Project Proposal

Prosthetic Hand Project

Engineering 1/15/07 Biomechanics

Participants

McGill	**VSRC**
Abdullah Abdelghani	Gabriel Alexander
Imran Jameel	Jessica Bao
Asal Kaveh	Mathieu Corbett
Yely Lapina	Nicolas Eliopoulos
Maged Yassin	Anna Gostevcic
	James Hanna
	Annika Lesage
	Peter Papas
	Jenisha Patel
	Osama Rehman
	Jung Seok Bae
	Elizabeth Siciliani

1. Abstract

A team of McGill University engineering students is collaborating with the biomechanics team at Vanier College to provide a better understanding of the fundamentals of biomechanics. This will be done through a combination of experiments and studies leading to the design and development of a prosthetic hand prototype. This research is aiming to provide a cheaper alternative to the robotic prosthetics offered in the market.

There is a gap between disability and ability that need to be filled and redefined; disability is nothing but a lack of human's innovation regarding a certain problem. We believe that focusing on such problems, closely related to other's daily life can help redefine the concept of disability.

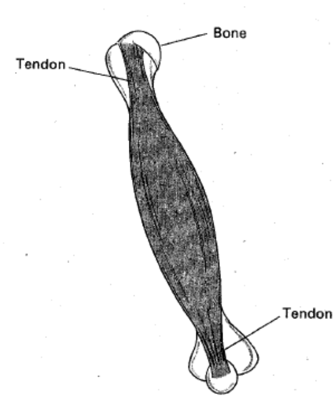
Vanier students will perform experiments to calculate force, speed, angular speed, torque, stress and strain on joints and bones, while McGill's design team will focus mostly on the development and manufacturing of the prototype. The students will get involved in each other's tasks so they will learn from each other skills.

The deadline for presenting the results will be March 2015.

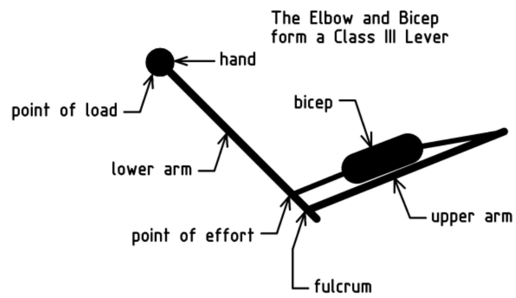
2. Theory

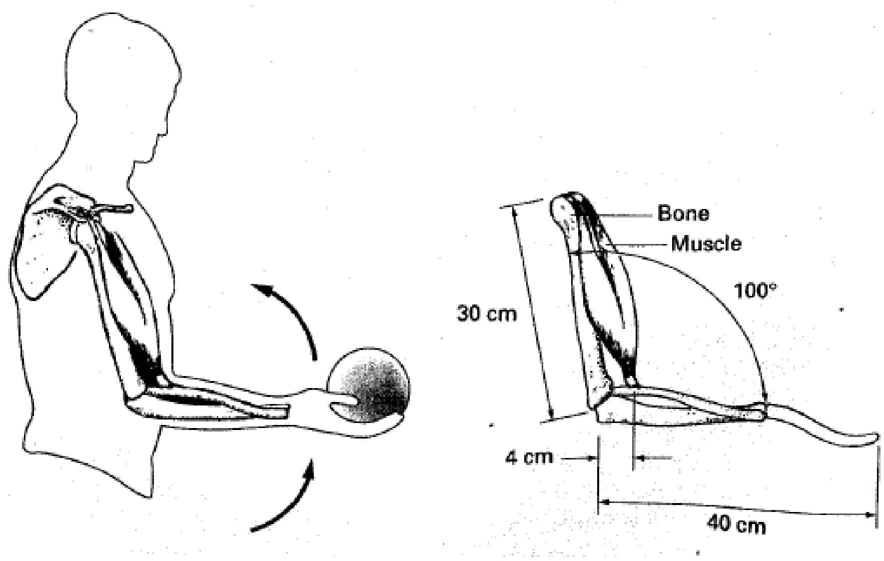
Biomechanics is defined as the study of muscle movement and the physical behavior of bones and organs (Davidovits 2). It therefore presents a vast variety of research topics including the biological and natural limits of athletes. How high and far an athlete can jump or run or how fast and strong a boxer can hit without any damage is dependent on many physical and biological factors.

Skeletal muscles are attached to the bones by means of tendons. Each of its ends is attached to a different bone. These bones are free to move with respect to the joint between them. When muscle fibers receive an electrical signal from the brain, they contract. A subsequent pulling force is then exerted on the bones. According to previous experiments, the maximum force a muscle can exert is about 7 x 10 6 dyn/cm2 of its area (Davidovits 8).



To analyze these forces and torques, we can treat the limbs as third-class levers (Davidovits 9). An example is given in the next picture:





Motion consists of translational and rotational components (Davidovits 31)

3. Methodology

The methodology used by all research teams will be based on the following equations:

$$\sum_{Forces} \vec{F}_{external} = 0$$

$$\sum_{Forces} \vec{F}_{X} = 0$$

$$\sum_{Forces} \vec{F}_{Y} = 0$$

$$\sum_{Forces} \vec{\Gamma}_{axis} = 0$$

$$\sum_{Forces} F \bullet LA_{axis} = 0$$

New topics of Elasticity and Strength of Materials will be studied extra curriculum and calculations of Stress and Strain will be done using the following formulas where: F = Force, A = Bone Area, S = Stress, $\Delta l/l$ = Strain and Y = Young's Modulus.

The force F_b that will fracture the bone is

$$F_B = S_B A = \frac{YA}{l}\Delta l$$

The compression Δl at the breaking point is therefore

$$\Delta l = \frac{S_B l}{Y}$$

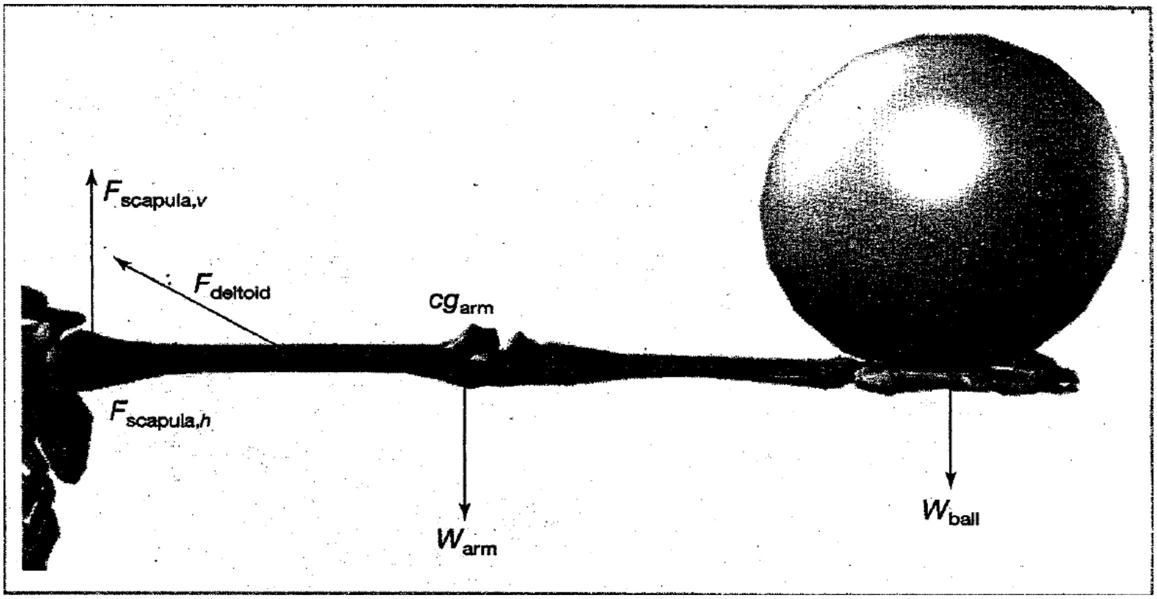
The energy stored in the compressed bone at the point of fracture is

$$E = \frac{1}{2}\frac{YA}{l}(\Delta l)^2$$

Substituting $\Delta l = S_B l/Y$, we obtain

$$E = \frac{1}{2}\frac{AlS_B^2}{Y}$$

Force, torque and stress calculations in the key parts of the arm will be used to shape the design and material of the prosthesis arm prototype. An example of Force diagram on a loaded arm is shown in the next figure (Davidowich)



Predicted results are the forces, torques and stress in different joints and bones to be used for the design of the hand prototype.

4. Research teams

A. Vanier Student Research Center (VSRC)

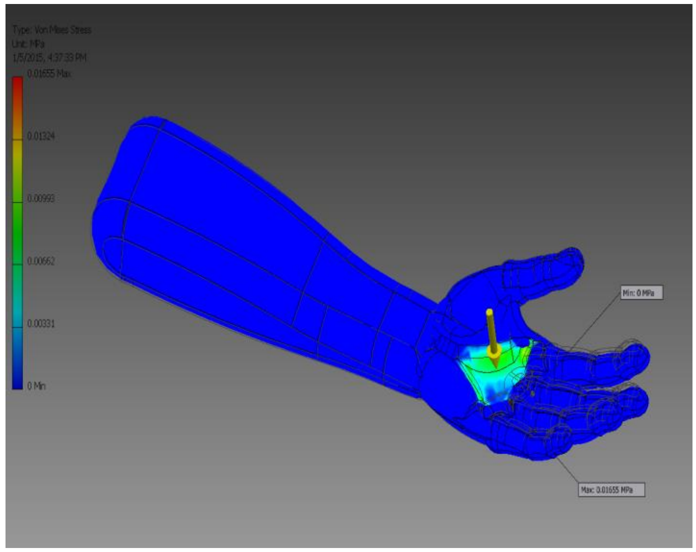
Vanier students who want to limit their research at a theoretical level will perform tests with athletes as well as with non-athletes at the sports center. They will analyze motions such as walking, running, jumping or lifting weights. Several physical quantities, such as velocity, acceleration, force, torque, etc. will be studied. The measurements will be obtained using PASCO sensors and analyzed with specialized PASCO software. The students will then present the results related to the biophysical limitations in certain sports.

Vanier students who want to get involved in the design and creation of a hand prototype will analyze the biophysical quantities of a hand, forearm and fingers in static equilibrium or in motion.

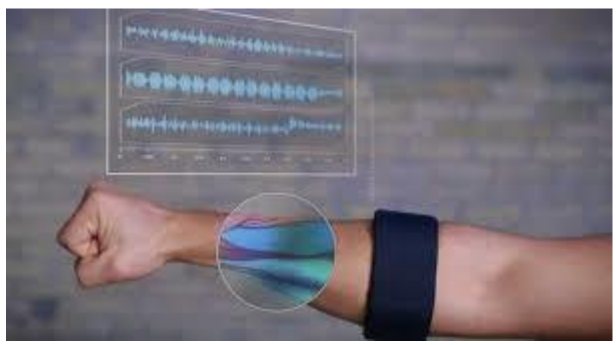
During the science fair, there will be a single presentation, divided into two parts to allow for both groups to present their findings.

B. Engineering and design led by McGill engineering students

Five mechanical engineering students are designing a robotic prosthetic hand that can perform basic activities as grasping and handling objects in response to the myographical muscles signals. The hand mechanical design will be 3D printed using a type of ABS plastic which will be decided after running a finite element analysis (FEA) test on the final CAD. We will use Fusion, Solidworks and Inventor as the main CAD software. The Myo and Arduino platforms will be used as a solid base to control and drive the hand.

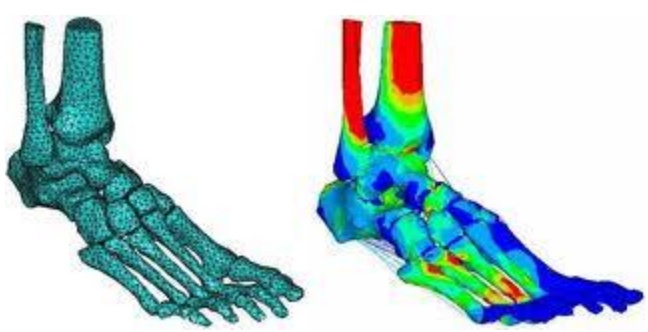


An example of Finite Element Analysis (FEM) on a hand model



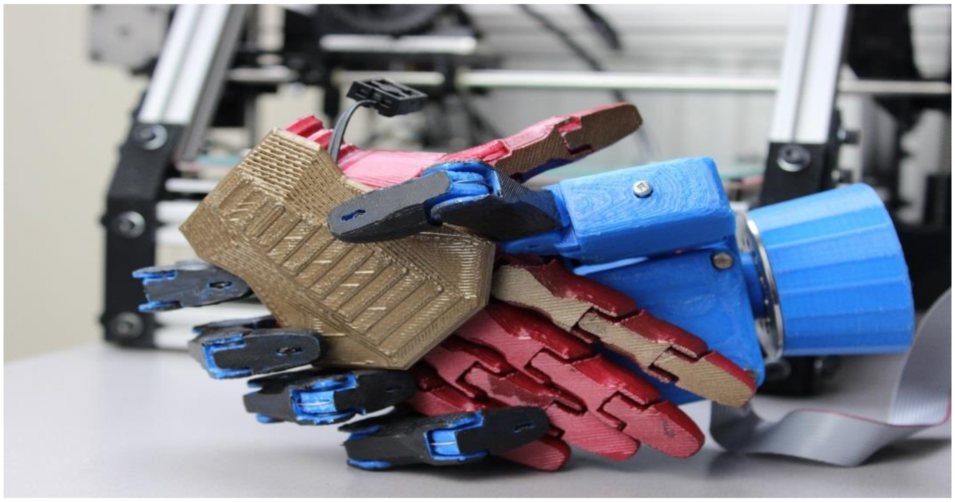
How thalamic lab's prototype works, it will be used later in the project to control the hand

The hand prototype will use lab-generated signals similar to the original ones from the muscles. Those signals get amplified and filtered then translated into hand movements using a microcontroller; the artificial fingers are mechanically driven using actuators and artificial tendons similar to those in a human hand. Team members will put their design, coding and critical thinking skills to help deliver a cheap functional prosthesis.



Stress analysis of the human body parts will help design and construct the prosthetic hand

During the science fair, McGill students and VSRC members involved in the design of the hand will present screenshots of the first assembly, which will look similar to the following picture:



Courtesy of the open hand project to give an overview of how a 3D printed prosthesis looks like (3)

5. Hardware and software used

- Actuators and servo motors
- 3D printed plastic
- Computer aided design (CAD) software which allows 3D modelling of parts as well as stress testing different materials.
- Arduino, an open-source micro-controller that will be used to receive signal input and drive the servos.
- Myo armband, which translates muscle movement into electrical signals for processing by the Arduino.
- C, C++, Arduino and LabView programming languages

6. References

1) Davidovits, Paul. Physics in Biology and Medicine. Amsterdam: Elsevier/Academic, 2008. Print.
2) http://www.math2learn.org/files/fwsm/ForcesWorkSM.html.LyXconv/LeverClass3.png
3) The Open Hand Project < http://www.openhandproject.org/>
4) Arduino boards <arduino.cc>
5) Thalmic labs Myo <https://www.thalmic.com/en/myo/>
6) Benson, Harris. University physics.