Project Base Learning
(PBL)

E-Care
Software Requirement Specification for a deep learning model to recognize potholes on roads and rank them according to severity.

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1. Introduction

1.1. Purpose

The purpose of a deep learning model to recognize potholes on roads and rank them according to depth and width or severity is to provide real-time, accurate and automated data to city authorities and maintenance crews. This information can help in prioritizing road maintenance activities and allocate resources more effectively. The deep learning model can process large amounts of image data captured by cameras or other imaging devices mounted on vehicles or drones, and identify the location, depth and width of potholes and the amount of garbage on roads.

The ranking of potholes based on their severity can provide an objective measure of the priority for repairs or clean-up, making it easier for city authorities to make informed decisions about road maintenance activities. The deep learning model can also continuously monitor the roads and provide real-time updates on the status of the roads, helping to prevent further damage and improve road safety for drivers and other road users.

1.2. Document Convention

- Section titles are 20pt Arial font.
- Sub Section titles are 14pt Times New Roman font.
- All text contained in this document is 12pt Times New Roman font.
- Any further subsection breakdown is 13pt Times New Roman font.
- All sections and subsection are numbered using the 1..2..3... number format.
- Document text will be single-paced and maintain 1” margins

1.3. Intended Audience and Reading Suggestion

The intended audience for E-Care includes:

- Technical Team: The technical team, including software engineers, data scientists and machine learning experts, will use the SRS to understand the requirements for the deep learning model, including the object detection, pothole characterization, and severity analysis.
- Stakeholders: Stakeholders, including end-users, and government agencies, will use the SRS to understand the purpose and scope of the project, as well as the expected outcomes and benefits.

It is recommended that each reader take the time to thoroughly review the SRS to ensure a complete understanding of the project requirements.

1.4. Product Scope

- Object Detection: The model will be able to detect potholes on roads using advanced deep learning algorithms.
- pothole Characterization: The model will be able to accurately characterize the depth, width, and severity of each pothole item detected on the roads.
- Real-time Location Monitoring: The model will be able to monitor real-time location of pothole item detected on the roads while capturing the image, providing real-time updates on the presence and severity of potholes and garbage.
- Data Sources: The model will be able to source data from various sources, including cameras, GPS, and mapping systems.
- User Interfaces: The model will be accessible via user-friendly interfaces, including a mobile app, to provide real-time information on potholes on roads.

- Scalability: The model will be designed to be scalable, able to process large amounts of data from multiple sources and provide real-time updates on potholes on roads.
- Integration: The model will be integrated with existing infrastructure and systems, such as road maintenance management systems, to provide a comprehensive solution for road maintenance and repair, and cleaning.

This product scope outlines the key features and capabilities of the project, providing a comprehensive solution for detecting and characterizing potholes on roads.

1.5. References

- Software Requirement Specification document Karl E. Wiegers @1999
- https://www.google.co.in/
- https://www.wikipedia.org/
- https://www.kaggle.com/datasets/sachinpatel21/pothole-image-dataset

2. Overall Description

2.1. Product Perspective

The context and origin of the product being specified in this SRS is the need for an effective and efficient solution for road maintenance and monitoring. The problem of potholes on roads is a widespread issue, causing significant damage to vehicles and affecting the safety of drivers and passengers. The current methods for monitoring and maintaining roads are time-consuming, labour-intensive, and often not very accurate.

This product is a new, self-contained deep learning model designed to address this problem. It is not a follow-on member of a product family or a replacement for existing systems. The model utilizes the latest advances in computer vision and deep learning algorithms to accurately identify potholes on roads and rank them according to severity.

The requirements of this deep learning model are distinct from the larger road maintenance management system. However, the model will integrate with existing systems, providing critical information about road conditions that can be used to prioritize maintenance efforts and improve the overall effectiveness of road maintenance management. The interfaces between the deep learning model and the larger road maintenance management system will be specified in this SRS.

2.2. Product Functions

The major functions of the deep learning model to recognise potholes on road and rank them according to depth and width or severity are as follows:

Image/Video Capture: The model must be able to process images or videos captured by cameras installed on vehicles or drones, providing real-time data about road conditions.

Pothole Detection: The deep learning algorithms must be able to accurately identify potholes on the road from the images or videos captured.

Severity Ranking: The model must rank the detected potholes based on their severity, taking into account factors such as depth, width, and location.

User Interface: The model must provide a user-friendly interface for data entry and analysis, making it accessible to a wide range of users.

Integration with Road Maintenance Management Systems: The model must be able to integrate with existing road maintenance management systems, providing critical information about road conditions to aid in the prioritization of maintenance efforts.
Data Storage and Management: The model must store the captured images, videos, and analysis results, allowing for easy access and retrieval of data.
Reporting and Analytics: The model must provide detailed reports and analytics about the detected potholes and garbage, allowing for easy analysis and interpretation of data.
These major functions will be organized in a logical and understandable manner in the SRS, allowing for clear and concise communication of the requirements for this deep learning model. A top-level data flow diagram or object class diagram may also be included in the SRS to provide a visual representation of the major groups of related requirements and how they relate to one another.

2.3. User classes and characteristics

The various user classes for the deep learning model to recognise potholes on road and rank them according to depth and width or severity are:

- Road Maintenance Engineers: This group will use the model most frequently and will require the highest level of technical expertise. They will be responsible for monitoring the road conditions and making decisions based on the data provided by the model.
- Government Officials: This group will also use the model frequently, but will require a lower level of technical expertise. They will be responsible for ensuring that road maintenance efforts are being properly managed and allocated.
- Drivers: This group will use the model on an as-needed basis and will require the least amount of technical expertise. They will benefit from the data provided by the model in order to avoid potholes and other road hazards.
- General Public: This group may use the model on an occasional basis, and will also require a lower level of technical expertise. They will benefit from the data provided by the model in order to plan their route and ensure safe travel.

Of these user classes, Road Maintenance Engineers and Government Officials are the most important to satisfy, as they are responsible for the management and maintenance of the roadways. Drivers and the General Public are less important to satisfy, as they primarily use the model for personal safety and convenience.
Each user class will be described in the SRS with their pertinent characteristics, such as technical expertise, educational level, and experience, in order to ensure that the requirements for each user class are properly understood and met. This will ensure that the deep learning model meets the needs of all users and provides a seamless and intuitive experience for all.

2.4. Operating Environment

The deep learning model to recognize potholes on road and rank them according to depth and width or severity will operate in the following environment:

- Hardware Platform: The model will run on high-end servers or cloud-based platforms with powerful GPUs to support deep learning algorithms. The minimum requirements will include a multi-core processor, a large amount of RAM, and a high-speed GPU.
- Operating System: The model will support both Windows and Linux operating systems, with specific versions to be determined based on compatibility with the hardware and software components.

- Other Software Components: The model will integrate with other software components such as image processing libraries, deep learning frameworks, and databases to store and manage the data. Compatibility with these components will be evaluated and verified before deployment.
- Other Applications: The model will peacefully coexist with other applications such as road maintenance management systems, mapping applications, and weather applications. Interfaces between the model and these applications will be defined and implemented to ensure seamless integration and data exchange.

The described environment will ensure that the deep learning model operates efficiently and effectively, and can be easily integrated into existing systems to provide valuable insights and support road maintenance efforts.

2.5. Design and Implementation Constraints

The following items will limit the options available to the developers for the deep learning model to recognize potholes on road and rank them according to depth and width or severity:

- Corporate Policies: Any corporate policies regarding data privacy, data storage, and data management must be adhered to. The model must be developed in a way that ensures the security and confidentiality of the data collected and processed.
- Hardware Limitations: The model must be developed in a way that meets the hardware requirements, including memory and processing power. The model must be optimized to run efficiently and effectively on the available hardware.
- Interfaces to Other Applications: The model must be developed with interfaces that are compatible with other applications, including road maintenance management systems and mapping applications. This will ensure seamless data exchange and integration.
- Specific Technologies, Tools, and Databases: The model must be developed using specific technologies, tools, and databases as specified by the customer. This may include deep learning frameworks, image processing libraries, and databases for data storage and management.
- Security Considerations: The model must be developed with security considerations in mind. This includes the protection of the data collected and processed, as well as the protection of the system from malicious attacks.
- Design Conventions and Programming Standards: The model must be developed in accordance with design conventions and programming standards specified by the customer. This will ensure consistency and maintainability of the code, and make it easier for the customer to maintain and update the software in the future.

The limitations specified above will ensure that the model meets the requirements of the customer and is developed in a way that meets their standards and expectations.

2.6. User Documentation

The user documentation components that will be delivered with the deep learning model to recognise potholes on road and rank them according to depth and width or severity include:

- User manual: This will provide a comprehensive guide on how to use the software and its features.
- On-line help: This will provide context-sensitive help and support for users who are not familiar with the software.

- Tutorials: This will include step-by-step guides and videos to help users understand the software and how to use it.

The delivery format for the user documentation will be in PDF format, which is easily accessible and can be used on any device with a PDF reader. The standards followed will be based on industry standards and best practices for software documentation.

2.7. Assumption and Dependencies

For a deep learning model to recognise potholes on road and rank them according to depth and width or severity, the following assumptions and dependencies may be considered:

- Data availability: The model will require large amounts of labeled data of potholes on roads for training and validating the model.
- Hardware requirements: The model will require high-performance computing resources such as GPUs for efficient and effective training.
- Image quality: The quality of images captured by the camera used to collect data will affect the accuracy of the model.
- Quality of annotated data: The accuracy of the annotations provided for the data will directly impact the model's performance.
- Technical expertise: The team developing the model will need to have expertise in deep learning, computer vision, and image processing.
- Dependency on external libraries: The model may rely on existing libraries such as TensorFlow or PyTorch for implementation, and their updates could impact the model.
- Integration with existing systems: The model may need to be integrated with other existing systems, such as road maintenance systems, to provide real-time updates on potholes and garbage.
- Privacy and security: There may be privacy and security concerns around collecting and storing data, which will need to be addressed while developing the model.

3. External Interface Requirements

3.1. User Interfaces

The deep learning model to recognise potholes on road and rank them according to depth and width or severity will have a user interface for inputting the road images. The user interface will be designed to provide a simple and intuitive way for the user to interact with the model.

The user interface will have a button to upload an image of the road and another button to start the recognition process. The model will process the image and display the results on the screen, showing the locations of the potholes along with their severity ranking based on depth and width.

The user interface will also have options for the user to adjust the parameters of the model, such as the sensitivity of the recognition process, to get more accurate results. Additionally, the user interface will have a help button that provides information on how to use the model and its features.

It is important to note that the user interface design will follow any GUI standards and product family style guides that may be in place. The user interface specification will provide

detailed information on the screen layout, standard buttons, error message display standards, and other aspects of the user interface.

3.2. Hardware Interfaces

For the deep learning model to recognise potholes on road and rank them according to depth and width or severity, the physical and logical characteristics of the interface between the software product and hardware components of the system need to be considered. The software product will be designed to work with different hardware components such as cameras, sensors, and GPS systems. The following are the characteristics of the interface:

- Supported Device Types: The software product must be compatible with various types of cameras and sensors that can be used for data collection. It should be able to work with different types of cameras and sensors that are commonly used for road inspection such as high-resolution cameras, thermal cameras, and LIDAR sensors.
- Data and Control Interactions: The software product must be able to collect data from cameras and sensors and process it to identify potholes on the road. It must be able to communicate with the cameras and sensors and control their operations.
- Communication Protocols: The software product must use standardized communication protocols to interact with the hardware components. It should be able to communicate with different types of cameras and sensors using protocols such as USB, Ethernet, and Wi-Fi.

These characteristics will ensure that the software product can interact seamlessly with the hardware components and provide accurate results for pothole recognition and ranking according to severity.

3.3. Software Interfaces

For a deep learning model to recognize potholes on roads and rank them according to depth and width or severity, the following software components are connected:
Connections with software components:

1. Operating System: The operating system used could be Windows, Linux, or macOS.
    - Deep Learning Library: TensorFlow, PyTorch, or Caffe could be used as the deep learning library for building and training the model.
    - Tools: Image processing tools like OpenCV could be used to pre-process the input images and extract features.
    - Databases: A database like MySQL or PostgreSQL could be used to store the input images and the results of the model's predictions.
2. Data flow:
    - Data items coming into the system: The input to the system would be images of roads with potholes captured using cameras or smartphones.
    - Purpose of data coming in: The purpose of the input images is to train the deep learning model to recognize potholes on roads.
    - Data items going out of the system: The output of the system would be the predictions of the model, including the location and severity of the potholes on the roads.
    - Purpose of data going out: The purpose of the output is to provide information to city authorities and road maintenance companies to prioritize and address the potholes on the roads.
3. Services needed:

- The system needs access to a server with a high-performance GPU to train and run the deep learning model.
- Nature of communications: The system communicates with the server using an API to send and receive data.

4. Data sharing mechanism:
   - Data shared across software components: The input images and the results of the model's predictions are stored in the database and can be accessed by other software components.
   - Implementation constraint: Access to the database should be secure and controlled, to maintain the privacy and security of the data.
5. API Protocols:
   - Detailed API protocols are documented in the API documentation, which can be used by developers to integrate the deep learning model into their applications.

3.4. Communication Interfaces

For a deep learning model to recognize potholes on roads and rank them according to depth and width or severity, the following communication requirements should be considered:

- E-mail: If the system sends notifications or updates via email, the requirements for email communication should be defined. This includes email address formats, message formats, and security requirements such as encryption.
- Web browser: If the system is accessed through a web browser, the requirements for web browser communication should be defined. This includes browser compatibility, message formatting, and security requirements such as SSL encryption.
- Network Server Communications Protocols: The communication between the deep learning model and the server should be defined. This includes the protocol used (such as FTP or HTTP), data transfer rates, and synchronization mechanisms.
- Electronic Forms: If the system requires electronic forms for data entry or retrieval, the requirements for electronic form communication should be defined. This includes form formats, security requirements such as encryption, and data transfer mechanisms.
- Communication Standards: The standards used for communication between the deep learning model and other software components should be defined. This includes communication protocols such as FTP or HTTP, and any data exchange formats used.
- Communication Security and Encryption: The security and encryption requirements for communication between the deep learning model and other software components should be defined. This includes encryption algorithms, secure authentication mechanisms, and data privacy requirements.
- Data Transfer Rates: The requirements for data transfer rates between the deep learning model and other software components should be defined. This includes the maximum and minimum data transfer rates required for the system to operate effectively.
- Synchronization Mechanisms: If the deep learning model requires synchronization with other software components, the synchronization mechanisms should be defined. This includes the methods used to ensure that data is consistent and up-to-date across all components.

4. System Features

4.1 System Feature 1

Image Recognition: The deep learning model should be able to accurately recognize and distinguish between potholes on the road.

4.2 System Feature 2

Depth and Width Detection: The model should be able to measure the depth and width of each pothole or garbage on the road to assess their severity.

4.3 System Feature 3

Severity Ranking: Based on the depth and width measurements, the model should be able to rank the potholes according to their severity, making it easier for authorities to prioritize repairs.

4.4 System Feature 4

Real-time Feedback: The model should provide real-time feedback to the user on the location and severity of the potholes on the road.

4.5 System Feature 5

Data Collection: The model should be able to collect and store data on the potholes detected on the road, which can be used for future analysis and improvement.

4.6 System Feature 6

Integration with Other Systems: The model should be able to integrate with other relevant systems, such as GPS and mapping systems, to provide a comprehensive view of the road conditions.

4.7 System Feature 7

User-friendly Interface: The model should have a user-friendly interface that is easy to use and navigate, making it accessible to all users, regardless of their technical expertise.

4.8 System Feature 8

Scalability: The model should be scalable, allowing it to accommodate increasing amounts of data and improve its accuracy over time.

4.9 System Feature 9

Robustness: The model should be robust and able to handle different types of road conditions, lighting, and weather conditions.

4.10 System Feature 10

Cost-effectiveness: The model should be cost-effective, making it accessible to different levels of government, organizations, and communities.