

**DEPARTMENT OF COMPUTER SCIENCE & ENGINEERING
THE UNIVERSITY OF TEXAS AT ARLINGTON**

**SYSTEM REQUIREMENTS SPECIFICATION
CSE 4316: SENIOR DESIGN I
FALL 2024**



**VIRTUROLL
VR WHEELCHAIR SIMULATOR**

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REVISION HISTORY

Revision	Date	Author(s)	Description
0.1	10.01.2024	HB, RC, JD, JM, SN	document creation
1.0	10.14.2024	HB, RC, JD, JM, SN	complete draft

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1 PRODUCT CONCEPT

This section describes the purpose, use, and intended user audience for the VirtuRoll Wheelchair Simulation Project. Users of the simulation will be able to experience various mobility challenges designed to replicate real-life scenarios in which a wheelchair-user may find themselves.

1.1 PURPOSE AND USE

This product should allow users to experience some of the mobility-based challenges which may be presented to a wheelchair user, although users of any background are invited and encouraged to utilize the simulation. It can be incredibly useful and informative, whether used as a training simulation so that wheel-chair users can "practice" their wheelchair mobility and feel more confident tackling these obstacles in the real world, or used as an empathy training and informative simulation for those who do not require the use of wheelchair or mobility aid to understand the point of view of those who do.

1.2 INTENDED AUDIENCE

The product is currently intended for adults or people who would be using an adult sized wheelchair, as that is the size in which the product was made. It is recommended for those who are able to operate a wheelchair, whether necessary for their own personal functioning or not. Those who do not rely on this disability resource may use it to grow their understanding of the challenges which their peers may experience, and those who do rely on the resource can use it to practice and become more confident in their mobility without ever risking their own safety. The product is not, however, recommended at this time for persons who are prone to motion-sickness as the virtual environment may be overwhelming.

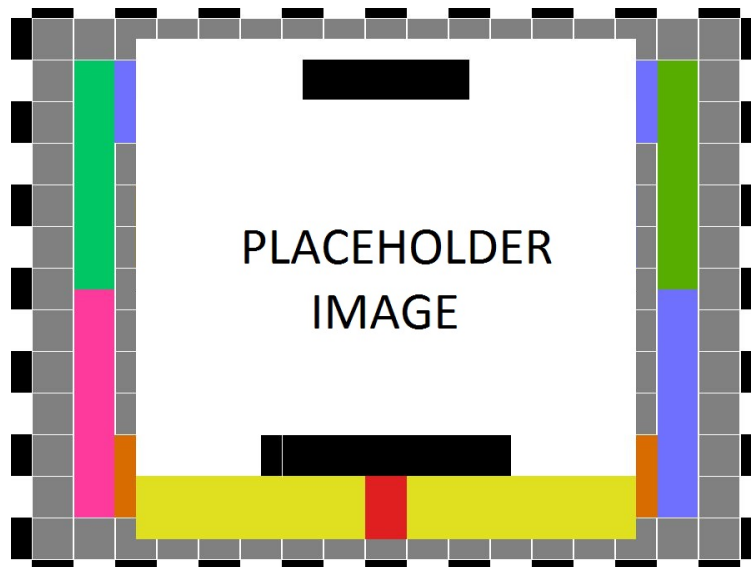


Figure 1: VirtuRoll conceptual drawing

2 PRODUCT DESCRIPTION

This section provides a description of your product and defines its primary features and functions. The purpose is to give the document reader/reviewer enough information about the product to allow them to easily follow the specification of requirements found in the remainder of the document. Your header for this section should introduce the section with a brief statement such as: "This section provides the reader with an overview of X. The primary operational aspects of the product, from the perspective of end users, maintainers and administrators, are defined here. The key features and functions found in the product, as well as critical user interactions and user interfaces are described in detail." Using words, and pictures or graphics where possible, specify the following:

2.1 FEATURES & FUNCTIONS

What the product does and does not do. Specify in words what it looks like, referring to a conceptual diagram/graphic (Figure X). Define the principle parts/components of the product. Specify the elements in the diagram/graphic that are part(s) of this product as well as any associated external elements (e.g., the Internet, an external web server, a GPS satellite, etc.)

2.2 EXTERNAL INPUTS & OUTPUTS

Describe critical external data flows. What does your product require/expect to receive from end users or external systems (inputs), and what is expected to be created by your product for consumption by end users or external systems (outputs)? In other words, specify here all data/information to flow into and out of your systems. A table works best here, with rows for each critical data element, and columns for name, description and use.

2.3 PRODUCT INTERFACES

Specify what all operational (visible) interfaces look like to your end-user, administrator, maintainer, etc. Show sample/mock-up screen shots, graphics of buttons, panels, etc. Refer to the critical external inputs and outputs described in the paragraph above.

3 CUSTOMER REQUIREMENTS

The VRWHEELCHAIR project aims to create an immersive virtual reality experience that simulates the challenges faced by wheelchair users. This system aims to help able-bodied individuals to develop empathy, awareness, and a deeper understanding of the experiences of wheelchair users. By stepping into their shoes, we hope, user can gain insights into the everyday challenges and barriers faced by those with mobility impairments. The following requirements establish the core functionalities and features expected by our customers and end-users.

3.1 VR EXPERIENCE

3.1.1 DESCRIPTION

The VRWHEELCHAIR system must provide a highly immersive virtual reality experience that accurately simulates the perspective and challenges of wheelchair users. This includes realistic environmental interactions, obstacle navigation, and sensory feedback.

3.1.2 SOURCE

1. Professor Shawn Gieser
2. CSE Senior Design project specifications

3.1.3 CONSTRAINTS

1. Economic: Consideration of the costs involved in creating realistic and high-quality virtual reality environments.
2. Ethical: Importance of accurately representing the experiences of wheelchair users to ensure the simulations are genuine and respectful.
3. Health and Safety: Attention to users' comfort, ensuring that the VR experience does not cause motion sickness or discomfort, especially during extended use.
4. Manufacturability: Ensuring the VR system is compatible with the physical wheelchair setup.
5. Compliance with Standards: The design must adhere to relevant safety, accessibility, and industry standards.

3.1.4 STANDARDS

1. USB Standards (USB 2.0, USB 3.0): These standards will be used to connect the VR system with the wheelchair, ensuring reliable and fast data transfer for a wonderful experience.
2. IEEE 2048.1-2022 (Standard for Immersive Video Taxonomy and Quality Metrics): This standard helps ensure that the immersive experiences are of high quality and supports industry collaboration.
3. W3C Web Content Accessibility Guidelines (WCAG) 2.1: These guidelines are important for making sure that digital content is accessible to everyone, including those with disabilities. Following these standards ensures that the VR experience is user-friendly for all.

3.1.5 PRIORITY

- Critical (must have or product is a failure): This is the first step in making the VRWHEELCHAIR. It is essential to ensure that the VRWHEELCHAIR can perform the basic functions. Without this, it will not be possible to implement other functionalities.

3.2 TILT MECHANISM

3.2.1 DESCRIPTION

The VRWHEELCHAIR must incorporate a tilt mechanism that simulates the physical sensation of navigating various places and obstacles. The tilt should be adjustable and provide realistic feedback to enhance the user experience.

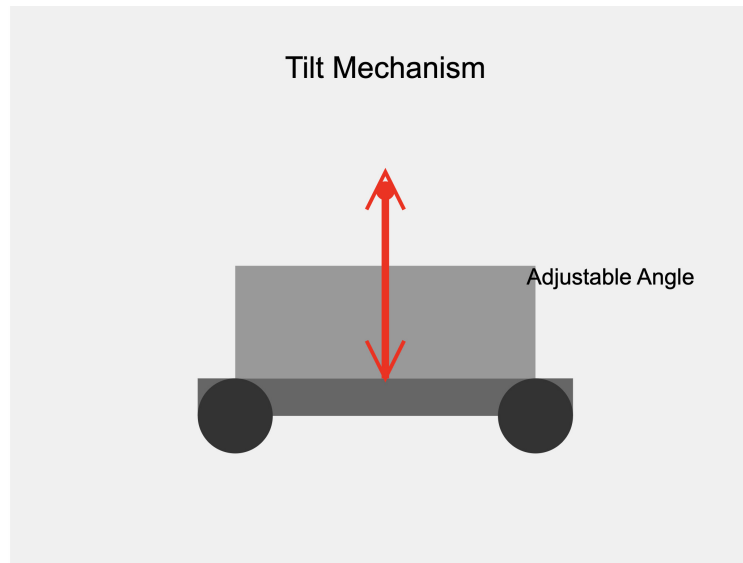


Figure 2: X conceptual drawing

3.2.2 SOURCE

- 1.Professor Shawn Gieser
- 2.CSE Senior Design project specifications

3.2.3 CONSTRAINTS

- 1.Safety: Ensuring the tilt mechanism operates safely is important. This involves designing it so that it doesn't cause physical discomfort to users or pose any risk during operation. We must include smooth transitions and secure locking mechanisms to prevent accidental movements, ultimately prioritizing user safety.
- 2.Manufacture: The design must focus on reliability and durability, making it easy to manufacture and assemble. A tilt mechanism should endure regular use without frequent repairs. Attention to material selection and design simplicity will help us achieve consistent quality during production.
- 3.Sustainability: It's essential to incorporate environmentally friendly materials and processes in the design. This means choosing sustainable materials that minimize ecological impact while also ensuring the mechanism's strength and longevity.
- 4.Power Supply: Ensure the tilt mechanism operates within the power limits of the wheelchair's existing electrical system.
- 5.Integration with Existing Systems: The tilt mechanism must be compatible with current wheelchair controls and the VR system without extensive modifications.
- 6.Compliance with Standards: The design must adhere to relevant safety, accessibility, and industry standards.

3.2.4 STANDARDS

- 1.ISO 7176-1:2014 WheelchairsPart 1: Determination of static stability
- 2.ASTM F2276-10 (Standard Specification for Fitness Equipment)

3.2.5 PRIORITY

High (very important to customer acceptance, desirability): Although the VR wheelchair can function without this feature, its absence limits the user experience to basic capabilities. Implementing this functionality is important for creating a more immersive and making the VRWheelChair more realistic, significantly enhancing the product's effectiveness and overall usability, which aligns with our aim for this project.

3.3 REALISTIC ENVIRONMENT SIMULATION

3.3.1 DESCRIPTION

The VR environment must accurately represent various real-world scenarios, including urban settings, indoor spaces, and outdoor environments. It should include common obstacles such as curbs, ramps, uneven surfaces, and narrow passages.

3.3.2 SOURCE

- 1.End-User
- 2.Testers

3.3.3 CONSTRAINTS

1. Technical: This involves creating high-quality graphics for the VR wheelchair experience while ensuring the system runs smoothly. The aim is to achieve impressive visuals without sacrificing performance, preventing lag or choppy experiences.
- 2.Social:This focuses on showcasing a variety of environments and situations that reflect different cultures and backgrounds. By doing so, the VR experience promotes empathy and awareness, helping users understand the unique challenges faced by wheelchair users in various contexts.

3.3.4 STANDARDS

1. Unreal Engine Marketplace Guidelines (for 3D environment assets): These guidelines will help ensure that the assets used for the VR environment meet the standards necessary for compatibility and quality within Unreal Engine.
- 2.ADA Standards for Accessible Design: These standards will be followed to accurately represent accessibility features, ensuring that the virtual environments reflect real-world accessibility considerations effectively.

3.3.5 PRIORITY

- High(very important to customer acceptance and desirability): Although the VR wheelchair can function without this feature, its absence restricts the user experience to basic functions. Implementing this functionality is essential for creating a more immersive and realistic experience and giving people ideas about different situations in the everyday lives of wheelchair users. This could even be critical because we absolutely need the different simulations; however, the program can run, but it is of no use for our project.

4 PACKAGING REQUIREMENTS

This section identifies the packaging requirements for the final deliverable project. The final deliverable will consist of hardware, including the simulator platform, and computer rack, as well as software, including the simulation program.

4.1 SIMULATOR PLATFORM

4.1.1 DESCRIPTION

A detailed description of the feature/function that satisfies the requirement. For example: *The GUI background will be slate blue. This specific color is required in order to ensure that the GUI matches other similar software products offered by the customer. Slate blue is specified as #007FFF, using six-digit hexadecimal color specification.* It is acceptable and advisable to include drawings/graphics in the description if it aids understanding of the requirement.

4.1.2 SOURCE

The source of the requirement (e.g. customer, sponsor, specified team member (by name), federal regulation, local laws, CSE Senior Design project specifications, etc.)

4.1.3 CONSTRAINTS

A detailed description of realistic constraints relevant to this requirement. Economic, environmental, social, political, ethical, health & safety, manufacturability, and sustainability should be discussed as appropriate.

4.1.4 STANDARDS

A detailed description of any specific standards that apply to this requirement (e.g. *NSTM standard xx.xxx.x. color specifications [1]*). Standards exist for practically everything (ATC standard fuses, IEEE 802.15.4 embedded wireless, TLS 1.3 encryption, etc.), so be sure that you research and document which ones will be followed in meeting this requirement.

4.1.5 PRIORITY

The priority of this requirement relative to other specified requirements. Use the following priorities:

- Critical (must have or product is a failure)
- High (very important to customer acceptance, desirability)
- Moderate (should have for proper product functionality);
- Low (nice to have, will include if time/resource permits)
- Future (not feasible in this version of the product, but should be considered for a future release).

4.2 REQUIREMENT NAME

4.2.1 DESCRIPTION

A detailed description of the feature/function that satisfies the requirement. For example: *The GUI background will be slate blue. This specific color is required in order to ensure that the GUI matches other similar software products offered by the customer. Slate blue is specified as #007FFF, using six-digit hexadecimal color specification.* It is acceptable and advisable to include drawings/graphics in the description if it aids understanding of the requirement.

4.2.2 SOURCE

The source of the requirement (e.g. customer, sponsor, specified team member (by name), federal regulation, local laws, CSE Senior Design project specifications, etc.)

4.2.3 CONSTRAINTS

A detailed description of realistic constraints relevant to this requirement. Economic, environmental, social, political, ethical, health & safety, manufacturability, and sustainability should be discussed as appropriate.

4.2.4 STANDARDS

A detailed description of any specific standards that apply to this requirement (e.g. *NSTM standard xx.xxx.x. color specifications [1]*). Standards exist for practically everything (ATC standard fuses, IEEE 802.15.4 embedded wireless, TLS 1.3 encryption, etc.), so be sure that you research and document which ones will be followed in meeting this requirement.

4.2.5 PRIORITY

The priority of this requirement relative to other specified requirements. Use the following priorities:

- Critical (must have or product is a failure)
- High (very important to customer acceptance, desirability)
- Moderate (should have for proper product functionality);
- Low (nice to have, will include if time/resource permits)
- Future (not feasible in this version of the product, but should be considered for a future release).

5 PERFORMANCE REQUIREMENTS

The VR Wheelchair aims to provide a seamless VR experience that makes use of a real wheelchair to simulate wheelchair movement in a virtual reality space. To ensure that the experience is seamless there are a few processes that need to occur to ensure that performance is up to standard.

5.1 REQUIREMENT NAME

5.1.1 DESCRIPTION

Detailed requirement description...

5.1.2 SOURCE

Source

5.1.3 CONSTRAINTS

Detailed description of applicable constraints...

5.1.4 STANDARDS

List of applicable standards

5.1.5 PRIORITY

Priority

6 SAFETY REQUIREMENTS

Include a header paragraph specific to your product here. Safety requirements might address items specific to your product such as: no exposure to toxic chemicals; lack of sharp edges that could harm a user; no breakable glass in the enclosure; no direct eye exposure to infrared/laser beams; packaging/grounding of electrical connections to avoid shock; etc.

6.1 LABORATORY EQUIPMENT LOCKOUT/TAGOUT (LOTO) PROCEDURES

6.1.1 DESCRIPTION

Any fabrication equipment provided used in the development of the project shall be used in accordance with OSHA standard LOTO procedures. Locks and tags are installed on all equipment items that present use hazards, and ONLY the course instructor or designated teaching assistants may remove a lock. All locks will be immediately replaced once the equipment is no longer in use.

6.1.2 SOURCE

CSE Senior Design laboratory policy

6.1.3 CONSTRAINTS

Equipment usage, due to lock removal policies, will be limited to availability of the course instructor and designed teaching assistants.

6.1.4 STANDARDS

Occupational Safety and Health Standards 1910.147 - The control of hazardous energy (lockout/tagout).

6.1.5 PRIORITY

Critical

6.2 NATIONAL ELECTRIC CODE (NEC) WIRING COMPLIANCE

6.2.1 DESCRIPTION

Any electrical wiring must be completed in compliance with all requirements specified in the National Electric Code. This includes wire runs, insulation, grounding, enclosures, over-current protection, and all other specifications.

6.2.2 SOURCE

CSE Senior Design laboratory policy

6.2.3 CONSTRAINTS

High voltage power sources, as defined in NFPA 70, will be avoided as much as possible in order to minimize potential hazards.

6.2.4 STANDARDS

NFPA 70

6.2.5 PRIORITY

Critical

6.3 RIA ROBOTIC MANIPULATOR SAFETY STANDARDS

6.3.1 DESCRIPTION

Robotic manipulators, if used, will either housed in a compliant lockout cell with all required safety interlocks, or certified as a "collaborative" unit from the manufacturer.

6.3.2 SOURCE

CSE Senior Design laboratory policy

6.3.3 CONSTRAINTS

Collaborative robotic manipulators will be preferred over non-collaborative units in order to minimize potential hazards. Sourcing and use of any required safety interlock mechanisms will be the responsibility of the engineering team.

6.3.4 STANDARDS

ANSI/RIA R15.06-2012 American National Standard for Industrial Robots and Robot Systems, RIA TR15.606-2016 Collaborative Robots

6.3.5 PRIORITY

Critical

7 SECURITY REQUIREMENTS

7.1 REQUIREMENT NAME

7.1.1 DESCRIPTION

Detailed requirement description...

7.1.2 SOURCE

Source

7.1.3 CONSTRAINTS

Detailed description of applicable constraints...

7.1.4 STANDARDS

List of applicable standards

7.1.5 PRIORITY

Priority

8 MAINTENANCE & SUPPORT REQUIREMENTS

The VRWHEELCHAIR project aims to create an virtual reality experience that simulates the challenges faced by wheelchair users. To ensure the longevity and effectiveness of this system after deployment, we will do comprehensive maintenance and support requirements as essential. These requirements will address how the product will be maintained, updated, and supported once it's in use by customers and end-users.

8.1 DOCUMENTS AVAILABILITY

8.1.1 DESCRIPTION

Comprehensive documentation will be available to support the maintenance and troubleshooting of the VRWHEELCHAIR system. This includes user manuals, technical specifications, and troubleshooting guides.

8.1.2 SOURCE

- 1.Project Teams
- 2.Testing Feedback
- 3.User Feedback

8.1.3 CONSTRAINTS

- 1.Confidentiality: Ensure that sensitive technical information is appropriately protected while still providing necessary details for maintenance.
- 2.Accessibility: Documentation should be available in multiple formats.

8.1.4 STANDARDS

IEEE 1063-2001 - IEEE Standard for Software User Documentation

8.1.5 PRIORITY

High (very important for system maintenance and user support)

8.2 SOURCE CODE ACCESS

8.2.1 DESCRIPTION

Determine the level of source code access that will be available to clients or authorized maintainers for customization and problem-solving specific to their needs.

8.2.2 SOURCE

- 1.Project Team
- 2.Client requirements

8.2.3 CONSTRAINTS

1. Security: Implement measures to prevent unauthorized access or modifications to the source code.
2. Intellectual Property: Finding the right balance between original code and providing the necessary access for ongoing maintenance and updates.

8.2.4 STANDARDS

- 1.ISO/IEC 27001:2013 - Information security management

8.2.5 PRIORITY

Medium (important for long-term maintenance and customization)

8.3 REMOTE SUPPORT CAPABILITIES

8.3.1 DESCRIPTION

Implement remote support capabilities to allow technicians to diagnose and resolve issues without on-site visits.

8.3.2 SOURCE

1.User Feedback 2.Support Team

8.3.3 CONSTRAINTS

- 1.Privacy: Ensure user data protection during remote access sessions.
- 2.Connectivity: Design for various network conditions to maintain support capabilities.

8.3.4 STANDARDS

- 1.GDPR (General Data Protection Regulation) for data privacy

8.3.5 PRIORITY

High (critical for efficient problem resolution and user support)

8.4 SOFTWARE UPDATE MECHANISM

8.4.1 DESCRIPTION

Develop a secure and user-friendly mechanism for deploying software updates to the VRWHEELCHAIR system.

8.4.2 SOURCE

- 1.Software Team
- 2.Security consideration
- 3.User Feedback

8.4.3 CONSTRAINTS

- 1.Backward Compatibility: Ensure updates don't break existing functionalities.

8.4.4 STANDARDS

- 1.IEEE 829-2008 - Standard for Software and System Test Documentation (for documenting update processes and testing)

8.4.5 PRIORITY

High (important for maintaining system functionality and addressing any issues that arise)

8.5 HARDWARE MAINTENANCE GUIDELINES

8.5.1 DESCRIPTION

8.5.2 SOURCE

- 1.Hardware Team
- 2.Safely regulation

8.5.3 CONSTRAINTS

1. Safety: Ensure maintenance procedures don't pose risks to users or technicians.
2. Skill Level: Design procedures that can be performed by technicians with appropriate training.

8.5.4 STANDARDS

1. ISO 13482:2014 - Robots and robotic devices – Safety requirements for personal care robots

8.5.5 PRIORITY

High (crucial for maintaining the physical components of the system)

9 OTHER REQUIREMENTS

Include a header paragraph specific to your product here. In this section specify anything else that is required for the product to be deemed complete. Include requirements related to customer setup and configuration if not specified in a previous requirement. Add any known requirements related to product architecture/design, such as modularity, extensibility (for future enhancements), or adaptation for a specific programming language. Consider requirements such as portability of your source code to various platforms (Windows, Linux, Unix Mac OS, etc.).

9.1 REQUIREMENT NAME

9.1.1 DESCRIPTION

Detailed requirement description...

9.1.2 SOURCE

Source

9.1.3 CONSTRAINTS

Detailed description of applicable constraints...

9.1.4 STANDARDS

List of applicable standards

9.1.5 PRIORITY

Priority

10 FUTURE ITEMS

In this last section, you will reiterate all requirements that are listed as priority 5. This is repetitive, but necessary as a concise statement of features/functions that were considered/discussed and documented herein, but will NOT be addressed in the prototype version of the product due to constraints of budget, time, skills, technology, feasibility analysis, etc. Use the following format for this section.

10.1 REQUIREMENT NAME

10.1.1 DESCRIPTION

Detailed requirement description...

10.1.2 SOURCE

Source

10.1.3 CONSTRAINTS

Detailed description of applicable constraints...

10.1.4 STANDARDS

List of applicable standards

10.1.5 PRIORITY

Priority

REFERENCES

- [1] Kenneth S Rubin. *Essential Scrum: A Practical Guide to the Most Popular Agile Process*. Addison-Wesley Professional, 1st edition, 2012.