DESIGN AND DEVELOPMENT OF A MODULAR BIO-IMPEDANCE-BASED WRIST BAND FOR HUMAN-MACHINE INTERFACES

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Introduction: Engineers envision a future in which technology amplifies the very essence of our human touch, turning even the most nuanced gestures into digital commands, bio-impedance presents itself as a promising avenue to achieve this vision. Evaluating biological tissue's reactions in electric fields, this technology lays the foundation for Electrical Impedance Tomography (EIT). EIT, unlike the established Surface Electromyography (sEMG) that simply captures existing signals, actively injects a current and measures the response, promising enhanced reliability. Guided by this knowledge, our primary ambition is to craft a bio-impedance band tailored for the dynamic realm of EIT research.

Applying the User-Centred Design Methodology:

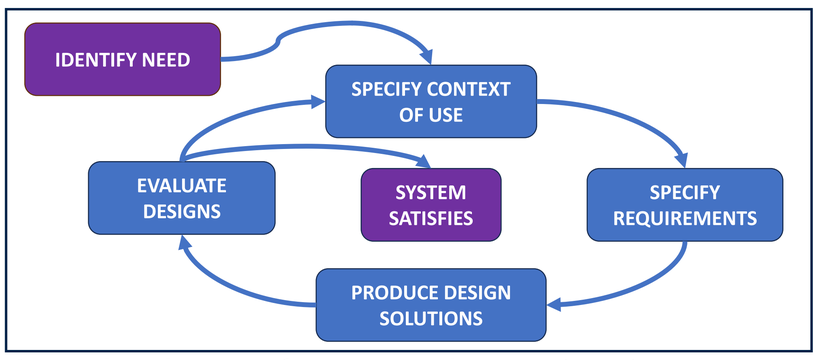


Fig. 1: Flow diagram of User Centred Design (UCD) Methodology.

Identifying the Need: Design a wristband for multiple electrodes, targeting bio-impedance analysis-based HMI systems.
Context of Use: Given research's fluid nature, prioritize band functionality and adaptability. Evaluation of existing designs shown below:

Old Designs and Their Drawbacks:

Fig. 2 (a): 3D printed design.
- Doesn't fit forearm contour; uses cumbersome closures.
- Fixed electrodes can cause discomfort and reduce contact near wrist.

Fig. 2 (b): Hook and loop closure band.
- Hard to add electronic components.
- Fixed electrode positions doesn't allow for forearm targeting.
- No consistent tightness measure affects data reproducibility

Specifying Requirements:

Electrode Configuration & Stability:
- Maintain consistent skin contact for reliable data.
- Accommodate 4-16 electrodes based on application needs.
- Prevent slippage to ensure accurate results.

Flexibility & Adaptability:
- Fit a range of hand sizes and potentially larger muscle groups.
- Incorporate modular attachments for hybrid research like status indicator LEDs and haptic feedback.
- Repositionable electrodes for optimal data accuracy.

User Experience, Aesthetics & Maintainability:
- Easy to put on solo.
- Professional appearance (i.e. no hanging wires).
- Designed for durability with easy-to-replace components and accessible wiring.

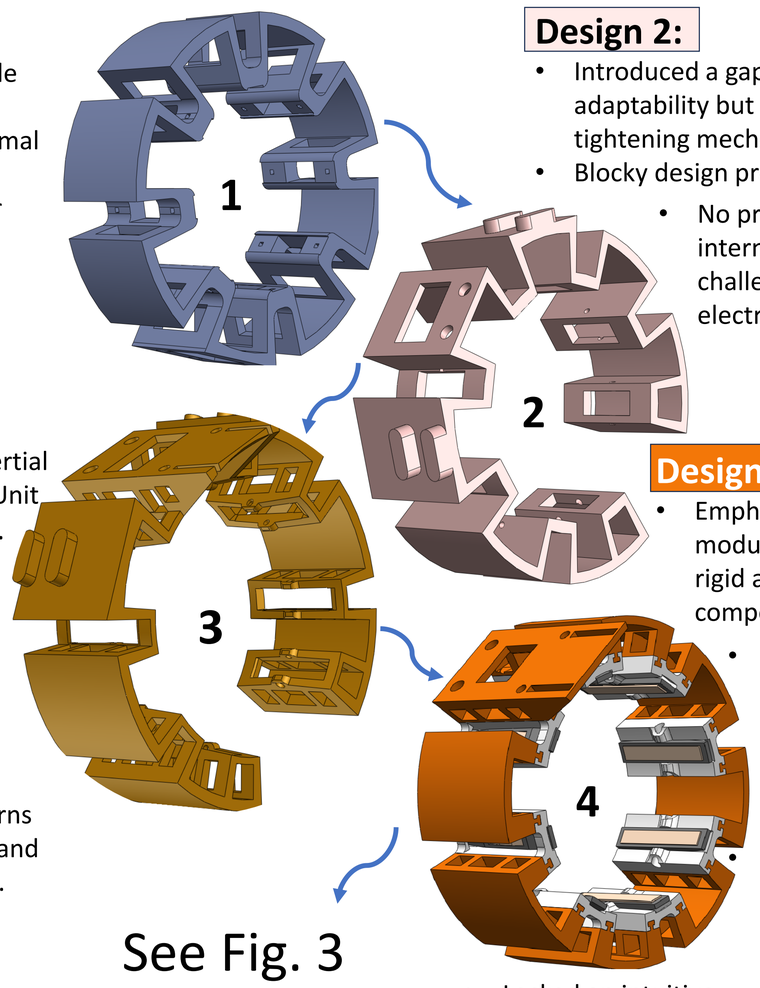
Iterative designs:

Design 1:
- Fixed electrode placement hindered optimal skin contact.
- Lacked a clear tightening mechanism.

Design 2:
- Introduced a gap for desired adaptability but lacked a tightening mechanism.
- Blocky design prone to tearing.
- No provision for internal wiring and challenges in electrode design.

Design 3:
- Features for Inertial Measurement Unit (IMU) inclusion.
- Improved electrode housing for rotation flexibility.
- Inefficient band fastening and durability concerns due to material and design thinness..

Design 4:
- Emphasis on modularity, blending rigid and flexible components.
- Interlocking design offers superior maintainability and functional modules.
- Finalized simple electrode design for consistent skin contact.
- Lacked an intuitive fastening system, limiting adaptability for various forearm sizes.



See Fig. 3 and Fig. 4

Final Design:

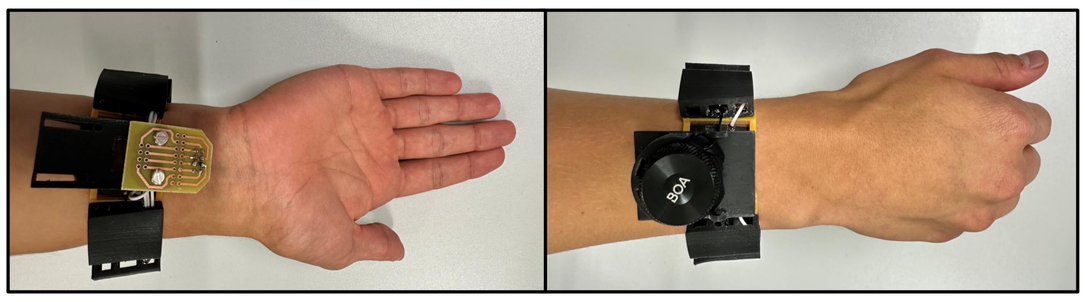


Fig. 3:. Final design produced

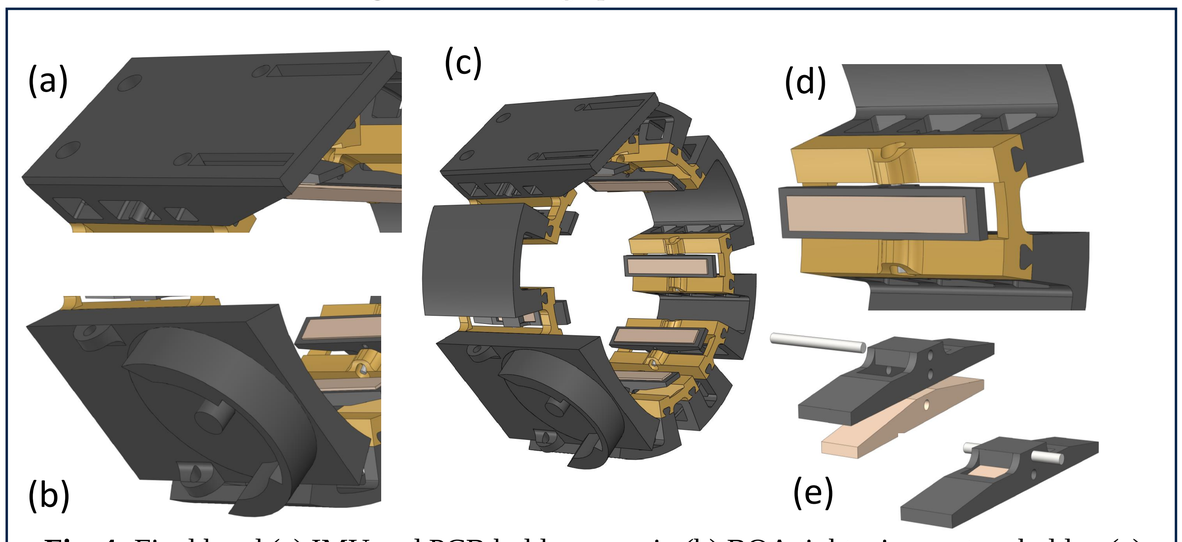


Fig. 4: Final band (a) IMU and PCB holder zoom in (b) BOA tightening system holder, (c) Full band 3D view, (d) interlocking connection zoom in, (e) final electrode and electrode holder design.

Key new design implementations:

Modular Design: Prioritizes adaptability and maintainability in HMI devices, proving resilience during component replacements.
Custom Rotating Electrodes: Enhances reliability by adapting to skin contours for accurate data and user comfort.
BOA Tightening System: Optimizes electrode fit (Fig. 5), enhancing both contact quality and ease of application.

Figure 5: Comparison of fit tightness between new design (left) and old designs (middle and right)

Venturing Beyond the Band:

Coming soon: using innovative application of EIT and IMU data to seamlessly translate continuous British Sign Language (BSL) phrases into text using recurrent neural networks. An exhilarating leap towards bridging communication barriers!

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