Requirements and Overall Specification Document

Florian Mayenfels

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1 Introduction

- Purpose of the Document: The purpose of this document is to outline the requirements and overall specification for the development of a 3D optical tracking system demonstrator to assist surgeons in performing operations on the brain.
- Objectives of the Demonstrator: The objectives of the demonstrator are to detect the position and alignment of a medical instrument using a camera and triangulation, and to visualize the 3D position and alignment on a brain model displayed on a monitor.

2 Stakeholders

- Key Stakeholders: Surgeons, medical professionals, researchers, potential investors.
- Stakeholder Needs and Expectations: The stakeholders expect the demonstrator to provide accurate instrument tracking, real-time visualization, user-friendly interface, and reliable performance.

3 Functional Requirements

- **Marker Detection and Tracking**
  - Marker Selection: Use retro-reflective spheres as markers for tracking.
  - Marker Detection Algorithm: Implement an algorithm for detecting retro-reflective spheres in the camera's field of view.
  - Marker Tracking: Develop a tracking algorithm to track the detected markers across consecutive frames.
- **Triangulation and Position Estimation**

  - Triangulation Method: Use geometric or algebraic triangulation to calculate the 3D position of the tracked instrument.
  - Calibration Validation: Implement a calibration validation process to ensure accuracy.

- **Brain Model Visualization**
  - Brain Model Selection: Integrate a 3D brain model obtained from medical imaging data or pre-existing library.
  - Model Integration: Align the brain model with the tracking system's coordinate system.
  - Rendering: Implement rendering functionality to display the brain model on the monitor.

- **Instrument Position and Alignment Visualization**
  - Overlay Visualization: Develop a mechanism to overlay the instrument's position and alignment on the brain model.
  - Real-time Updates: Ensure real-time updates of the visualization as the instrument's position and alignment change.

- **Graphical User Interface (GUI)**
  - GUI Design: Design an intuitive and user-friendly graphical user interface for the surgeon.
  - Integration: Integrate visualization components, camera data display, and control mechanisms into the GUI.

4 Non-Functional Requirements

- Performance: The system should provide accurate and responsive tracking with minimal latency.
- Reliability: The system should operate reliably without frequent failures or crashes.
- Usability: The user interface should be intuitive and easy to navigate for the surgeon.
- Compatibility: The software package should be compatible with Windows devices.

5 User Interface Design

- Description of User Interface Layout and Organization: The user interface should include a 3D visualization area
- Description of User Interface Layout and Organization: The user interface should include a 3D visualization area to display the brain model and the instrument's position and alignment overlay. It should also have controls for starting and stopping the tracking, adjusting visualization settings, and displaying relevant information.
- Interaction and Controls: The user interface should support intuitive interaction, such as zooming and rotating the 3D view, selecting different instrument models or visualization modes, and providing feedback on tracking status and accuracy.

6 System Integration

- Integration with NDI Polaris Camera and its Software: The software package should be able to establish a connection with the NDI Polaris Camera and receive real-time camera data for marker detection and tracking.
- Cable Connection: Define the required cable connection specifications between the camera and the Windows device (e.g., USB, Ethernet).

7 Data Management

- Storage and Management of Camera Calibration Parameters: Implement a mechanism to store and manage camera calibration parameters, including intrinsic and extrinsic parameters required for triangulation.
- Handling and Processing of Marker Positions and Data: Develop data structures and algorithms to handle and process the marker positions and other relevant data for tracking and visualization purposes.

8 Performance Evaluation

- Performance Metrics and Criteria: Define metrics such as tracking accuracy, frame rate, latency, and visualization smoothness as performance evaluation criteria.
- Acceptable Performance Thresholds: Specify the acceptable thresholds for each performance metric to ensure the system meets the desired performance requirements.

9 Development Constraints

- Time Constraints: The development of the demonstrator should be completed within the specified timeline.
- Resource Availability: Ensure the availability of the required hardware, software, and development resources.
- Programming Languages and Frameworks: Utilize C++ programming language and appropriate libraries or frameworks compatible with Windows for the software implementation.
- Platforms and Hardware Requirements: Define the minimum hardware specifications and Windows versions required for running the software package.

10 Risk Analysis

- Identified Risks and Challenges: Identify potential risks and challenges, such as hardware compatibility issues, algorithm complexity, or performance limitations.
- Impact Assessment: Assess the impact of each risk or challenge on the development and functionality of the demonstrator.
- Mitigation Strategies: Propose strategies to mitigate the identified risks and challenges, including alternative solutions, contingency plans, or additional development efforts if necessary.

11 Conclusion

- Summary of Requirements and Overall Specification: Summarize the key requirements and specifications outlined in this document, highlighting the goals and objectives of the 3D optical tracking system demonstrator.