Carl Demolder: Harvard Proposal

**Research Field:**

Medical Devices

**Title:**

Characterization of Finger Tapping Patterns in Autistic Children with Flexible Wearable Sensors

**Abstract:**

Recent research suggests that autism is not simply a mental health issue but rather a complicated neuro-biological disorder. Autism spectrum disorder (ASD), the most prevalent developmental disabilities in North America, is usually characterized by atypical verbal and nonverbal communication and restricted and repetitive behaviors. However, early symptoms of ASD are categorized by motor abnormalities and repetitive patterns of behavior that correlate with late social and communication skills. This correlation highlights the importance to focus research on the motor skill proficiency of children and the severity of their repetitive behaviors. Current assessment of these motor patterns consists of a qualitative analysis of direct observation and a process-oriented skill assessment that lacks the quantitative quality to compare data. Unfortunately, qualitative data does not allow us to directly draw correlation between two variables statistically with precision. Therefore, there is a need for a quantitative diagnostics tool to measure motor patterns and objectively characterize movement to provide adequate therapy interventions. Our collaborative project aims to engineer low-cost, flexible, integrated circuits embedded with sensors used for movement characterization in autistic children. Our diagnostics tool consists of a flexible glove worn by the subject coupled with a programmed graphical-user-interface (GUI). This GUI is used to record, display, and analyze their tapping pattern. The glove would have sensors placed on the thumb, index finger, middle finger, and ring finger. This glove enables the objective characterization of finger tapping by counting how many times a finger touches the thumb, which finger touches the thumb, and the duration that the finger touches the thumb during a defined amount of time.

In the first stage of our research, we have fabricated a simple, printed, flexible glove with resistive sensors constructed from silver, conductive epoxy electrodes with a complementary MATLAB GUI. Through preliminary trials, we have showed that autistic children tapped their index finger fewer times than typical developed children for a given time frame. Additionally, the tapping pattern of autistic children are more likely to be uneven in both duration and counts per finger. Our results suggest that children on the autistic spectrum can tap their fingers less times than healthy children for given time frame, and are more likely to skip a finger when patterned tapping is required. We have further modified our program to add gamification function and encourage the children to participate in the study.

In the second stage of this research, we have improved our diagnostics tool by implementing capacitance sensors that are composed of porous PDMS dielectric material sandwiched between two silver electrodes. This addition enables our diagnostics tool to measure the total amount of pressure and the change in pressure applied in each tap. Our next improvement is the integration of a specifically designed board placed on the glove itself offering enhanced mobility and accuracy. Our last improvement is the next generation python GUI that enables digital signal processing as well as the gamification of the interaction between the children and the diagnostics tool to motivate participation. Clinical assessments and trials are being conducted in late December and early January.

In the future, we plan on fabricating more complex diagnostics tools to measure the repetitive motion response of autistic children and the physiological signals related to anxious behaviors, as manifested by motion and heart rate changes and monitored with accelerometer and infrared pulse sensors. Through the incorporation of wearable sensors to objectively characterize movement patterns, we can provide a platform to evaluate the effectiveness of intervention therapies and for novel motor interventions.

**In 500 words or less, explain to an individual not acquainted to your field why you chose to do research.**

"If I have seen further it is by standing on the shoulders of Giants." This quote by Sir Isaac Newton drives researchers, inventors, scientists, and doctors to push to the limits of knowledge and expand their expertise into the unknown. Through research, I am able to perch upon their broad shoulders, glance across the horizon, and start to identify problems with no known solution. These uncharted waters are humbling ; they deflate your hubris and cockiness while begging you to dig deeper into the unknown. The challenge of research is enticing, not only intrinsically, but also from my peers, as the research community pushes me to dig deeper and ask more questions. As an undergraduate, my knowledge has been based off of the theoretical derivation of past works where our curriculum is preset to a finite number of classes in a specific depth. Research, on the other hand, allows me to expand my educational scope into other disciplines and discover other methods of performing research. These projects consist of multi-disciplinary teams that expand my connections from engineers to medical professionals and material science physicists. These professor, PhDs, and post docs not only provide new opportunities, but they introduce different perspectives, new ways of thinking, and research methods that I am able to incorporate into my own research. Under their guidance, I am able to develop a deeper understanding of the scientific process, proposing research questions to test my hypothesis.

My research is in the development of medical devices as tools for medical professionals and doctors to diagnose different diseases, measure the effectiveness of different therapy treatments, and advance the current state of technological integration into medical practices. Although there have been late nights sitting at my desk in the lab trying to implement new features into medical devices, I know that my perseverance will have compounding effects in the future. Through academic research channels, I can exponentially increase the significance my research will have on the field. As compared to private research and development where patents, intellectual property, and economic pressures block collaboration and the spread of unrestricted information. Through research, I am able to develop the future, work on cutting edge technology that one day would hopefully be implemented in hospitals and doctor offices across the globe assisting doctors diagnose medical conditions and hopefully improve their therapies. Most of all, my research is fun and gratifying, with the most satisfying part of it being the implementation of your hard work in everyday life. Although my research is ongoing, whether I hit a dead-end or have a "Eureka!" moment, I know that my work will be benefiting others and contributing to the ever-growing shoulders of giants.