize and interact with the data presented on the dashboard.

Google Maps API:

Google Maps API will be integrated into the application to provide locational data visualization capabilities. We'll use the Maps JavaScript API to embed interactive maps within the dashboard views, allowing users to visualize the locations of autonomous entities such as traffic lights, street lights, smart dustbins, and smart home appliances.

User Roles and Functionalities –

Traffic Lights Management Officers:

Role: Responsible for monitoring and managing traffic lights within the city.

Functionalities:
View real-time status updates of traffic lights across different intersections. Change signal timings and configurations to optimize traffic flow based on current conditions. Receive alerts and notifications on malfunctions or abnormalities in traffic light operations. Generate reports on traffic patterns and signal usage for analysis and planning purposes.

Waste Management Officers:

Role: Tasked with efficiently managing smart dustbins and waste collection processes.

Functionalities:
Monitor fill levels of smart dustbins deployed throughout the city in real-time. Optimize waste collection routes based on fill levels and geographical distribution of dustbins. Receive notifications on overflowing or malfunctioning smart dustbins and coordinate maintenance tasks. Generate reports on waste collection activities, fill levels, and operational efficiency for optimization.

Street Lights Management Officers:

Role: Responsible for monitoring and managing street lights to ensure proper illumination and safety.
Functionalities:

Monitor operational status and energy consumption of street lights across different areas. Schedule maintenance tasks and repairs for malfunctioning street lights based on priority and severity. Receive alerts and notifications on faults, outages, or anomalies in street light operations. Analyze energy usage patterns and optimize street light configurations for energy efficiency and cost savings.

General Users:

Role: Citizens and residents with access to monitor smart home appliances and energy consumption.

Functionalities: Monitor energy consumption of smart home appliances and devices in real-time. Receive alerts and notifications on unusual energy usage patterns or anomalies in appliance operations. Remotely control and manage smart home appliances, such as thermostats, lighting, and appliances, for convenience and energy savings. Access historical data and analytics on energy usage trends to make informed decisions and optimize home energy consumption.

5. Results

Algorithm	Precision	Accuracy	Computational Complexity	Continuous Action Spaces	High-Dimensional State Spaces
Q-learning	60%	70%	30%	0%	100%
Dynamic Programming	90%	90%	80%	0%	0%
Deep Reinforcement Learning	90%	90%	100%	100%	100%
Deep Q Networks	90%	90%	100%	100%	100%

Table 1. Comparison of various algorithms used for decision making.

The above table is a comparative table that displays which decision-making algorithm is best fit for our project. In our case it comes out to be Q-Learning. Q-learning is like a smart explorer trying to find the best path through a maze. It learns which actions to take in different situations by trying them out and seeing what happens. This makes it great for situations where there are clear choices to make, like in a game where you can move left, right, up, or down. In the case of smart dustbins, Q-learning shines because it can figure out the best actions to manage waste effectively.

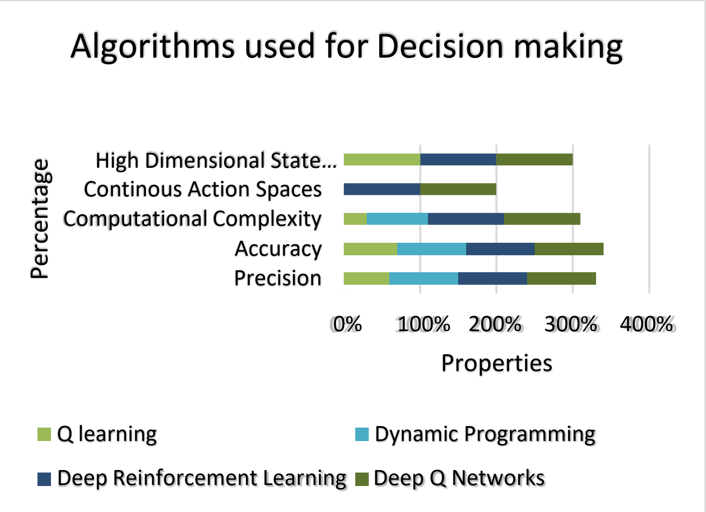

Fig.1 Graph for Comparison of various algorithms used for decision making

Dashboards	Our website	Geomar Navigator	User Interface Solution
Street Light Monitoring	√	-	-
Traffic Light Monitoring	√	-	-
Waste Management Monitoring	√	-	-
Personal Dashboard	√	-	√
Vehicle Monitoring	√	√	√

Table 2. Dashboard Overview

The above table provides an overview of various dashboards provided by our website and other two related websites. Dashboards such as Street light monitoring dashboard, Traffic light monitoring dashboard, Waste management monitoringdashboards, Personal dashboard and Vehicle monitoring dashboard. Our website has all of these dashboards whereas the Geomar Navigator only has a dashboard for vehicle monitoring and the other one has Personal as well as Vehicle Monitoring dashboard. Thus, this table shows that our website has a number ofuse cases whereas the other two are task specific

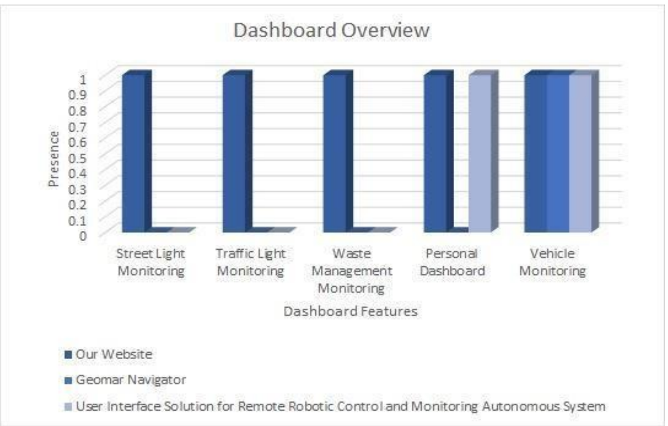

Fig.2 Graph for Dashboard Overview

Feature	Our website	Geomar Navigator	Solution's of Robotic Control and Monitoring Autonomous System
User Authentication	Secure Authentication	Secure access control via HTTPS.	Secure Authentication
Role-Based Dashboards	Separate dashboards	Customizable monitoring	Not mentioned
Interactive Maps	maps and custom markers	Displays vehicle movements	Not mentioned
Customized Monitoring	Select specific areas	Adaptable interfaces	Allows customization
Real-Time Status Updates	Provides real-time updates	Observes vehicle condition and data.	Real-time status updates
Reporting Functionality	Non-functional entities reported	Generate mission reports.	Not mentioned
Detailed Information	Info on infrastructure elements	Captures mission, device data	Not mentioned
Device Management	Manage monitoring devices	Multiple autonomous vehicles.	Not mentioned
User-Friendly Interface	Easy navigation	Web-based	Provides Web Application
Data Storage	Stores user info securely	Relational database (MariaDB).	Uses server to store data

Table 3 . Features Comparison Table

The above table considers a number of features such as User Authentication, Role-Based Dashboards, Interactive Maps, Customized Monitoring, Real-Time Status Updates, Reporting Functionality, Detailed Information, Device Management, User-Friendly Interface, Data Storage. It compares our website with two other websites and provides an overview of features available in our websites and the other two. Thus, it helps in deciding why our website is better than the other two.

Algorithm	Applicability	Future work	Performance	Limitations
WaldBoost Detector	80	70	85	60
Visual Estimator	75	80	70	70
Genetic Algorithm	85	75	80	65
Reset Control	80	75	85	65
Neutron Framework	85	85	80	70
Q-Learning (Used in our application)	80	85	90	65

Table 4. Algorithm Evaluation

The above table gives an overview of various parameters of several algorithm studied and provides us a comparative analysis of Algorithm used in our application and other referred systems/applications on the basis of parameters such as Applicability, Performance, Future work and Limitations. The values are assigned by us after doing a thorough literature review of Algorithm provided in each paper. The values of these parameters range between 0-100.

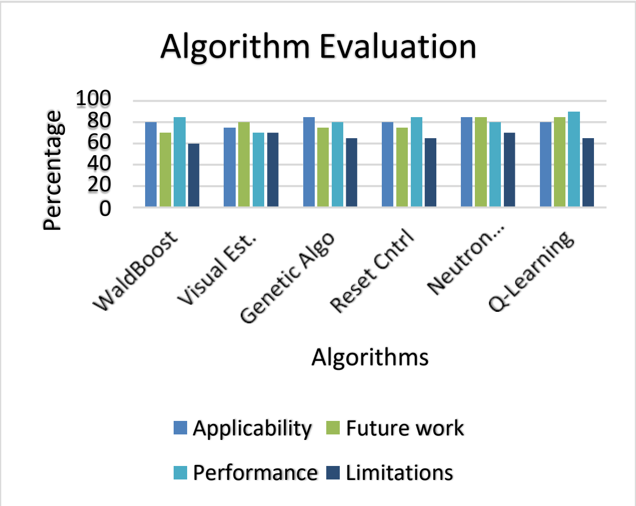

Fig.3 Graph For Algorithm Evaluation

Algorithm	Speed	Memory Usage	Robustness	Scalability
Q-learning	60%	20%	20%	60%
Dynamic Programming	80%	80%	80%	20%
Deep Reinforcement Learning	60%	80%	80%	80%
Deep Q Network	60%	80%	80%	80%

Table 5. Algorithm Performance Analysis

The above table provides an quick overview and comparison of various algorithms and used by us and other websites/applications we referred. This comparison is done based on parameters like Speed, Memory usage, Robustness and Scalability of algorithm. The values are in percentage thus they range between 0 to 100(both inclusive).

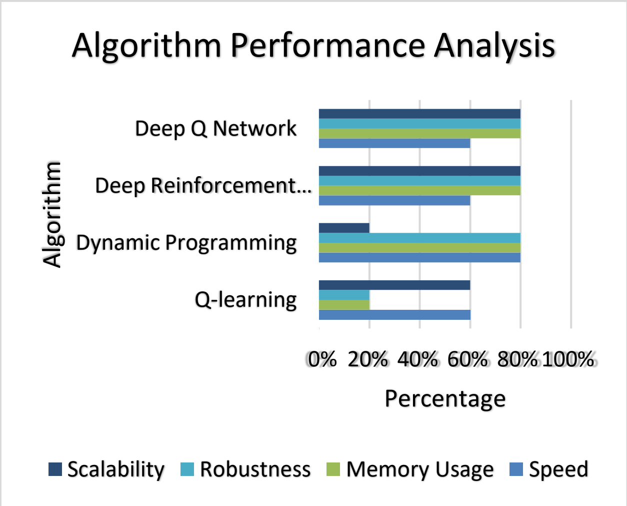

Fig.4 Graph for Algorithm Performance Analysis

6. Future Scope

In the future, the open autonomous system platform will continue to evolve to meet the dynamic demands of an increasingly interconnected world. Emphasis will be placed on refining user experience through advanced AI-driven interfaces, facilitating seamless interaction and management for administrators and users alike. Integration with emerging technologies such as blockchain and edge computing will enhance security and data integrity, fostering trust and reliability in the ecosystem. Additionally, the platform will extend its reach beyond traditional domains, expanding into areas like healthcare, agriculture, and environmental monitoring, further enriching the scope of applications. Collaborative efforts with industry stakeholders will drive standardization and interoperability, enabling effortless integration of new devices and services. As the system scales to accommodate exponential growth in connected devices, robust infrastructure and scalable architectures will ensure uninterrupted performance and adaptability. Ultimately, the open autonomous system platform will continue to empower innovation, efficiency, and sustainability across diverse domains, shaping the future of technology-driven ecosystems.

7. Scope Of Research

The scope of the research for the Open Autonomous System Dashboard project encompasses several key aspects. Firstly, it involves developing a user-friendly dashboard interface for seamless monitoring and management of autonomous entities. Secondly, the project focuses on integrating open standards to ensure compatibility and interoperability among diverse electronic devices. Advanced technologies like machine learning algorithms and predictive maintenance are also implemented to enhance functionality. Additionally, scalability, security, and real-time monitoring functionalities are crucial considerations. Insights from the literature survey inform potential future research directions, contributing to ongoing advancements in autonomous systems technology. Overall, the project aims to deliver a comprehensive solution that addresses key challenges and enhances efficiency across various applications in smart cities, homes, and industrial settings.

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