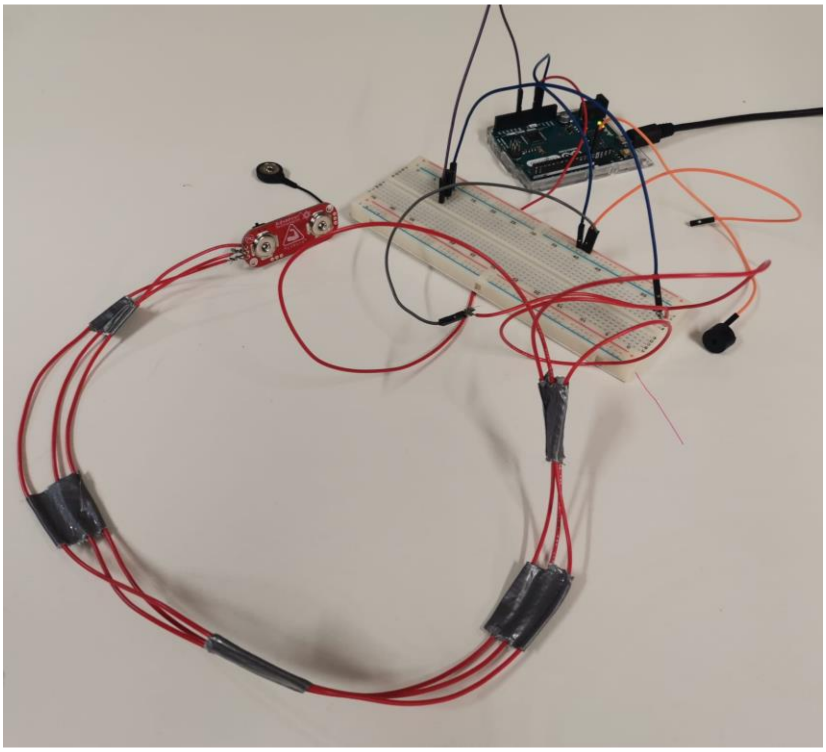
Final report Thor



Project made by: Ignasi Blancher, Álex Campañá, Martina Gràcia, Maria Gelabert, Gerard Gutiérrez, Blanca Lamarca and Roger Pons

From CIC Batxillerats, Barcelona

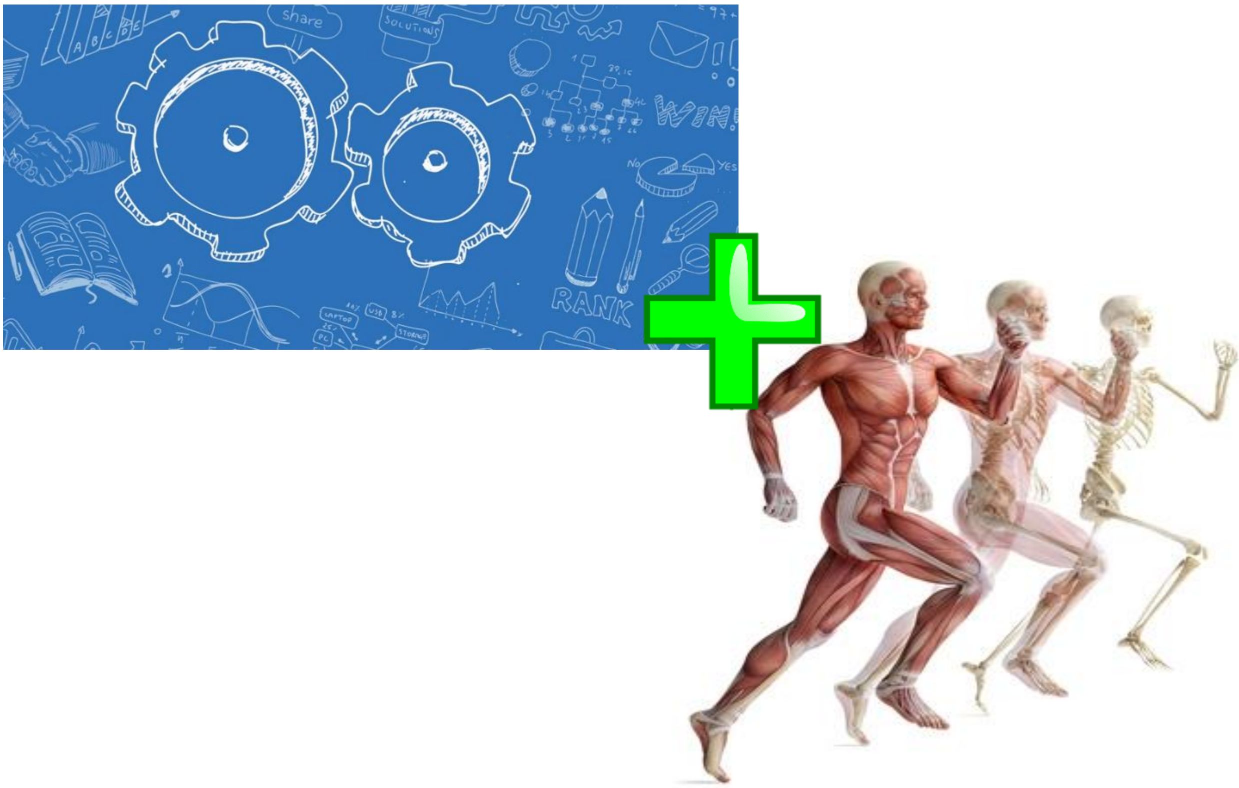
Index

Contenido

Introduction

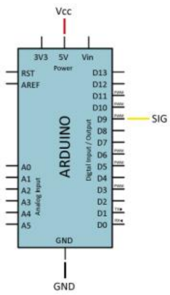
This project consists of the creation of an instrument that can produce 7 different musical notes. The frequency of the note emitted, which is proportional to its pitch, will vary depending on the electrical signal received from the impulses of a human arm. So, to say, the higher the intensity of the electrical impulses the system computes, the higher the pitch of the note the human ear receives. This process will be made through an Arduino, the function of which will be to receive the data of the intensity of the muscle contraction and generate the different notes through a passive buzzer.

Our interest in this field (the combination of engineering and human biology) comes from our motivation to learn about biotechnology, more specifically about our body functionality and its applications in the engineering field. And, although we are aware of the apparent simplicity of the circuit we plan to elaborate, we believe that this project can have a very interesting outcome and can surely accomplish the objectives that are asked of this proposal. Not only that, but we think that, were we to have more time to develop our idea, we could find other ways of turning internal physical abilities into music. We are fascinated by the possibility of coming up with a design that combines both technology and musicality through human aptitudes and we hope that we can reach our goals.

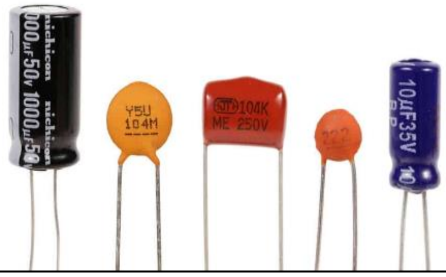
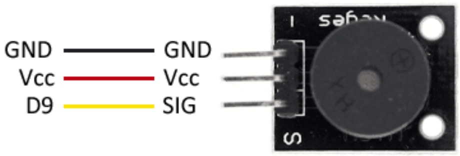
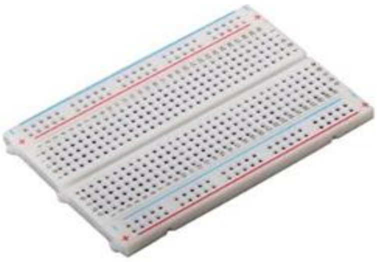


Tools and materials

The materials and tools that we will need during the creation of the Thor's Project are mentioned and described in the list below:

Cables Short cables that will pass the current between the different parts of the circuit.	
One Arduino Leonardo (x1) Board that will serve as a microcontroller of the "Thor" so that it performs the corresponding functions at the indicated time.	 
Adhesive electrodes (3 or more) Conductive pad coated with adhesive gel and terminated on the opposite side with a snap connector. We will apply it on one's arm.	

Two 9-volt batteries (you can also do it with a computer, but you'll need a special cable) The nine-volt battery, or 9-volt battery, is a common size of battery that was introduced for the early transistor radios. It has a rectangular prism shape with rounded edges and a polarized snap connector at the top.	 **OPTIONAL:** 
Soldering iron (x1) It supplies heat to melt solder so that it can flow into the joint between two workpieces.	
LED (Optional to see if the circuit works) Light-Emitting Diode) is a semiconductor light source that emits light when current flows through it.	
EMG sensor MyoWare (x1) Sensor that is capable to amplify the electronic waves of the muscle.	

<u>Capacitor</u> (x1) Device that stores electrical energy in an electric field. In this specific circuit we will use 1μF and 10μF capacitors.	
<u>Arduino Passive Buzzer</u> (x1) We will use it to produce the sounds.	
<u>Breadboard</u> (x1) It will be our construction base where we will connect all the electronic systems.	

Methodology

It is key to have a clear method to be able to distribute your time, to be productive and to be able to be constantly multitasking. As a group, we generate different roles and subgroups to increase our diligence.

1. Firstly, it is necessary to get hold of the different indispensable material and tools needed for the project, listed above. When doing so, we used internet-bought materials, materials that were lent to us by the technology laboratory and some materials that members of the group already had.
2. Write the Arduino code with the specific lines of code that enable its emissions of different frequencies depending on the electrical impulses that are received from one's muscle contractions. We wrote the code with the help of some similar projects that we found in the Arduino project hub.
3. Arrange the electronic circuit in the Arduino board according to the corresponding example panel given. (https://youtu.be/_TFvk07KxKo?t=52)
4. In order to emit different musical notes, seven is the minimum, that are distinguished via the frequencies processed by the Arduino, connect the passive buzzer to the board. This will emit the seven musical notes. As a matter of fact, the range of the sound emissions is not limited to seven but is wider.
5. Connect the two nine-volts batteries to the Arduino board.
6. The receptors of the muscle contractions are the electrodes that have been previously granted, these must be connected to the electromyograph, which is connected to the Arduino board, and to one's arm, so that they can both receive and transfer the contraction values that are given by one's arm.

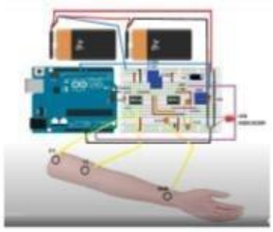
Visual scheme of the project organisation

Get hold of the different indispensable material and tools needed

Write the arduino code

Enable its emissions of different frequencies depending on the electrical impulses that are received from one's muscle contractions.

Arrange the electronic circuit in the Arduino board



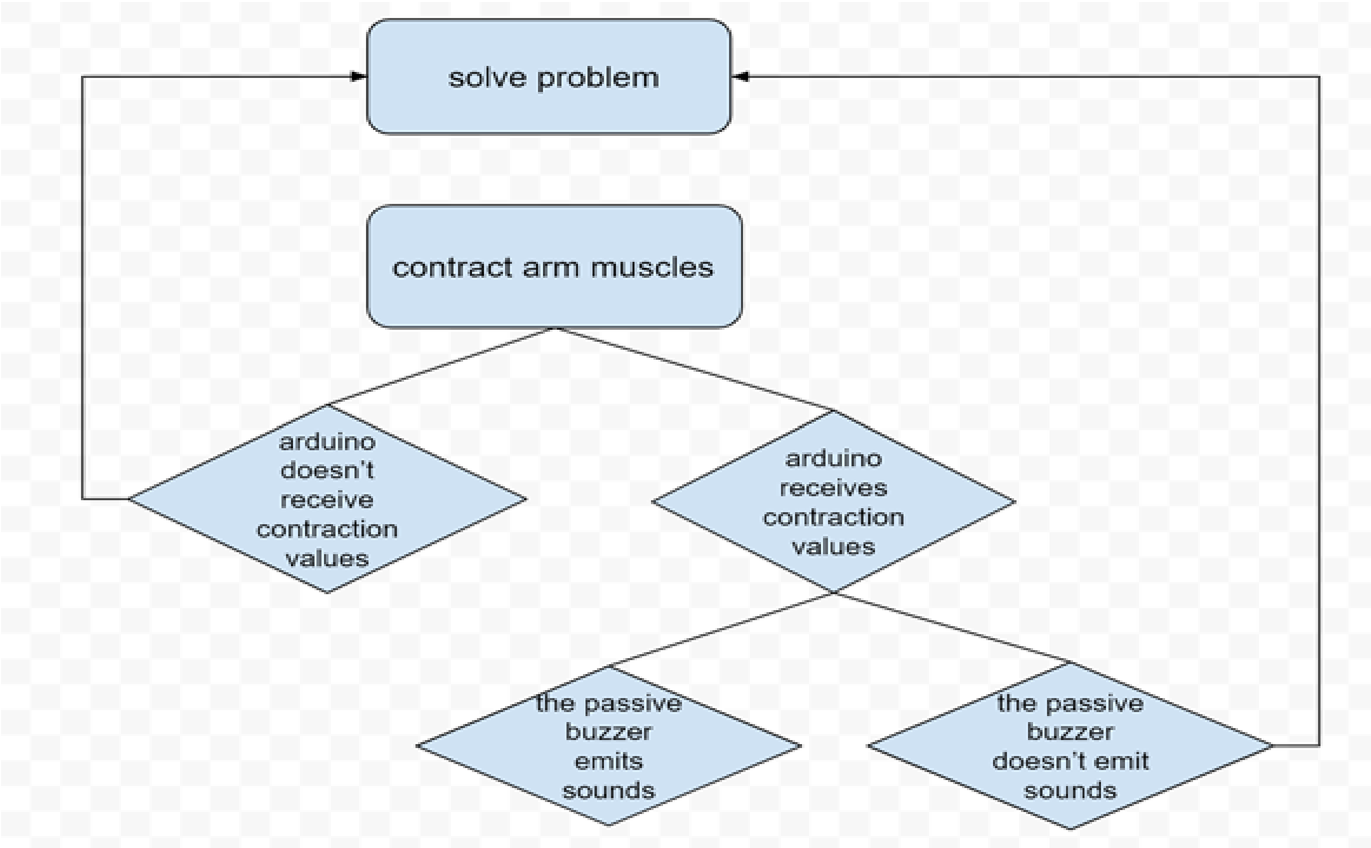
Connect the passive buzzer to the board

In order to emit different musical notes, seven is the minimum, that are distinguished via the frequencies processed by the arduino

Connect two nine-volts batteries to the arduino board

The electrodes recept of the muscle contractions

These have to be connected to the arduino board and to one's arm, so that they can both receive and transfer the contraction values that are given by one's arm.



Here we expose the different options that we contemplate during the process of developing the instrument.

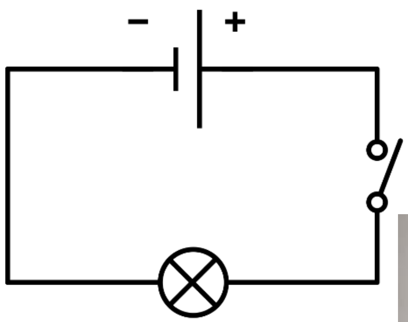
Temporal organisation

We could divide our project in three main tasks: programming the code, building the circuit, and editing and writing the final video and written memory.

For programming the code, we will have to put in some work. There will be two people fully dedicated to the task while another one will be there for helping and support. As we do not know anything about programming, first we will have to learn how to program and then we will have to write the specific code for the project. That is why we reckon that it will take us about 10/12 hours to learn and write the code. Considering that some things will not work as expected, we think that 14 hours would be the ideal time destined to do the task.

Building the circuit will not be a difficult task because we have found an integrated circuit that simplifies a lot all the schematics. That is why considering all the problems that we might encounter along the way; we think that 4 hours is a reasonable time to finish this task.

Finally, we will have to hand in a memory that reflects all the work that we have done during all this time. The written memory will be a task that will take us approximately 8 hours to do, as we have already done the scientific corpus. On the other hand, we will have to hand in a video that will be the reflection of hours of hard work and dedication, so we reckon that it will take us near 16 hours to make the perfect video.



Economical organisation

This is the first contact with economic issues of this project. Considering the initial idea that we had we must buy the following:

Materials	Price (€)
Passive buzzer	0.45
adhesive electrodes x10	10.95
EMG sensor	54.65
capacitor	0.5
Total	**66.55**

Risk analysis

As we all know, carry out a project involves certain risks. The project that we idealise before we start often does not match a lot with the result. This section will be destined to analyse, and reconduct some problems that we might have during the project. In addition, this part is going to be dynamic, like our group, because it is going to have the possibility to readapt some aspects of the project during the process of construction.

We remark that improvisation is not an enemy; sometimes this brings us the opportunity to put in practice different abilities to upgrade the project.

Firstly, we are going to expose some risks that generate us some insecurities before the realization of the project.

- The main insecurity that we have is the circuit properly. We are not experimented in building circuits. The only support that we have is the systems that some YouTube videos brings to us, but they are not exactly what we want to do. This project is something unique and has a willingness to innovate.
- Another problem that we might have is that, due to the non-invasive method that we are going to use, the recording of the data collected from the muscle will be not readable.
- We are going to start the project with no base of knowledge of Arduino's programming. We wish that with our dedication and time we will be able to execute and write the code.
- Another insecurity, related with the one above, is that we don't know exactly if the buzzer can generate 7 sounds or more depending on the muscle contractions.
- Finally, these uncertain feelings make us be unsure about what we have, and we do not have to buy. The thing is that we must start as quickly as possible; however, it is essential to have an exceptionally good organization from the beginning.

As we can see this risks that we are taken are generally related with the absence of knowledge that we have about the scope that we are going to study. Nevertheless, there is no winning without taking risks.

Arduino

F4TZ10AJHKU1S4U Arduino 1.8.11

Archivo Editar Programa Herramientas Ayuda

F4TZ10AJHKU1S4U

```
#define T_C 261
#define T_D 294
#define T_E 329
#define T_F 349
#define T_G 392
#define T_A 440
#define T_B 493
#define T_c 523
const int Buzz = 13;

void setup() {
  Serial.begin(9600);
  pinMode(13, OUTPUT);
}
void loop() {
  // read the sensor signal on analog pin 0:
  int sensorValue = analogRead(A0);
  // print out the value you read
  Serial.println(sensorValue);
  delay(1);          // delay in between reads for stability
  if (sensorValue <= 158){
    tone(Buzz,T_C);
    Serial.println("prova");}
  else if ((sensorValue > 158) && (sensorValue <= 256)){
    tone(Buzz,T_D);
  }
  else if ((sensorValue > 256) && (sensorValue <= 384)){
    tone(Buzz,T_E);
  }
  else if ((sensorValue > 384) && (sensorValue <= 512)){
    tone(Buzz,T_F);
  }
  else if ((sensorValue > 512) && (sensorValue <= 640)){
    tone(Buzz,T_G);
  }
  else if ((sensorValue > 640) && (sensorValue <= 768)){
    tone(Buzz,T_A);
  }
  else if ((sensorValue > 768) && (sensorValue <= 896)){
    tone(Buzz,T_B);
  }
  else {
    tone(Buzz,T_c);
  }
}
```

This is the Arduino code that we used for our project. It consists in a lecture of different Arduino

This is the Arduino code that we used for our project. It consists of a lecture of different values that we assigned to our muscles contractions, more specific to the electrowave amplitude produced by this contraction. We assigned the numbers that we could see above by analyzing the numbers generated on some previous tries on the Arduino board and graphics.

We divided the values into seven different frequencies, written on the top part with the name T_X (tone plus a random letter).

This code is composed in the third octave of the C major scale and depending, as we said, on the amplitude, it will choose a tone.

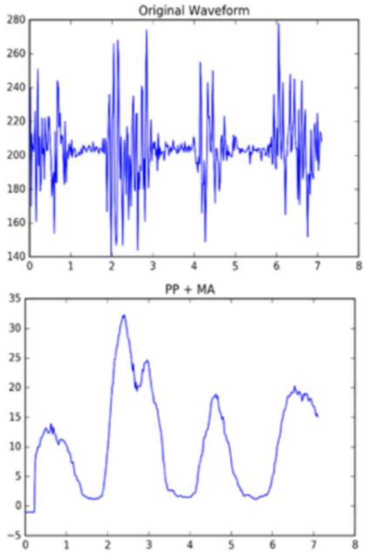
It's important to remark that we used an Arduino Leonardo for this project but it will work with other types of them, for example, and the most common: Arduino Uno.

Finally, we assigned the passive buzzer OUTPUT to port number 13 and the EMG sensor INPUT to port A0.

Scientific corpus

Electromyography

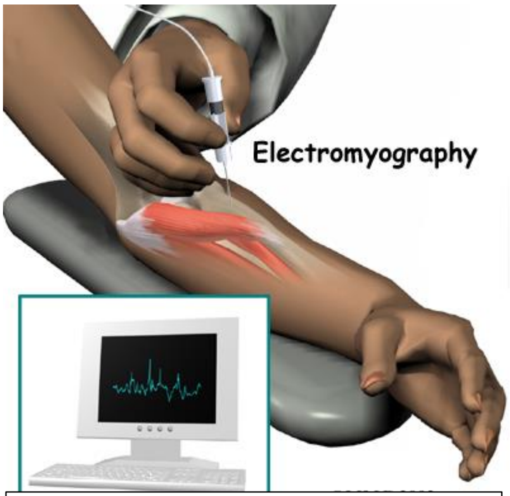
Electromyography (EMG) is an electrodiagnostic medicine technique for evaluating and recording the electrical activity produced by skeletal muscles. EMG is performed using an instrument called an electromyograph to produce a record called an electromyogram. An electromyograph detects the electric potential generated by muscle cells when these cells are electrically or neurologically activated. The signals can be analysed to detect medical abnormalities, activation level, or recruitment order, or to analyse the biomechanics of human or animal movement. In Computer Science, EMG is also used as middleware in gesture recognition towards allowing the input of physical action to a computer as a form of human-computer interaction.



examples of electromyography (EMG) signals

Types of electromyography

There are two types of EMG: The invasive EMGs and the non-invasive EMGs.



Invasive EMG

The invasive EMG is characterised by the intramuscular use of the sensors. It receives this name because it crosses the limit of your skin to obtain information of the muscle. This procedure can be done with a fine-wire or a needle.

The advantages of this type of EMG are the sensibility increment, the ability to focus the area of study, the access to deep musculature and the little cross-talk concern.

There are also some disadvantages. This method is extremely sensitive and because of that it is difficult to adjust and requires medical personnel with certification. In addition, the detection area may not be the representative of the entire muscle.

On the other hand, the non-invasive EMG is a method that do not cross the limit of your skin to obtain information of the muscle. This procedure can be done with stickers.

The non-invasive EMG is quicker and easier to apply. Additionally, there is no need of medical supervision or certification and the discomfort is minimum.

The disadvantages of this method are the difficult position of the electrode stickers, the limitation with recording dynamic muscle activity and the superficially area affected that we want to focus.

Medical uses

EMG testing has a variety of clinical and biomedical applications. EMG is used as a diagnostics tool for identifying neuromuscular diseases, or as a research tool for studying kinesiology (the scientific study of human or non-human body movement), and disorders of motor control. EMG signals are sometimes used to guide botulinum toxin or phenol injections into muscles. EMG signals are also used as a control signal for prosthetic devices such as prosthetic hands, arms and lower limbs.

An acceleromyography may be used for neuromuscular monitoring in general anesthesia with neuromuscular-blocking drugs, to avoid postoperative residual curarization (PORC).

Except in the case of some purely primary myopathic conditions EMG is usually performed with another electrodiagnostic medicine test that measures the conducting function of nerves. This is called nerve conduction studies (NCS). Needle EMG and NCSs are typically indicated when there is pain in the limbs, weakness from spinal nerve compression, or concern about some other neurologic injury or disorder. Spinal nerve injury does not cause neck, mid back pain, or low back pain, and for this reason, evidence has not shown EMG or NCS to be helpful in diagnosing causes of axial lumbar pain, thoracic pain, or cervical spine pain. Needle EMG may aid with the diagnosis of nerve compression or injury (such as carpal tunnel syndrome), nerve root injury (such as sciatica), and with other problems of the muscles or nerves.

Your doctor may order an EMG if you have signs or symptoms that may indicate a nerve or muscle disorder. Such symptoms may include:

- Tingling.
- Numbness.
- Muscle weakness.
- Muscle pain or cramping.
- Certain types of limb pain.

EMG results are often necessary to help diagnose or rule out a number of conditions such as:

- Muscle disorders, such as muscular dystrophy or polymyositis.
- Diseases affecting the connection between the nerve and the muscle.
- Disorders of nerves outside the spinal cord (peripheral nerves), such as carpal tunnel syndrome or peripheral neuropathies.
- Disorders that affect the motor neurons in the brain or spinal cord, such as amyotrophic lateral sclerosis or polio.
- Disorders that affect the nerve root, such as a herniated disk in the spine.

Risks

The question that is more commonly asked is if EMG can be painful.

The answer is yes and no at the same time. It depends on the type of EMG involved. For example, in an invasive EMG there is some discomfort at the time the needle electrodes are inserted. They feel like shots (intramuscular injections), although nothing is injected during an EMG. Afterwards, the muscle may feel a little sore for up to a few days. On the other hand, using surface electrodes it is not painful and aggressive with the muscle and there is no risk of fatigue after the information gathering.

Sounds

In material science, sound is a vibration that engenders as an acoustic wave, through a transmission medium, for example, a gas, fluid or strong.

In human physiology and brain research, sound is the gathering of such waves and their discernment by the brain.

There's many ways sound waves travel not only through air but also through water or even the ground. When they arrive at our ear, they cause the sensitive films in our ears to vibrate, permitting us to hear the voices of our friends and family, music or the quieting hints of raindrops on a tin rooftop and the far-off sound of thunder. As a matter of fact, this is a somewhat basic clarification of an unpredictable cycle.

Moreover, sound recurrence is a significant part of how we decipher sounds, however it is not the one and only one. A sound wave has five attributes: Wavelength, time span, adequacy, recurrence, and speed. While sufficiency is seen as clamour, the recurrence of a sound wave is seen as its pitch. Also, the higher the recurrence waves sway, the higher the pitch of the sound we hear.

As you see, sound recurrence is controlled by how sound waves sway while venturing out to our ears, implying that they switch back and forth among compacting and extending the medium, which by and large is air. In a similar medium, all solid waves travel at a similar speed.

Noisy sounds, like the blow of a whistle or a shouting kid, waver at a high recurrence, bringing about intermittently stunning shrill sounds. The low thundering of an approaching tempest or a bass drum, then again, is delivered by low-recurrence wavering, so we hear it as a low-pitched clamour.

The absolute number of waves delivered in one second is known as the recurrence of the wave. The quantity of vibrations checked every second is called recurrence. Here is a basic model: If five complete waves are created in one second then the recurrence of the waves will be 5 hertz (Hz) or 5 cycles for every second.

Likewise called infrasound, low-recurrence sounds represent sound waves with a recurrence beneath the lower furthest reaches of perceptibility (which is for the most part at around 20 Hz). Low-recurrence sounds are altogether sounds estimated at around 500 Hz and under. On the other hand, a high-recurrence sound is estimated at around 2000 Hz and higher.

Muscle contractions

A muscle contraction is the activation of tension-generating sites within muscle fibres. It begins when the nervous system generates an action potential, an impulse that travels through a nerve cell called a motor neuron.

The neuromuscular junction is the name of the place where the motor neuron reaches the muscle cell. Skeletal muscle tissue is composed of cells called muscle fibres, when the nervous system signal reaches the neuromuscular junction, a chemical message is released by the motor neuron. This chemical message, a neurotransmitter called acetylcholine, binds to receptors on the outside of the muscle fibre that starts a chemical reaction within the muscle.

A multistep molecular process within the muscle fibre begins when acetylcholine (an ester of choline and acetic acid that serves as a transmitter substance of nerve impulses within the central and peripheral nervous systems), binds to receptors on the muscle fibre membrane. The proteins inside muscle fibres are organized into long chains that can interact with each other, reorganizing to shorten and relax. When acetylcholine reaches receptors on the membranes of muscle fibres, membrane channels open and begins the process that contracts a relaxed muscle fibre.

Conclusion

Having developed the project, we can confirm that we have accomplished our main objective, since the system is able to reproduce a wide scale of musical notes depending on the muscle contractions of the subject that has the electrodes connected to their arm. To see a video on how it works and the notes it reproduces, check our video report where all this is shown.

Strong points, difficulties and potential solutions

Throughout the project, we have encountered several complications in order to achieve the goals we set for ourselves in the beginning of the proposal. One recurrent issue has been the unreliability of the different buzzers that we've used, since we ended up not buying any of them because we thought the ones that we already had, that were previously ours and, hence, used, were going to work. As it turned out, these did not function correctly, and we found ourselves unbeknownst of whether the reason why the buzzer wasn't emitting any sounds was because there was something wrong with the Arduino or because the buzzer wasn't working properly. In order to prevent this situation, we could've tested in advance if all the material was working and, if not, we should have bought spare buzzers, since they're cheap and easy to get. Also, although having bought a considerable number of electrodes (over ten), these were not sufficient in order to try out the project the amount of times we thought we needed. So, getting hold of more and better material is one of the points we think that we should have planned better.

Regarding the amount of time spent on each task, because there is seven of us involved in this project, we think that we managed to keep busy everyday we got to go to physical class by organising all of the tasks to complete beforehand and arranging who was in charge of doing them. With help of the Trello app, we could organise this easily and keep track of what was the next thing to do.

One of the objectives that we set for ourselves and haven't yet achieved is having all of the members of the group gain basic knowledge of Arduino coding, since we decided to divide the areas of work so that we could specialise in our particular task and, hence, be more time efficient.

Prospective projects

As we developed the idea for our project and the project itself, we started to think of how we could look for alternative ways of emitting different sounds with our bodily functions. Different variables that we think could be interesting to explore are, as suggested by our mentors, blood oxygen levels and body temperature, since we think these are interesting ways of expanding our project exploring new ideas in a similar study area.

Because of the fact that detecting changes in blood oxygen levels would mean having to use invasive Electromyography, since measurements of internal values (with tools such as a needle) would be in place, we would start with exploring with the detection of changes of body temperature.

If you want more visual insight to our project, check out our video report, where the process is filmed, and the final project and its functionality is shown.