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Proof of Concept- Halo Gravity Traction Monitoring System

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1.0 Definitions

POC - Proof of Concept

HGT - Halo Gravity Traction

2.0 Purpose

- The purpose of this document is to provide a comprehensive summary of the detailed design for a Halo Gravity Traction (HGT) system with integrated real-time load monitoring, based on insights from the proof of concept. It outlines the functional elements, performance requirements, and operational workflow necessary to implement a reliable, accurate, and user-friendly monitoring device for clinical and non-clinical evaluation.

3.0 Scope

-This document details the technical specifications and functional breakdown for the HGT load monitoring device, including sensor selection, data acquisition, storage, transmission, user interface, and power management. It covers system integration, calibration procedures, and performance validation under controlled conditions. Current halo traction systems lack continuous, automated load monitoring, relying on manual checks that can lead to inconsistent force application, patient discomfort, or safety risks. Without real-time data tracking, clinicians cannot promptly detect deviations in applied load, increasing the potential for complications such as nerve damage or suboptimal spinal correction

4.0 Question(s) to be Answered

1. **How can we ensure constant and accurate monitoring of the load applied to patients?**
 - It is essential to develop a reliable system that tracks the load in real-time, ensuring that patients remain securely connected to the device throughout their treatment. This continuous monitoring helps in identifying any deviations from the prescribed load immediately.
2. **What mechanisms can be implemented to alert physicians of load changes?**
 - An effective alert system is needed to notify healthcare providers instantly if there are fluctuations in the load being applied. This timely information is crucial for making prompt adjustments to the treatment plan.
3. **How can physicians facilitate quick adjustments to the load when necessary?**

- The proof of concept seeks to explore solutions that allow physicians to modify the load settings efficiently. This responsiveness is vital for maintaining the efficacy of the treatment and ensuring patient safety.

Rationale for Addressing These Challenges First

These challenges have been prioritized because they directly impact patient safety and treatment outcomes. By ensuring that load monitoring is accurate and that physicians can respond quickly to any changes, we can minimize risks associated with improper load application. Addressing these issues early in the development process lays a strong foundation for further innovations in patient care and device effectiveness, ultimately leading to improved health outcomes.

5.0 Approach

1. Equipment and Setup

- Load Sensors : High-accuracy strain gauge load cells (e.g., 0-50 kg range) with an accuracy of $\pm 1\%$ to $\pm 2\%$.
- Microcontroller: Arduino for real-time data collection and transmission.
- Cloud Database: A secure platform such as AWS for data storage and access.
- Data Visualization Dashboard: Software like Power BI for live monitoring and alert display.
- Calibration Weights: Known weights (5 kg, 10 kg, 15 kg, etc.) to verify load sensor accuracy.

2. Experimental Setup

1. System Assembly:

- Attach load sensors to a test device, simulating points of load application that would be present in a clinical setting.
- Connect load sensors to the microcontroller for data collection. Ensure each sensor has been calibrated beforehand to ensure accuracy.
- Set up the microcontroller to send data to the cloud database every second, ensuring real-time data transmission.

2. Calibration and Baseline Testing:

- Place calibration weights on the test device incrementally (e.g., 5 kg, then 10 kg) to verify that the sensors accurately measure the applied load.
- Record the sensor output for each weight, comparing it to the actual weight to confirm the system's accuracy within $\pm 2\%$.
- Perform initial tests in both static and dynamic conditions (e.g., slowly adding or removing weight) to ensure consistency in data transmission and sensor accuracy.

3. Real-Time Load Monitoring

1. Continuous Load Tracking:

- After initial calibration, set a target load on the Halo Gravity device (e.g., 10 kg) and maintain it over a 3-hour period as the patient moves between walker, wheelchair, etc.
- Record load measurements every second, monitoring for any drift or deviations in sensor readings. This will help confirm the reliability of the sensor and data transmission setup over time.

2. Testing for Load Deviations:

- Simulate a deviation by increasing or decreasing the load by 5-10% (e.g., from 10 kg to 10.5 kg or 9.5 kg) at random intervals.
- Verify that the system identifies and records these deviations in real-time, with accurate logging in the cloud database.

4. Data Visualization and Alert Testing

1. Dashboard Setup:

- Configure the visualization dashboard to display live load data and track deviations over time.
- Program the dashboard to issue visual alerts (e.g., color-coded indicators or pop-up messages) when the load deviates by more than $\pm 5\%$ of the target.
- Set up the dashboard to allow test observers to view load data changes and alert indicators in real-time.

2. Real-Time Alert Validation:

- During load deviation simulations, observe how quickly the dashboard updates with new data and triggers alerts.
- Record the latency between actual load changes and visual alerts on the dashboard, ensuring it remains within an acceptable delay

6.0 Results


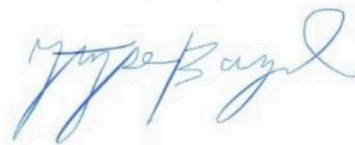



The load monitoring system was able to successfully detect and maintain constant surveillance on the load within a 5% error margin throughout the day. Data collection within the system was able to provide continuous tracking of any load changes that occurred during the experimental period. There was some trouble in translating the load data into a graphical display and then sending it to physicians, to improve this we are planning to refine the data visualization process for quicker display updates.

Force detector

7.0 Conclusions and Direction

Based on the results of this POC, we can confidently conclude that a real-time monitoring system for HGT is feasible within a 5% error margin for the tracking of a load. The system was able to detect and maintain surveillance on the load even as the force applied on the patient fluctuated with body position. This is very important for ensuring patient safety during the whole treatment process and making sure that the system can serve as a reliable and accurate tool in clinical settings. Challenges with data visualization and transmission has been mentioned as areas that need improvement in our design; moving forward we will focus on refining the display process to make sure that the data is presented in a more intuitive way and that the data is updated in a quicker manner to be transmitted to physicians in real time.

8.0 Signatures and Approvals

Name	Role	Signature
Davi Lima	Conclusion	
Ayse Baysal	Definition+Purpose+Scope	
Lucas Kiukawa	Results	
Ari Jindal	Questions to be Answered	
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9.0 Controlled Documentation Approval Sheet

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