

Projects for BME 7 & BME 8 [Biomedical Engineering Senior Design I & II]
AY 2017-2018

PROJECT TITLE: Designing a Modular Headset for Non-invasive Optical Imaging of the Human Brain

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PROJECT DESCRIPTION:

The objective of this project is to design a headset that facilitates the placement of optical fibers on all parts of the scalp. We will achieve this by keeping in mind that this helmet needs to be : adjustable in fit, keep the fibers in a conformation that facilitates good data, and allows the placement of fiber clusters on all parts of the head. This headset will be in the form of either a soft or hard helmet in design that facilitates optical fiber clusters. Finally, possible constraints of this device is the ability for it to properly fit all head sizes, allow for data collection in the presence of hair, and minimize the effects of subject's motion

ENGINEERING DESIGN ELEMENTS:

What are the objectives of the project and the criteria for selecting them?

The objective of the project is to improve on the previously established design of a prototype for the Fantini laboratory's optical headset. We will aim to improve upon and add to the existing design by increasing the capability of the design to measure signals across the brain. This will be done by expanding the area on the head on which the fibers of the device can operate, as the prototype only covers the forehead.

What system, component, or process is to be designed? TOM

Over the course of this project, we shall design an optical headset that extends the functionality of the previously prototyped headset such that measurements can be taken beyond the forehead region.

The optical data gathered is contingent on both the proximity of the fibers to one another along with the arrangement of said fibers in space. This next iteration of the helmet will need to ensure that the pre-established dimensions and conformations of fibers are maintained.

The optical headset to be designed will consist of modular components for flexibility of placement and selection of the head area to be covered. The individual headset modules and their interconnections will be the focus of individual design requirements.

What need does it fulfill (clinical, research, etc.)?

This device will help improve the quality of optical data, and expand the scope of non-invasive brain imaging with diffuse optical techniques, as currently performed in Professor Fantini's lab. Currently only data from a part of the frontal lobe can be gathered due to the

physical constraints of the headset used. The new design of the optical headset should be able to facilitate placement of optical fibers on all parts of the head.

What scientific, math, and/or engineering methods will be applied?

The propagation of light within optical fibers is governed by geometrical optics laws. The optical signals to be measured with this device are described by diffusion theory and photon migration in highly scattering media. General engineering design approaches will be used, including consideration of practical constraints, testing, and iterative improvements.

What realistic constraints (cost, safety, reliability, aesthetics, ethics and social impact, etc.) are to be considered?

In terms of allowing the device to cover more parts of the head and therefore read signals from more parts of the brain, hair is a distinctive constraint. The fibers need to be touching the skin as directly as possible, and this is difficult to do on parts of the head that are covered by hair. We must ensure that any plans for the placement of our fibers takes this obstacle into consideration. Along with this, the optical headset must be comfortable to the subject, and be relatively lightweight.

Moreover, there is also a limitation in the spatial conformation of the fibers. Although an increase in the distance between two fibers increases the depth of optical penetration, the increased distance also adds a considerable amount of noise to the signal reading.

What alternative solutions or changes to the plan will be considered?

Depending on how well the helmet is able to secure the optical fibers to the head and get proper data, designs for the type of headset will be further explored (soft designs vs hard designs). Also, it may be that the interference introduced by the hair regardless of fiber proximity to the scalp. If this is so, we will consider options to physically displace hair from underneath each optical fiber

What are the planned tests and what are the quantitative milestones that will demonstrate achievement of the objectives?

The main milestone would be the to build optical headset modules that can be integrated to allow for the collection of good quality optical data on the human head without causing any discomfort to the subject.

Competition: what else is going on in the field that would compete with the project plans?

There are a number of commercial instruments and laboratory devices built in other labs that include optical headsets for functional optical imaging of the brain. However, the modular approach proposed here, and the specific features of the individual headset modules, are unique.