fNIRS Optode Helmet Construct

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Abstract

Optodes are optical sensor type devices that are used to make hemodynamic and oxygen measurements of a subject, and are placed orthogonal to the subject's head in varying specific arrays to obtain measurements [1]. They are used in a procedure called functional near infrared spectroscopy abbreviated as fNIRS . These optodes are arranged on the head in current products like a rigid body 'cap' design or a swimmers cap [2]. These designs are essentially caps with holes in them to place the optode on. These caps lack spatial control and do not allow the user full degrees of freedom. Our fNIRS Optode Helmet Construct (fOHC) allows the user to place the optodes all around the eye fields on the head. The user would first however move or 'part' the hair away from the optode hole using our optode pattern system. Our design, is a structure system to allow the movement of these patterns around the head which would then correlate to moving optodes around the head, with stability and accuracy, while parting the hair automatically with shape geometry / morphology of the hair parting patterns.

Customer Needs

Product Description

A lightweight fNIRS helmet designed to possess inherent displacement of subject hair, dampen relative motion between the patient and the optodes contained within the device as well as create reproducible measurements of the patient's head.

Customer Needs

- Precise - Within 5mm of a target
- Modular - Add and remove components
- Stable - No relative change in position
- Durable - Survive multiple falls
- Affordable - Cost less than $100 to make
- Prevent interference - Move hair
- Comfortable - Wear for over an hour
- Consistent - Same position and angle

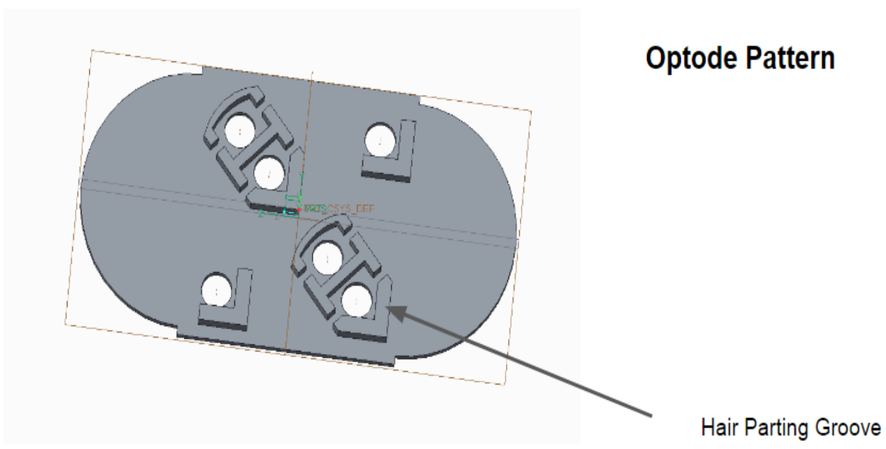
Design Concept

Our Design incorporated the following

- A slider system which can allow movement across the delrin track which impart moves the optode pattern.
- An adjustable main support strap that allow the fOHC to be modular in size, with adjustments of different head sizes.
- A hair parting optode groove pattern capable of hair parting assistance during the pattern adjustments.
- And a full range of optode pattern movements allowing for all the necessary degrees of freedom.
- And the Hair Parting Optode Pattern satisfies the mathematical expression for optode to scalp relationship, which states that the Optodes must be orthogonal to the subjects scalp.

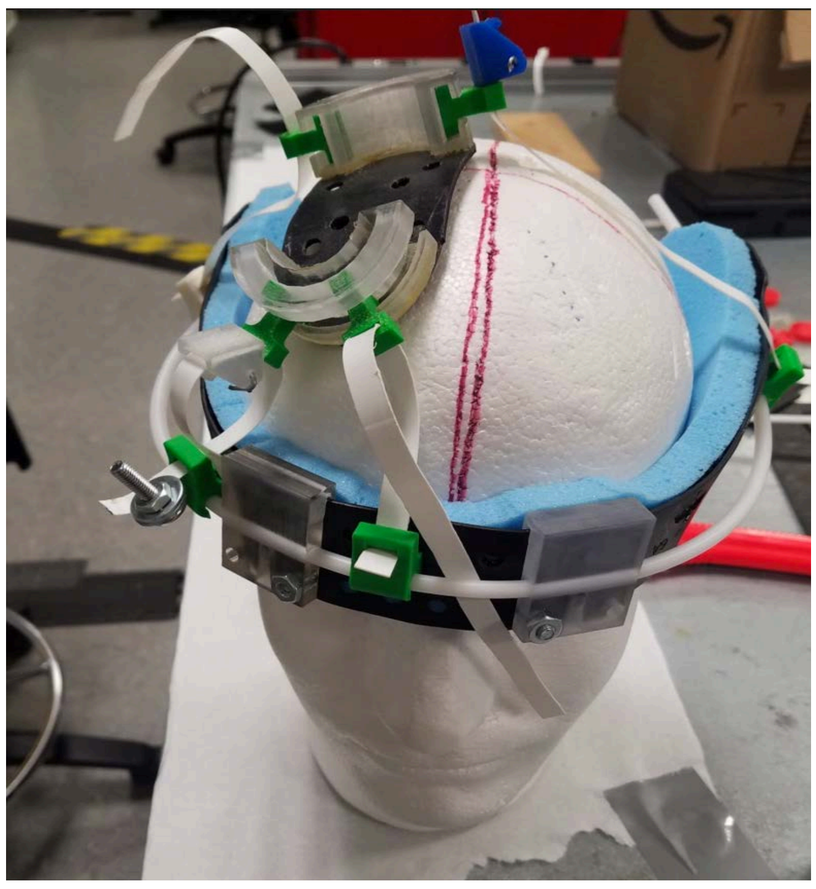
Optode ⊥ Scalp

This was achieved by the following image showing the optode pattern.



Optode Pattern

This is the fOHC designed in accordance with the customer requirements.



Test Plan

Customer Needs	Requirements	Engineering Design	Test Pass/Fail
Precision of Optode Pattern	-Using adjustable pattern movements by slider action connected to suspension.	New Heavy Slider design	Pass
Prevent movement once in place	-Slider locking -Strap durability	Slider locking through bulge contacting suspension	Pass
Reduce Setup time (user ergonomics)	-Slider and suspension part of one continuous system (helmet)	Slider on track (delrin) connected to suspension by stabilizers. Allowing for ease in adjusting groove pattern around the head.	Pass
Stability	-Suspension is stationary and does not move		Pass
Hair parting	-Grooved Pattern	Create a pattern with shape geometry to move hair away from optode holes.	Pass
Comfort for subject (subject ergonomics)	-Foam inserts contacting subject and helmet.	Foam inserts coating the inside of the suspension are removable. By turning the adjustment wheel the helmet size changes	Pass
modularity for head sizes	-Helmet can adjust circumference for different head sizes.		Pass

Acknowledgement

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References

[1] Ohmae, Etsuko, et al. "Cerebral hemodynamics evaluation by near-infrared time-resolved spectroscopy: correlation with simultaneous positron emission tomography measurements." *Neuroimage* 29.3 (2006): 697-705.

[2] Cui, Xu, Signe Bray, and Allan L. Reiss. "Functional near infrared spectroscopy (NIRS) signal improvement based on negative correlation between oxygenated and deoxygenated hemoglobin dynamics." *Neuroimage*49.4 (2010): 3039-3046.