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Manufacturer's Specification for Smart Pediatric Epilepsy Monitoring Device

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Abstract

Epilepsy monitoring equipment has recently shown innovative promises for metaverse-integrated devices tailored for professional pediatric use. The specification emphasizes critical biomechanical elements, including structure-to-topology optimization, for weight and durability. Key components are collected by a scoped review of books from the identification used for the design. Key components reveal high-stress areas, optimize material efficiency, and ensure biocompatibility through careful material selection. Ergonomics and comfort are prioritized for long-term wear by children, along with considerations for the device's lifespan and durability. The device's integration with Metaverse facilitates real-time monitoring and more extended data collection. The specification also outlines qualification and validation protocols. Further refinement could benefit from additional details, as simulating sensor placement, specific wear locations, and data on typical wear patterns and stress points.

Keywords: Biomechanics; User Requirements; IoT-based device; Epilepsy monitoring; Mechanical design

Abbreviations

FEA - Finite Element Analysis.
EPS32 - A specific microcontroller (Espressif Systems ESP32).
FRs - Functional Requirements.
DPs - Design Parameters.
FR1 - Monitor epileptic seizures.
DP1 - IoT-based sensing system.
FR2 - Ensure long-term comfort.
DP2 - Ergonomic design and material selection.
FR3 - Provide durability.
DP3 - Structural optimization and material properties.
FR4 - Enable real-time data transmission.
DP4 - Wireless connectivity components.
FR5 - Maintain power supply.
DP5 - Battery and power management system.

Introduction

Epilepsy, a common neurological disorder affecting over 50 million people worldwide, of which millions are children (World Health Organization, 2019), is on the brink of a technological revolution. For pediatric patients, epilepsy itself can significantly lower their quality of life and development. Recent advancements in metaverse-integrated technology have led to the development of wearable devices that provide continuous, real-time monitoring of epileptic seizures (Edris & Altural, 2021). This revolution holds the potential to significantly improve the quality of life for pediatric patients. However, designing these devices for long-term pediatric use requires careful consideration of biomechanical factors as comfort, ergonomics, and durability.

The design of a metaverse-integrated epilepsy monitoring device for children must consider various biomechanical factors to ensure long-term comfort, durability, and safety. This Biomechanics User Requirements Specification outlines a framework for developing a device, emphasizing critical elements from structural analysis to topology optimization, material selection, and integration (Heilala, 2019). The specification aims to optimize the device's design to enhance its performance, reduce weight, and improve user experience for pediatric patients.

Materials and Methods

Various open-source databases were examined during the research for pediatric anatomical models; only BodyParts3D1/3D Print Exchange showed scientific intelligence but was not usable for this scientific matter (National Center for Biotechnology Information 2009)—more: (Life Science Database Archive 2024). The decision of the most suitable model was sourced simply from GrabCAD under a Creative Commons license, the model was prepared for further development and testing in Academic SolidWorks 2024.

The architectural design sample led to creating a tailored medical device for pediatric epilepsy patients, focusing on framework integration and testing, as shown in Figure 1. The device is depicted on the chest and wrist of the model, highlighting its intended positioning for optimal functionality and patient comfort.

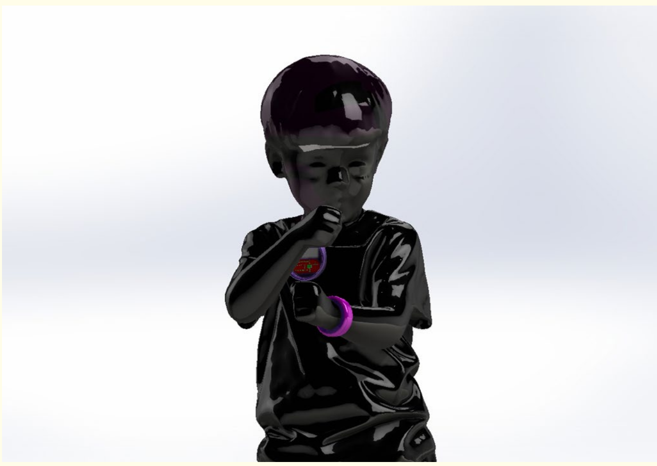

Figure 1: The brand for epilepsy includes the medical device parts on the wrist and to the side of the chest for the conceptual device modellable to a form of a wristwatch appearance for the professional monitoring.

Since Shwethaa (2024) presented design literature showing a complete model. This is an original science to the metaverse integration of epilepsy monitoring device tailored for children. Building on this work, the current biomechanics user requirements specification outlines a framework for optimizing the device's physical design to enhance its suitability for pediatric use.

Results

As a result, device manufacturing organizations can achieve greater efficiency and effectiveness in their sustainability endeavor by considering the following requirements for concretizing the operations (Heilala & Kantola 2023). The widespread use of wearable technology has led to the development of innovative health monitoring devices for conditions like epilepsy. Shwethaa (2024) proposed a metaverse-integrated epilepsy monitoring device that is best tailored. Building upon this work, the device's Biomechanics User Requirements Specification outlines a framework for the device's biomechanical design for Table 1. This framework is crucial to the success of our project.

Table 1. The optimized design matrix involves FR1. To monitor epileptic seizures, DP1 of an IoT-based sensing system is needed. FR2 ensures long-term comfort for DP2 through ergonomic design, contributing to the device's wearability. FR3 Provides durability for the structural design to determine the device's longevity. FR4 Enable real-time data transmission to require DP4 of wireless connectivity for continuous serial. FR5 Maintain power supply is primarily determined by DP5 of battery and power management for its power draw. The design is fully drawn decoupled while the embedded systems share interdependencies in the chip design. The methodology applied could be shown as coupled. However, a decoupled design is only acceptable for innovative systems with minimal power use. Decoupling must be achieved independently to improve the device's overall performance in each functional requirement.

	DP1	***DP2***	***DP3***	***DP4***	***DP5***
FR1	X				
FR2		X			
FR3			X		
FR4				X	
FR5					X

Discussion

The need of wearable technologies intrigue to develop innovative health monitoring devices to various condifitions. Shwethaa (2024) proposed an metaverse-based epilepsy monitoring device, providing framework for pediatric use. Building upon past works, the device's Biomechanics User Requirements Specification outlines a framework for the device's biomechanical design too. The framework and design can enhance both durability and lightweight built by the complete validation. The process the device structurally is mapping max stress by statistics in tribology and mechanics in organic biofield. The specification's optimized software for the displacement and structure optimization shall reach comfortability (e.g., UI/UX and durability to each pilot); Material Selection to the optimized Structure from biocompatibility skin-safe, wear-resistant, and metaverse-compatibility is the priority. Ergonomics for comfort and Minimum pressure points for all sized generations require adjustments to be the comfortable one for each one. while the plastic durability for the lifespan is confirmed; dependent on a modular design, easy battery replacement with ESP32-based customization involve the metaverse integration for replacement. The international protection code markings and shields secure housing in the place. This specific surface stands for heat management and wireless connectivity components need to be measured at the electric grounding for the metaverse adaptability. The last phases of the validation are the testing and commission to verify finite elements and conduct stress tests with pediatric trials.

The scoped focus areas included are weight optimization to structural analysis to identify high-stress regions, topology optimization to reduce weight and improve durability, and material selection to balance biocompatibility, strength, and compatibility with components to become metaverse integrated. A review by Shwethaa et al. (2024) shows Heliyon's article as an example of a system capable of complete system transmission. Ergonomics and comfort are prioritized for long-term wear by children, along with considerations for the device's lifespan and durability. Integrating the metaverse facilitates real-time monitoring and data collection of the device's advanced capabilities. Rigorous testing and validation protocols are in place to ensure the device's performance and safety, as shown by the example of Shwethaa et al. (2024), who adapted a device to random simulated data first. The system development on engineering requires model-level learning with random samples to compare a range of device size differences until they meet the minimum operating conditions for the qualification and validation process.

Conclusion

Biomechanics user requirements specification's outlined development framework for a metaverse-integrated epilepsy monitoring device is primarily designed for pediatric use. The specification emphasizes critical biomechanical elements: placement must be non-intrusive; perfect material for comfortable wear; adjustable band to flexible electrodes; and reliable in-build chips. The serial-wireless short-range mobile systems power provide the architecture. The electronics compatibility, material selection, and integration confirm the antenna and beam topology optimization to the device's structure. Metaverse integration to ergonomics performed in a user-friendly manner can be child-safe. The added value of innovative features measures abnormalities. It sets a series of requirements for diabetes blood sugar levels to other diagnostic capabilities, such as epilepsy monitoring, to extend to various product families collaboratively and in a less intrusive manner. The biomechanical design of the epilepsy monitoring definitions involved objectives set reading and treatment protocol medically require a robust design. Stress, topology, materials, and validation of the advanced goal of creating a comfortable, durable, and practical monitoring device can significantly improve epilepsy management of children more comfortable in pediatric healthcare.

Conflict of interest

There are no conflicts of interest.

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