**SMART PUBLIC RESTROOM**

**Naan Mudhalvan Phase 2 Project**

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**Project Title: Smart Public Restroom**

**Phase 2: Innovation**

**1. Data Analysis:**

**Data Gathering:** Collect a comprehensive historical dataset from various IoT sensors installed in public restrooms. This dataset should include information on restroom occupancy (e.g., the number of people in the restroom), cleanliness levels (e.g., air quality, waste bin levels), and maintenance records (e.g., timestamps of cleaning or maintenance activities). The historical data is the foundation for building predictive models.

**Data Preprocessing:** Before deploying predictive algorithms, it's crucial to clean and prepare the data. This step involves addressing issues such as missing data, outliers (data points that deviate significantly from the norm), and data alignment. Data should be cleaned to ensure its quality and reliability.

**Data Normalization:** Normalize the data to ensure that all sensor readings are on a consistent scale. Normalization is important when sensor data is measured on different scales or units. For example, if one sensor measures occupancy on a scale of 0-100 and another measures air quality on a scale of 0-1, normalizing the data makes it directly comparable and ready for analysis.

**2. Anomaly Detection:**

**Anomaly Identification:** Develop sophisticated anomaly detection algorithms that continuously analyze the sensor data to identify anomalies or deviations from established baseline patterns. Anomalies could include unusual occupancy patterns, abrupt drops in cleanliness levels, or any irregularities that might indicate an impending maintenance need. These algorithms should be adaptable and responsive to real-time changes.

**Dynamic Thresholds:** Instead of using static, fixed thresholds, employ adaptive and dynamic thresholds for different sensor readings. For example, the system should recognize that the acceptable level of restroom occupancy varies depending on factors like the time of day, location, and event schedules. Dynamic thresholds ensure that anomalies are assessed within their context.

**Multi-Sensor Fusion**: Combine data from multiple sensors to identify complex anomalies. For example, the system should recognize that a combination of high occupancy and a decrease in air quality is more indicative of a cleanliness issue than each metric on its own. This holistic approach provides a more accurate assessment of restroom conditions.

**3. Predictive Models:**

**Machine Learning Algorithms:** Utilize a variety of machine learning algorithms to create predictive models. The choice of algorithms should be based on the nature of the data and the specific prediction problem. For example, time series analysis might be suitable for predicting future occupancy trends, while classification algorithms can be used to predict cleanliness issues.

**Feature Selection:** Carefully select the most relevant features or attributes from the sensor data. These features should have a significant impact on predicting maintenance needs. For instance, waste bin levels, air quality, restroom foot traffic patterns, and historical maintenance logs could be essential features. Feature selection helps streamline the model and reduce computational complexity.

**Model Training**: Train the predictive models using historical data. The models should learn patterns that precede maintenance issues. For instance, they should recognize that a significant drop in air quality often precedes an increase in user complaints. Training models involve exposing them to historical data, allowing them to discover relationships and patterns that are useful for prediction.

**Ensemble Methods:** Implement ensemble methods to improve model accuracy. Ensemble techniques combine predictions from multiple models, reducing overfitting (when a model is too specific to the training data) and enhancing overall prediction quality. Bagging and boosting are common ensemble methods used in machine learning.

**4. Alerting and Notifications:**

**Alert Generation:** When the predictive models detect potential maintenance needs, the system should generate alerts. These alerts not only indicate the presence of an anomaly but also provide information about the nature and urgency of the issue. For example, an alert could specify that a restroom cleaning is required within the next 24 hours, based on an anomaly in cleanliness data.

**Severity Levels**: Categorize alerts based on severity levels. This categorization allows maintenance staff to prioritize their actions. For example, a minor cleanliness issue can be scheduled for regular cleaning, while a critical issue demands immediate attention. Severity levels help maintenance staff allocate resources effectively.

**Notification Channels**: Implement multiple notification channels for conveying alerts to the relevant parties. Options include the web-based platform, mobile app notifications for users, email notifications to maintenance staff, and integration with a ticketing system to automatically create maintenance requests. Different stakeholders receive alerts through their preferred communication channels.

**5. Maintenance Scheduling:**

**Proactive Maintenance Scheduling:** In addition to generating alerts, the system should assist in scheduling maintenance proactively. For example, if the predictive model foresees that restroom cleanliness will likely deteriorate in a day or two, it can schedule cleaning staff to address the issue before it escalates. Proactive scheduling helps prevent issues from becoming urgent.

**Optimizing Resources:** By scheduling maintenance based on predictive data, the system ensures efficient resource allocation. Maintenance staff can focus on tasks that need immediate attention, reducing downtime and optimizing their work schedules. This resource optimization minimizes unnecessary maintenance visits and maximizes the efficiency of maintenance staff.

**Historical Data Analysis**: Continuously assess the accuracy of the predictive models by comparing their predictions with actual maintenance records. By analyzing historical data alongside real-world maintenance outcomes, the system can learn from its predictions and improve its accuracy over time. This iterative process ensures that the predictive models become increasingly precise and reliable.

Incorporating predictive maintenance algorithms into the Smart Public Restroom project is a substantial step towards efficient restroom management and improved user experience. By addressing maintenance needs proactively, the system not only increases user satisfaction but also optimizes resource allocation and reduces the likelihood of emergency maintenance situations. The innovative application of data analysis and machine learning techniques ensures the project's long-term success and reliability.

***THANK YOU!!!***

***Done by:***

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