Computer On Wheels Project
Software Requirements Specification
Version <6.0>

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Software Requirements Specification

1. Introduction

The introduction of the Software Requirements Specification (SRS) provides an overview of the entire SRS with purpose, scope, definitions, acronyms, abbreviations, references and overview of the SRS. The aim of this document is to gather and analyze and give an in-depth insight of the complete **Computer On Wheels software system** by defining the problem statement in detail. Nevertheless, it also concentrates on the capabilities required by domain expert and stakeholders and their needs while defining high-level product features. The detailed requirements of the **Computer On Wheels** are provided in this document.

1.1 Purpose

The purpose of the document is to collect and analyze all assorted ideas that have come up to define the system, its requirements with respect to consumers. Also, we shall predict and sort out how we hope this product will be used in order to gain a better understanding of the project, outline concepts that may be developed later, and document ideas that are being considered, but may be discarded as the product develops.

In short, the purpose of this SRS document is to provide a detailed overview of our software product, its parameters and goals. This document describes the project's target audience and hardware and software requirements. It defines how our client, team and audience see the product and its functionality. Nonetheless, it helps any designer and developer to assist in software delivery lifecycle (SDLC) processes.

1.2 Scope

Primarily, the scope pertains to the key functionalities required for the autonomous vehicle project to operate effectively. It focuses on integrating sensors and algorithms for environmental perception, path planning for optimal route determination, path following for precise vehicle control, and real-time obstacle detection and avoidance to ensure safe navigation.

This SRS aims to specify the software requirements to be developed, which can also assist in selecting suitable in-house and commercial software products. The standard can be used to create software requirements specifications directly or serve as a model for defining project-specific standards, without identifying any specific method, nomenclature, or tool for preparing an SRS.

1.3 Elicitation technique(s)

Requirements are gathered using a variety of techniques, including **interviewing domain experts and conducting documentation analysis**. Our approach involves reviewing existing documentation, research papers, industry standards, and guidelines related to autonomous vehicle navigation.

1.4 Definitions, Acronyms, and Abbreviations

CARLA	Car Learning to Act
FAQ	Frequently Asked Questions
ROS	Robotic Operating System
IMU	Inertial Measurement Unit
GPS	Global Positioning System

1.5 Overview

The remaining sections of this document provide a general description, including characteristics of the users of this project, the product's hardware, and the functional and data requirements of the product. General description of the project is discussed in section 2 of this document. Section 3 gives the functional requirements and constraints and assumptions made while designing the product. Section 3 also gives the specific requirements of the product. Section 4 is for supporting information.

2. Overall Description

This document contains the problem statement that the current system is facing which is hampering the growth opportunities of the company. It further contains a list of the stakeholders and users of the proposed solution. It also illustrates the needs and wants of the stakeholders that were identified in the brainstorming exercise as part of the requirements workshop. Its further lists and briefly describes the major features and a brief description of each of the proposed system.

3. Specific Requirements

The specific requirements are –

3.1 Problem Scenarios

Problem Statement # 1: Hazards caused by human errors	
The problem of	hazards caused by human errors
Affects	passengers, drivers, and pedestrians
The result of which	more injuries/deaths, Damage to property and Emotional stress
Benefits of	mitigation of human errors thus reduces accidents and fatalities

Table 3.1 | problem statement

Problem Statement # 2: Limited driver productivity	
The problem of	driver's unproductiveness while driving
Affects	drivers
The result of which	it decreased efficiency
Benefits of	increased productivity by doing other important tasks

Table 3.2| problem statement

Problem Statement # 3: Poor mobility for the aged, disabled, and children.	
The problem of	transportation reliance for vulnerable groups such as children, the elderly, and the disabled
Affects	passenger.
The result of which	increased risks to the health vulnerable individuals, potentially leading to delayed or insufficient medical care in emergency situations
Benefits of	accessibility, independence and reduced burden on caregivers

Table 3.3 | problem statement

3.2 Functionality

Introduction –

This subsection contains the requirements for this product. These requirements are organized by the features discussed with domain expert. Features are then refined into use case diagrams and to activity diagram to best capture the functional requirements of the system. All these functional requirements can be traced.

3.2.1 Vehicle control

3.2.1.1 Autonomous navigation: The system shall be capable of autonomously navigating from a starting point to a destination.

3.2.1.2 Acceleration control: The system shall control the vehicle's acceleration to maintain desired speeds along the planned trajectory.

3.2.1.3 Emergency stop: The system shall include a mechanism for the driver to perform an immediate emergency stop, halting all vehicle operations.

3.2.1.4 Throttle control: The system shall control the throttle to regulate vehicle speed within a range of 0 to 120 km/h, adjusting for road conditions and traffic regulations.

3.2.1.5 Steering control: The system shall control the vehicle's steering to maintain a maximum lateral deviation of 0.5 meters from the planned trajectory under normal conditions.

3.2.1.6 Braking control: The system shall control the vehicle's braking to safely decelerate and stop as required by the planned trajectory.

3.2.2 Path Planning

3.2.2.1 Route Calculation: The system shall calculate the most efficient route i.e. shortest path from the vehicle's current location to the driver-specified destination.

3.2.2.2 Lane Assignment: The system shall assign appropriate lanes for the vehicle to travel in along the calculated route, based on legal navigation rule.

3.2.2.3 Waypoint Generation: The system shall generate waypoints along the calculated route to guide the vehicle towards the destination.

3.2.2.4 Map Reading: The system shall be able to read and interpret digital map data to determine the vehicle's precise location within the road network.

3.2.2.5 Dynamic Obstacle Avoidance: The system shall adapt the vehicle's path in real-time to safely avoid unexpected obstacles.

3.2.3 Path Following:

3.2.3.1 Path smoothing: The system shall apply path smoothing techniques to limit acceleration changes to within 0.3 m/s², ensuring a smooth ride for passengers.

3.2.3.2 Lateral Control: The system shall maintain a lateral deviation of no more than 0.5 meters from the planned path under normal driving conditions.

3.2.3.3 Longitudinal Control: The system shall maintain a longitudinal deviation of no more than 1 meter from the planned path under normal driving conditions.

3.2.3.4 Speed Control: The system shall control the speed to reach the destination.

3.2.3.5 Waypoint Following: The system shall follow waypoints along the calculated waypoints to guide the vehicle towards the destination.

3.2.4 Sensor integration

3.2.4.1 Inertial Measurement Unit (IMU) Utilization: The system shall use an IMU to provide orientation and acceleration data at a frequency of 100 Hz.

3.2.4.2 Global Positioning System (GPS) Utilization: The system shall use GPS to determine the vehicle’s global position.

3.2.4.3 Radar/Lidar Utilization: The system shall utilize radar/lidar sensors to provide additional information about surrounding objects' velocity and distance, enhancing situational awareness.

3.2.5 Trajectory Planning

Trajectory Generation: The system shall plan a smooth and optimal trajectory, based on destination specified by user.

3.2.6 Obstacle Detection

3.2.6.1 Detection Using Sensors: The system shall utilize various sensors to detect obstacles in the vehicle's path.

3.2.6.2 Environmental Awareness: The system shall maintain the awareness of static and dynamic objects in the vehicles vicinity.

3.2.6.3 Dynamic Obstacle Tracking: The system shall continuously track the moving obstacle.

3.2.6.4 Destination Estimation: The system shall be able to calculate the distance to detected

obstacles

3.2.7 Obstacle Avoidance

3.2.7.1 Re-Plan Path: The system shall re-plan the path, once the object is detected.

3.2.7.2 Trajectory Adjustment: The system shall dynamically adjust the vehicle's trajectory to avoid obstacle in urban environment.

3.2.7.3 Multi-Obstacle Handling: The system shall manage avoidance of multiple obstacles simultaneously

3.2.7.4 Steering Control: The system shall dynamically adjust steering angles to guide the vehicle away from obstacles and keep it on its intended path.

3.2.7.5 Maneuver Execution: The system shall execute safe and efficient avoidance maneuvers to navigate around detected obstacles and maintain collision-free travel.

3.2.8 Destination Arrival

3.2.8.1 Destination Approach: The system shall approach the driver-specified destination with a positional accuracy of within 1 meter, following the calculated trajectory and waypoints.

3.2.8.2 Stop at Destination: The system shall bring the vehicle to a complete stop within 1 meter of the designated destination, ensuring deceleration rates do not exceed 2 m/s^2 for passenger safety and comfort.

3.2.9 User Input

3.2.9.1 Ride Initiation: The driver shall be able to initiate journey.

3.2.9.2 Destination Setting: The driver shall be able to input the desired destination, triggering the route planning process.

3.2.10 System Integration

3.2.10.1 ROS Integration: The system shall utilize the Robot Operating System (ROS) to facilitate communication and data exchange between different software components.

3.2.10.2 Simulation Environment: Development and testing of the system shall be conducted in a simulated environment (e.g., CARLA simulator) for thorough validation before real-world deployment.

3.3 Safety

Non- Functional Requirement	Description	Subfactor
Safety Requirement	Ensure reliable object detection in adverse weather conditions to assure safety	**Hazard Protection** The system must detect and respond to hazards arising from adverse weather conditions, such as rain, fog, or snow, which may reduce visibility.

3.4 Purchased Components

Not Applicable

3.5 Hardware Interfaces

Since the application is simulation based, no hardware will be included due to multiple constraints such as cost.

3.6 Software Interfaces

- **ROS Integration:** The system shall communicate with the Robot Operating System (ROS) to facilitate data exchange and coordination between different software components.
- **CARLA Simulator Integration:** The system shall integrate with the CARLA simulator to develop and test algorithms in a simulated environment before real-world deployment.
- **CARLA-ROS Bridge:** The system shall utilize the CARLA-ROS bridge for seamless integration between the CARLA simulator and ROS, enabling data exchange and control commands.
- **rospy Integration:** The system shall use rospy for Python-based ROS programming to develop and implement control algorithms, perception modules, and navigation strategies.

3.7 Communications Interfaces

- **Internal Communication Protocol:** The system shall use TCP/IP protocol for communication between different software modules within the vehicle's onboard computer system.

- **External Communication Protocol:** The system shall use TCP/IP or UDP/IP protocols for communication with external devices or systems, such as remote monitoring stations or control centers.

3.8 Licensing Requirements

Not Applicable

3.9 Applicable Standards

It shall be as per the automotive industry standard.

4. Supporting Information

Please refer the following document:

1. Use case analysis.
2. Detailed use case analysis.
3. Activity analysis.
4. WBS
5. Research papers