4 Design

4.1 Design Context

4.1.1 Broader Context

Our project differs from most of what is openly available in that it is a non-invasive prosthetic. This is relevant to a new market because by nature of its use not requiring surgery, it will be considerably more affordable. The accessibility of prosthetics to amputees not only improves the life of the amputee, but also reduces the burden on their friends and family. Allowing amputees to become more functional benefits their contribution to society, increases their feeling of normalcy, and can greatly improve mental health.

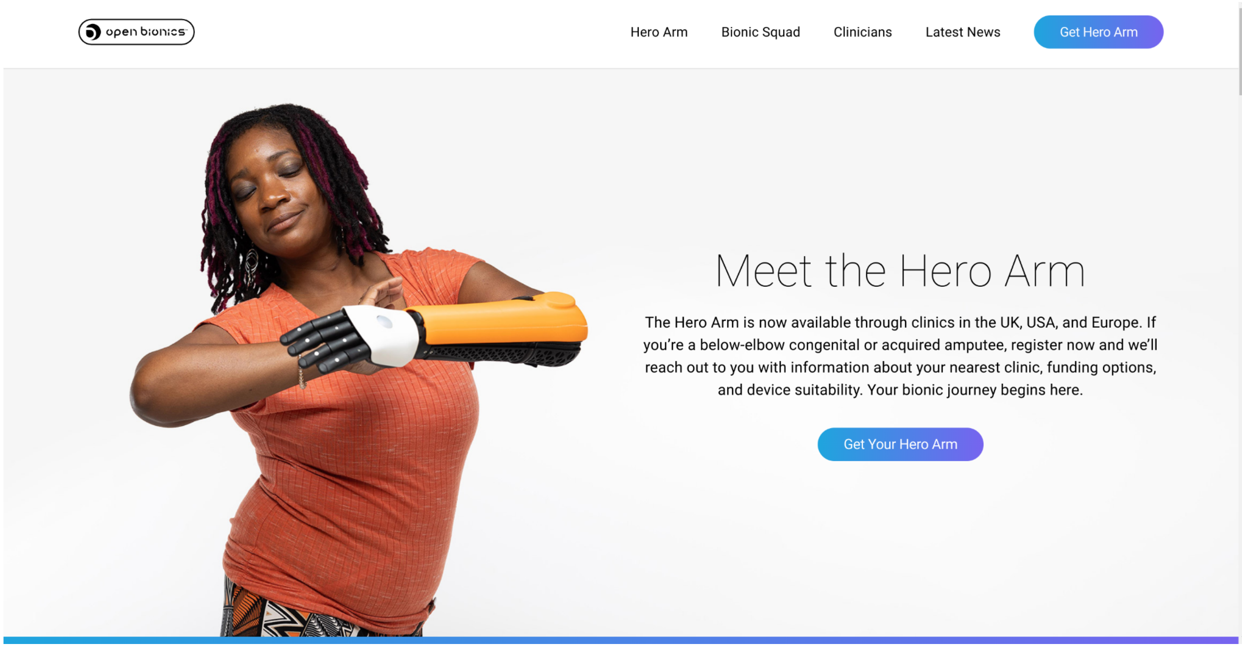
Hopefully, our research and final product can benefit the entire amputee community by furthering non-invasive prosthetic technology. Our findings could also pressure other companies to make their prosthetics more accessible and affordable through competition.

List relevant considerations related to your project in each of the following areas:

Area	**Description**	**Examples**
Public health, safety, and welfare	How does your project affect the general well-being of various stakeholder groups? These groups may be direct users or may be indirectly affected (e.g., solution is implemented in their communities)	No major public health or safety impact. However, having an affordable but effective prosthetic arm will help others feel more integrated in society.
Global, cultural, and social	How well does your project reflect the values, practices, and aims of the cultural groups it affects? Groups may include but are not limited to specific communities, nations, professions, workplaces, and ethnic cultures.	From a social aspect, the arm users will feel more included in society. Friends/family of the user will feel satisfied that the user has regained
Environmental	What environmental impact might your project have? This can include indirect effects, such as deforestation or unsustainable practices related to materials manufacture or procurement.	Increasing usage of non-recyclable plastics. Usage of lithium-ion batteries, energy used to manufacture silicon and electronics inside.
Economic	What economic impact might your project have? This can include the financial viability of your product within your team or company, cost to consumers, or broader economic effects on communities, markets, nations, and other groups.	The product will be affordable to users and will be easily obtainable. Within our company, the product's pricing must be competitive enough but enough to make profits.

4.1.2 Prior Work/Solutions

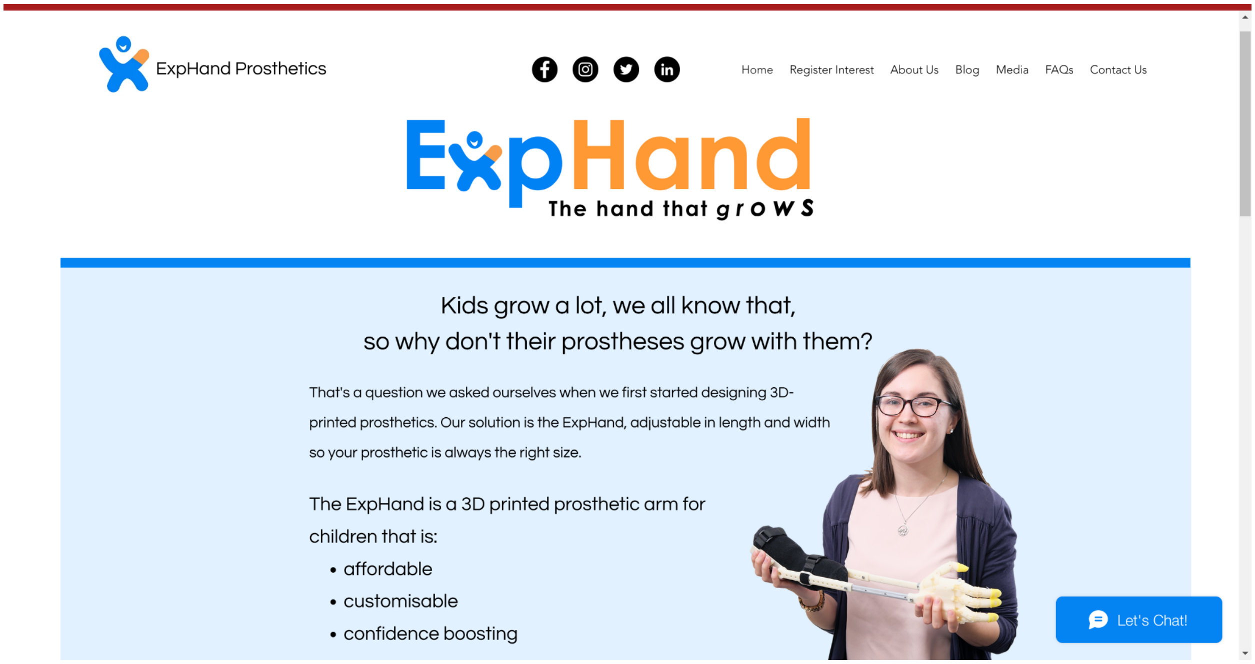
https://openbionics.com/



Openbionics main website

"Advanced, intuitive, robust and light. The Hero Arm is the world's most affordable advanced multi-grip prosthetic arm, with multi-grip functionality and empowering aesthetics… the Hero Arm is a custom lightweight and affordable myoelectric prosthesis…" This prosthetic is custom made from nylon 12 and uses "haptic vibrations, beepers, buttons and lights [to] provide you with intuitive notifications to help you control bionic arm movements."

https://www.exphandprosthetics.com/



Exphand front website

Exphand is an open source solution to provide a sense of normalcy to mostly child amputees. The goal of this hand is to be highly adjustable to conform to a rapidly growing child. It has no electronics and works through mechanical inputs to adjust the contraction of the hand. These controls are intuitive but very limited. Some design techniques from the Exphand that are very simple but could work well for us are velcro straps to help fasten the prosthetic to the amputee's arm; also the mechanism for contracting the hand seems to work really well.

4.1.3 Technical Complexity

Our project satisfies the requirements for complexity by requiring circuit design, component selection based on design constraints and technical requirements, pcb construction, signal obtainment, signal processing, software development, power delivery requirements, and power systems design. Our project aims to research, build, test, and adapt a fully functional robotic arm. These varying challenges relate to the scientific method of solving problems, relevant mathematical knowledge, and basic engineering design principles.

All of the previously mentioned aspects of the project are issues that are still faced within the industry of prosthetic limb design and manufacturing. Some of the methods that we are using to design and build this prosthetic meet and in some aspects exceed those found within the current industry.

4.2 Design Exploration

4.2.1 Design Decisions

One of the biggest design decisions being made for our solution is the materials being used for the arm. We chose to use a mixture of ABS and a small amount of aluminium in order to maintain strength and durability while allowing the arm to be as strong as possible. The next large design decision made was the inclusion of pressure sensors for touch feedback. The success of this project layes on the fact that the patient will be able to regain a great majority of what he/she lost after the amputation, in this specific case the sensation of touch. By giving the user this critticle sense back to them it is more likely that the arm will be used to its fullest potential and give the user an overall better experience. A third design choice that was made was to create a more accurate and longer lasting EMG reading circuit. In most instances of EMG signals the electrode pads used are only good for a day and can lead to excessive noise if used any longer. By researching materials and layouts to improve this length of time it not only gives the user a better experience but allows for easier and less frequent calibration by the doctors and technicians of the device.

4.2.2 Ideation

When identifying the best way to read muscle movements from the patient a few possiblites came up. The first of which was EMG signal reading through surface electrode also know as Surface EMG. This was identified as it is the most rudimentary way to read EMG signals with the least amount of complicated equipment. The next option was in vivo EMG sensing which is a little more difficult and is intrusive to the patient. Ultrasonic signal reading was the third option discussed and this requires custom made sensors which allow for high accuracy at the cost of high difficulty and expense. Nural network signal reading was the fourth option discussed however this relies on two different surgeries and is quite costly and potentially harming to the patient. The final option discussed was the oposite method which is a fairly new technique that allows for all movements of the prosthetic to be based off of the opposite limb which causes difficulty with physical therapy as well as use of the arm.

4.2.3 Decision-Making and Trade-Off

The pros and cons of each option were weighed using a few simple metrics, the first of which is ease of implementation. This metric completely ruins the idea of having any other form discussed during the design decision process due to the specilized implementation of all the other methods. The second metric was cost. The cost to generate readable EMG signals from any of the methods other than the opposite method and surface EMG is exponentially higher simply due to the equipment or surgery cost that is associated with it. The final metric used to chose the final solution in our design was amount of background knowledge/ research. Most of the methods had a large amount of research and papers that allowed for a greater understanding of how to use these techniques however, only the surface EMG method had the least amount of background knowledge necessary in order to implement.