Literature review draft for the Capstone
PES University, Bangalore
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Transradial prosthesis - A Bionic Arm using EEG and EMG sensors and signals.

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Beyond Bionics

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1. **Control systems for prosthetic limbs**: Review literature on the various control systems that have been developed for prosthetic limbs, including myoelectric control (using EMG signals) and hybrid control (using a combination of EMG and EEG signals).
   Brain controlled - **Neuroscience researchers receive $3.4 million NIH grant to develop brain-controlled prosthetic limbs -** https://www.uchicagomedicine.org/forefront/neurosciences-articles/neuroscience-researchers-receive-grant-to-develop-brain-controlled-prosthetic-limbs
   Using magnets to control prosthetics - https://news.mit.edu/2021/magnet-prosthetic-limb-control-0818
   Prosthesis of legs to understand the system better - https://www.sralab.org/research/labs/neural-engineering/projects/advanced-control-systems-powered-prosthetic-legs
   Bionic arms are artificial arms that use advanced technology to mimic the movements of a real arm. They are powered by motors and utilize sensors to respond to signals from your brain. Prosthetic arms, on the other hand, are mechanical limbs made of a plastic or metal frame and designed to look and act like real arms. They are generally lightweight, strong, and have joints that move just like a real arm. - We intend to build and fabricate a product that takes the best of the two worlds!

2. **EEG and EMG signal processing**:
   https://biologicalproceduresonline.biomedcentral.com/articles/10.1251/bpo115.
   EEG- https://ieeexplore.ieee.org/document/9305784
   EMG- https://ieeexplore.ieee.org/document/894636
   Some on enhancing both - **Enhanced EEG–EMG coherence analysis based on hand movements**
   Exploring MLP and CNN in both - https://ieeexplore.ieee.org/document/9027853
   Myography can only do so much, to enhance the UX, we look up to EEG.
   EEG and EMG signals are biological signals generated by the brain and muscles, respectively. They are used as input signals for controlling bionic arms. Signal processing techniques such as filtering, normalization, and feature extraction are used to prepare and enhance the signals for use in control systems. The extracted features from the processed signals are then used to control various functions of the bionic arm. Machine learning techniques are used to identify patterns and correlations between the signals and their associated controls. To ensure accuracy of the control system, regular calibration is performed to ensure that the signals are being interpreted correctly.

3. **Mechanical design of bionic limbs**:
   a. Designing the necessary mechanical components such as joints to enable effective movement
   b. Incorporating the appropriate muscles, tendons, and other anatomy elements to provide a realistic range of motion
   c. Ensuring that the overall system is strong enough to support the user's weight and desired activities
   d. Utilizing materials that are lightweight yet durable, and
   e. Incorporating sensors and feedback mechanisms to provide a realistic biological experience.

4. **Brain-Computer interface - Neural prosthesis**: EEG - https://www.ftands.in/
   Your brain is constantly producing electrical signals while it operates, as the cellular components of the brain (neurons) communicate with each other. At a macro scale, they produce a range of frequencies that scientists have found relate to particular mental states. For example, a sleeping person's brain produces an abundance of delta waves, whereas an alert and awake person concentrating hard on something will produce far more beta waves.
   The Mindwave headset picks up your brain's electrical activity and divides the signal by frequency into various types of waves, allowing it to infer your mental state. For most of the non-scientific apps however, it primarily reads how relaxed (as measured by alpha/theta waves) or concentrated (as measured by beta/gamma waves) you are.

5. **Human-machine interface**: EMG - https://www.seeedstudio.com/blog/2019/12/29/what-is-emg-sensor-myoware-and-how-to-use-with-arduino/
   - The whole process starts off in your brain
   - Neural activity in the motor cortex (part of your brain) signals to the spinal cord
   - The signal is then conveyed to the muscle part via motor neurons
   - Motor neurons innervate the muscle directly, causing the release of Calcium ions within the muscle and ultimately creating a mechanical change
   - This mechanical change involves depolarization (change in electromechanical gradient), which is then detected by EMG for measurement

6. **Assessing biocompatibility**: We have yet to do a clinical study on the above but thanks to a groundbreaking surgery called **Sensory Reinnervation**, the patients' nervous system is remapped to be able to sense touch. Will be updating more on the same soon.

7. **Societal impact**: Explore the current research being done in this field and the potential future developments that could improve the performance of transradial prostheses and in turn **help our people who've unfortunately lost their arm, get a second life.**