Auto-Priority Classification Of Road Segments For Repair For The Mandaluyong LGU

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Abstract: Road infrastructure is essential for economic and social development. In the Philippines, approximately 23% of the national road network is deteriorating due to insufficient investment. Mandaluyong City's road maintenance, overseen by the Mandaluyong LGU, faces challenges in prioritizing repairs due to subjective decision-making and a lack of structured methodologies. This study aims to address these challenges by analyzing current technologies for road data visualization and repair prioritization, developing a web-based Automatic Priority Classification System (APCS) that integrates the Road Physical Feature Extraction (RFEX) system, and evaluating the system's efficiency through User Acceptance Testing (UAT). The Agile Scrum methodology guides APCS development, allowing for iterations and stakeholder feedback. Preliminary testing of the APCS indicates promising outcomes in optimizing repair prioritization by leveraging geospatial data processed by the RFEX system and considering key factors identified by the LGU. The system streamlines the repair prioritization process, enhances resource allocation, and reduces delays in addressing critical road issues. Implementing the APCS for Mandaluyong LGU offers a structured, data-driven approach to road repair prioritization, aiming to improve road conditions and service delivery. Continued evaluation and stakeholder feedback will refine the system for successful implementation. User Acceptance Testing showed high overall satisfaction ratings ranging from 4.8 to 5.0 with the system's usability and data accuracy, though some learning curve was observed.

Key Words: Road Infrastructure, Automatic Priority Classification System, Road Physical Feature Extraction, Agile Scrum, Geospatial Technology

1. INTRODUCTION

Road infrastructure forms a critical network vital for economic, social, and cultural development, connecting regions and supporting various sectors (Arts et al., 2021; Henderi et al., 2020). However, inadequate investment has led to approximately 23% of the Philippine national road network deteriorating, posing barriers to economic growth.

In Metro Manila, entities like the Department of Public Works and Highways (DPWH) rely on subjective factors, and lacks structured guidelines, leading to inefficiencies and potential misallocation of resources. The lack of structure

approach to road repair prioritization can result in increased costs, delayed repairs, and potential safety hazards.

Interviews with Mandaluyong LGU personnel highlighted the need for a more objective, data-driven approach to prioritize road repairs. To address this, the proponents have proposed an Automatic Priority Classification System (APCS) that integrates a computer vision-based Road Feature Physical Extraction system (Agulto et al., 2023). The APCS aims to assess road repair urgency based on various factors, aiding the Mandaluyong LGU in making informed decisions and improving road infrastructure maintenance. The APCS offers a novel approach to road repair management by integrating computer vision-based road feature extraction with a web-based system for prioritization, addressing the limitations of subjective, non-data driven methods.

2. CONCEPTUAL FRAMEWORK

Figure 1 presents a conceptual framework for a web application designed for automatic prioritization classification in the context of road repair. It addresses identified issues in decision-making for road repair by tailoring modules to utilize opportunities and tackle problems. Stakeholder feedback highlighted the subjectivity of current decision-making processes, prompting the need for objective solutions. This framework enables data visualization and automatic prioritization and classification of which road segments to repair, empowering Mandaluyong LGUs to make informed decisions. The User Services Module provides secure access and personalized experiences, while the Dashboard Module offers a centralized interface for monitoring and analysis, supporting data-driven decisions. The Explore Module integrates a Geographic Information System (GIS) map for visualizing geographical data and implementing auto priority classification. The Contribution Module streamlines data gathering, and the Quality Control Module ensures data suitability. The Reports Module provides structured, customizable reports, and the Job Order Calendar Module facilitates the management of active job orders.

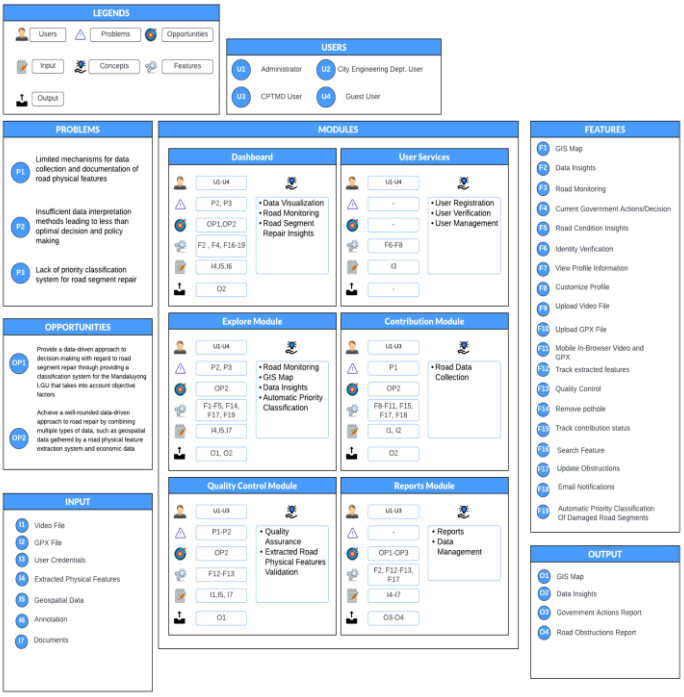

Figure 1. Conceptual Framework

2.1 User Services Module

The Users Services Module allows different types of users to access and utilize the features of the web application. This module includes features such as user registration, user verification, and user management. With the following features, users can securely access the system, personalize their experience, and interact with the platform effectively. It also integrates security measures, access controls, and user-specific settings, making it an essential part of any user-centric application. This module supports the objective of providing a user-friendly and secure platform for all stakeholders involved in the road repair process.

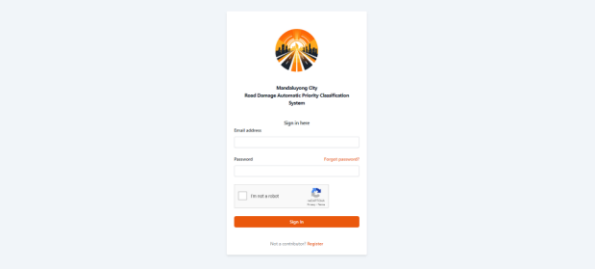

Figure 2. User Services Module

2.2 Dashboard Module

The Dashboard Module offers a centralized interface for monitoring and analyzing road network data, aiding LGU decision-making. It presents essential factors and classifications determining repair priorities. Users can customize their dashboards for specific insights, promoting data-driven decisions and productivity. An email notification system ensures proper task assignment and enhances departmental coordination. This module directly addresses the problem of subjective decision-making by providing data-driven overview of road conditions and repair priorities.

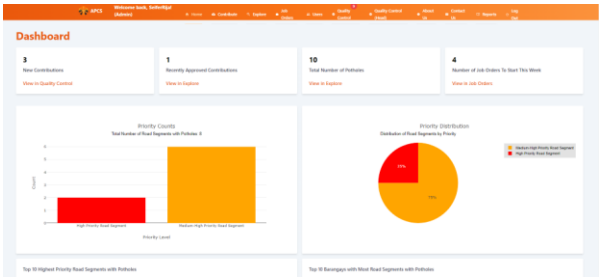

Figure 3. Dashboard Module

2.3 Explore Module

The Explore Module integrates a Geographic Information System Map for visualizing and analyzing geographical data, including government actions, road conditions, and pothole discoveries. It supports LGU decision-making by incorporating various geospatial layers and implementing auto priority classification for potholes. Users of all types can access this module, which also notifies validators about changes in pothole data that affect the priority levels of other segments. By integrating a GIS map, this module enables a more comprehensive understanding of the spatial distribution of road damage, facilitating more effective resource allocation.

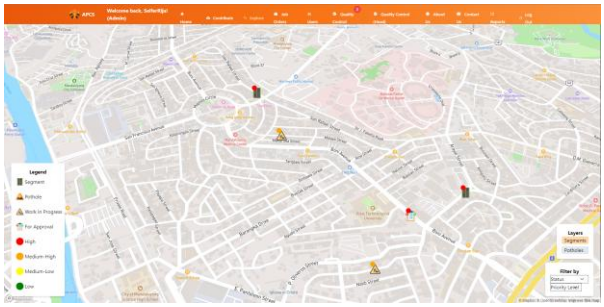

Figure 4. Explore Module

2.4 Contribution Module

The core data that is needed in this application is gathered through the Contribution Module. Here, designated user types can upload or capture images or video files displaying road data, with the module assessing their suitability for road monitoring. Additionally, the Global Positioning System (GPS) Exchange Format (GPX) file, which provides the GPS coordinates of the road data captured in the videos, should also be included when submitting videos. The Contribution Module significantly streamlines the process of integrating road network data into the system and the GIS map. This module enhances the efficiency of data collection, ensuring that the system has access to timely and relevant information of road conditions.

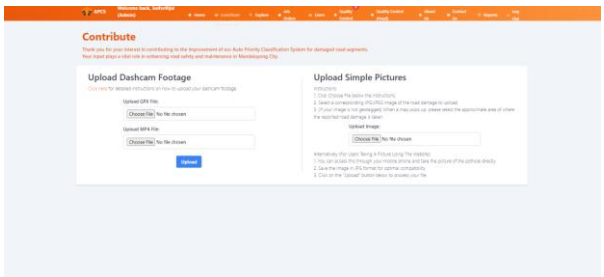

Figure 5. Contribution Module

2.5 Quality Control Module

In this module, user-submitted data from the Contribution Module undergoes manual examination to ensure suitability for system input. It serves as a

quality control tool, assessing parameters like image and video quality and road network content. The TPMO Officer approves or disapproves submissions based on these factors, with validation by the TPMO Manager for added reliability. Accepted data is integrated into application features reliant on user-submitted images and videos containing road network data. This process minimizes defects, enhances efficiency, and delivers high-quality results. The module also prevents duplicate contributions and notifies validators of potential impact on priority levels when validating potholes. This module ensures the accuracy and reliability of the data used in APC, which is crucial for effective decision-making.

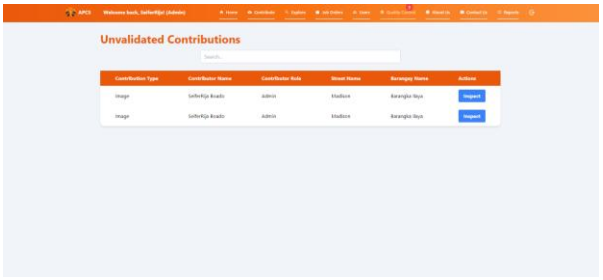

Figure 6. Quality Control Module

2.6 Reports Module

The Reports Module offers a structured interface for viewing data-driven reports derived from RFEX application analysis, ensuring quality control. Users can customize reports for tailored insights and summaries, streamlining data presentation and interpretation for informed decision-making in road repairs. The module also includes filtering options for effective consolidation, aiding LGU officers in documentation needs. This module provides Mandaluyong LGU officers with the information they need to make informed decisions about road repairs, supporting accountability and transparency.

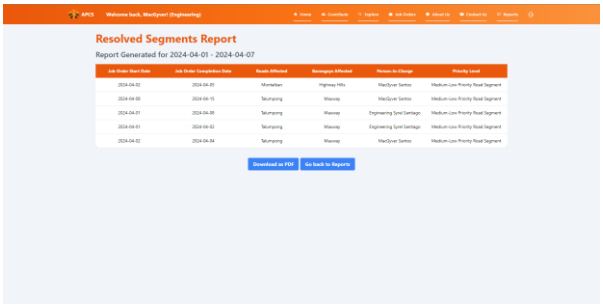

Figure 7. Reports Module

2.7 Job Order Calendar Module

The Job Order Calendar module is where the respective Engineering users and Managers can handle active Job Orders to resolve and reschedule job orders. The module offers features such as rescheduling and captures necessary data such as rescheduling reasons. Similar to the Quality Control Module, a job order's rescheduling and approval will require another layer of validation from an Engineering Head user. This module helps to ensure that road repairs are carried out in a timely and efficient manner, minimizing disruptions to traffic flow.

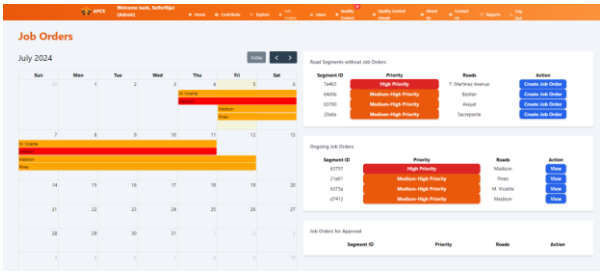

Figure 8. Job Order Calendar Module

3. METHODOLOGY

The study employs the Agile Scrum methodology as the framework for developing the APCS. Agile is well-suited for projects requiring iterative development, continuous feedback, and adaptability, ensuring that the system aligns with stakeholder needs (Šimícková et al., 2021). Scrum, is a subset of Agle, was chosen due to its structured approach to development, emphasizing incremental progress, collaboration, and flexibility. The

methodology involves: scrum roles, sprint planning, daily standups and client feedback (Scrum.org, n.d.).

The development of APCS followed a structured sequence: Requirement Gathering and Stakeholder Consultation – initial discussion with Mandaluyong LGU officers identified challenges in prioritizing road repairs. Insights from these consultations guided the design of the system functionalities; Module Development – the system was developed in modular increments, incorporating features such as the Dashboard Module, Explore Module, Contribution Module, and Quality Control Module. Each module underwent review and refinement in subsequent sprints; Data Processing and Classification – the system integrates the RFEX system, which processes geospatial data to determine road repair priorities. Priority classification is automated using key parameters defined by the Mandaluyong LGU; Testing and Validation – User Acceptance Testing (UAT) was conducted with Mandaluyong LGU officers and system users to assess the functionality and usability. Statistical methods, including mean, media and standard deviation, were used to evaluate UAT results; Deployment and Feedback Integration – after testing, final modifications were made based on stakeholder feedback. Plans for continuous monitoring and updates were established to ensure long-term system effectiveness.

The Agile Scrum methodology was chosen for its iterative nature, which allows for continuous feedback and adaptation to changing requirements (Scrum.org, n.d.). The development process was divided into several sprints, each lasting two weeks. Regular sprints reviews and retrospectives were held with the Mandaluyong LGU officers to ensure that the system met their needs. The specific parameters used by the Mandaluyong LGU for road repair prioritization include factors such as the severity of damage (e.g. pothole size, crack length), traffic volume, and the road's importance (e.g. major thoroughfare, access road to critical facilities). These parameters were selected based on discussion with Mandaluyong LGU engineers and officials, who identified them as the most critical factors in determining repair urgency. By following the Agile Scrum methodology, the study ensures that the APCS is efficient, user-centered, and adaptable, effectively addressing Mandaluyong LGU's road repair prioritization challenges.

4. RESULTS AND DISCUSSION

In analyzing the UAT Questionnaire results, the proponents chose to focus on the statistical measures such as the mean, median, mode and standard deviation to summarize the data effectively. The study used a Likert scale from 1 to 5, which avoids outliers and makes these measures suitable for analysis.

Table 1. Summary of the UAT Results by the Contributors

Question Theme	Contributors (Mean)	Contributors (Mode)
Ease of Registration	5.0	5.0
Verification Process	4.8	5.0
Dashboard Clarity & Usefulness	4.7 – 5.0	5.0
Priority Count Chart Clarity	4.6	5.0
"Top 10 Road Segments" List	4.9	5.0
Barangay Data Usefulness	5.0	5.0
Dashboard Real-Time Updates	5.0	5.0
About & Contact Pages	4.77	5.0
Report Generation (LGU only)	N/A	N/A
Task Completion Ease	4.6	5.0
Learnability	4.6	5.0
Frequency of Use Desire	4.6	5.0
Technical Support Needed	3.6	3.0
System Reliability	4.8	5.0
Overall Satisfaction	4.8	5.0

As seen on Table 1, the UAT results for contributors to the APCS reflect high satisfaction levels. Mean ratings for each question range from 3.69 to 5.00, with the mode frequently being 5, indicating that most contributors rated the system highly. Users noted the system's usefulness in gathering relevant data for the LGU and found the contribution methods

convenient. High satisfaction areas include ease of registration, priority information, and system integration. However, the learning curve for the system was noted, as reflected by a higher standard deviation. Overall, the satisfaction score is high, with a mean of 4.85, mode of 5, and standard deviation of 0.38, indicating general approval of the APCS. The higher the standard deviation (0.38) for the learning curve suggests that some contributors found the system more challenging to learn than others. This indicates a need for improved user training and documentation.

Table 2. Summary of the UAT Results by the LGU Officers

Question Theme	LGU (Mean)	LGU (Mode)
Ease of Registration	5.0	5.0
Verification Process	4.8	5.0
Dashboard Clarity & Usefulness	4.8 – 5.0	5.0
Priority Count Chart Clarity	4.8	5.0
"Top 10 Road Segments" List	4.8	5.0
Barangay Data Usefulness	5.0	5.0
Dashboard Real-Time Updates	5.0	5.0
About & Contact Pages	5.0	5.0
Report Generation (LGU only)	4.8 – 5.0	5.0
Task Completion Ease	4.8	5.0
Learnability	4.4	4.0
Frequency of Use Desire	4.6	5.0
Technical Support Needed	2.4	5.0
System Reliability	5.0	5.0
Overall Satisfaction	4.8	5.0

As gleaned in Table 2, the UAT among LGU officers reveals a positive reception for the APCS. Users appreciated the ease of registering new accounts and the reliability of the verification process, both receiving perfect scores and zero variability. TPMO users found the contribution module useful for streamlining reporting processes, while the Engineering department valued the job order calendar and information presentation, especially during budget cuts. The dashboard's clarity and up-to-date information, along with the "Priority Counts" chart, were highly rated, with minimal variability. Report generation and accuracy were also praised, with perfect scores indicating uniform approval. However, user experiences varied in learning and navigating the system, with some needing technical support. Overall, the APCS has been well-received, particularly for its dashboard, real-time data, and efficient report generation. Addressing the learning curve and technical support needs can further improve user satisfaction. The positive results indicate that the APCS has the potential to significantly improve efficiency and effectiveness of road repair prioritization in Mandaluyong LGU. The system's data-driven approach helps to ensure that resources are allocated to the areas where they are most needed, reducing delays and improving the overall quality of road infrastructure.

5. CONCLUSIONS

Mandaluyong LGU faces significant challenges in prioritizing road repairs due to the absence of a systematic approach to managing pothole data, leading to inefficiencies and delays in road maintenance efforts. The proposed APCS addresses these issues by automating data integration and prioritization processes. Key modules, such as the Dashboard and Reports Module, provide actionable insights into road conditions, while the Contribution Module engages citizens in reporting potholes. Administration tools such as the Quality Control, Explore, and Job Order Calendar modules help Mandaluyong LGU officials validate data and optimize resource allocation. The system was validated through UAT with residents and Mandaluyong LGU officers, showing high satisfaction in usability, data accuracy, and reporting effectiveness with ratings ranging from 4.6 to 5.0. Contributors valued the intuitive pothole reporting interface and real-time updates on repair priorities, enhancing transparency and citizen engagement giving a rating of 5.0. The implementation of APCS improves operational efficiency, data management, and collaboration among LGU departments. It sets a foundation for sustainable road repair practices and serves as a

model for other municipalities. The positive UAT results indicate that APCS effectively addresses current road repair prioritization challenges in Mandaluyong LGU. Future work will focus on expanding the system's functionality to include predictive maintenance capabilities and integrating additional data sources, such as traffic flow and weather conditions, to further improve the accuracy of repair prioritization.

6. ACKNOWLEDGMENTS

The authors would like to extend their heartfelt gratitude to their adviser, for her invaluable guidance and unwavering support throughout the research process. The authors wish to acknowledge the Traffic & Parking Management Office and City Engineering/Maintenance Department of the Mandaluyong LGU. Their cooperation, willingness to share information, and collaboration were pivotal in identifying the problem's nuances and developing a viable solution. Their contributions have been invaluable in shedding light on the challenges faced in road maintenance and repair in Mandaluyong City and in crafting the proposed Automatic Priority Classification System.

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