Final Report

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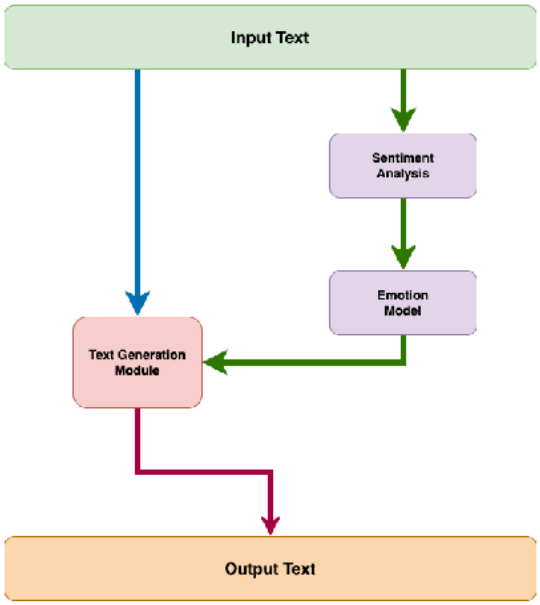
About Research in My University

My research in my university is about trying to build an extra module to make a chat bot based on LLM (Large Language Model) to have its own emotion.

- Motivation

For the reason why I want to study this topic is because I have an idea to build a human-like general A.I. So first I started to think what factors make us a human, I think one of the factors is emotion. Emotions provide an extra way to pass information which rich our expression. And also emotions effect our body and spirit in both explicit and implicit way. Most of advanced A.I models like LLM today don't deal with the emotion while processing text data. I think that adding emotion information can help A.I model act more like human.

- Model Structure



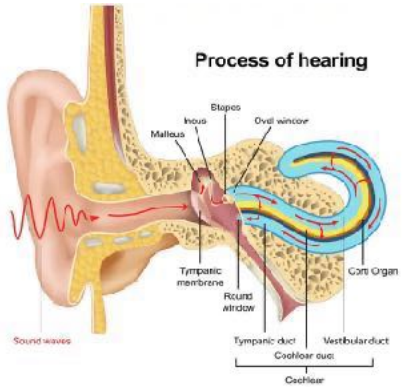
The figure above simply shows the structure of the model I want to make. It mainly consists of two modules, text generation module (left, red), emotion module (right, purple).

In text generation module, I choose to use advanced LLM. At first I want to build my own text generation model but with the limited time, resource and knowledge. And also I want to focus on emotion module. I choose to take advantage of LLM's prompt to help me put more effort on emotion module.

And in emotion module, first I also take advantage of LLM to do sentiment analysis to recognize emotion in input text. Then I use recognized emotion as input for the most important part in my model emotion model. Emotion model is a energy based model mimicking how human react to emotion. It tries to figure out what is the most appropriate emotion which can comfort emotion state of model. I believe this structure can make model more like human.

About Auditory

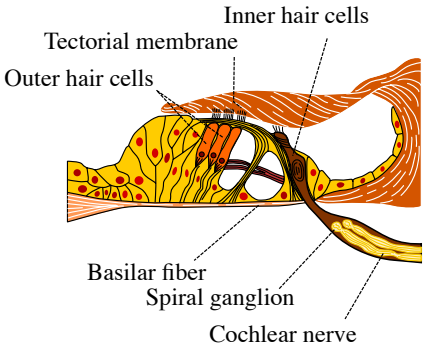
- Working Mechanism



Human's sensory organ of auditory is ear. Everyone all has two ears on both left and right side of head. Ear consists of 3 parts, outer ear, middle ear, and inner ear.

Outer ear consists of auricle and ear canal. Auricle is just what we mean ear in our daily life. When sound wave reaches outer ear, auricle works like a receptor of radio telescope, it collects sound wave and also amplifies the sound to some degree. Then the sound wave will go through the ear canal, finally reaches middle ear.

The middle ear works as a conductor and an amplifier. When sound wave reaches middle, the first thing it will face is tympanic membrane. Tympanic membrane collects sound wave and pass to a series of small bone, ossicles. Ossicles consists of three bones which is malleus, incus, and stapes from tympanic membrane side to inner ear side respectively. These three bones works as sound amplifier to adjust the wave energy passing to inner ear.

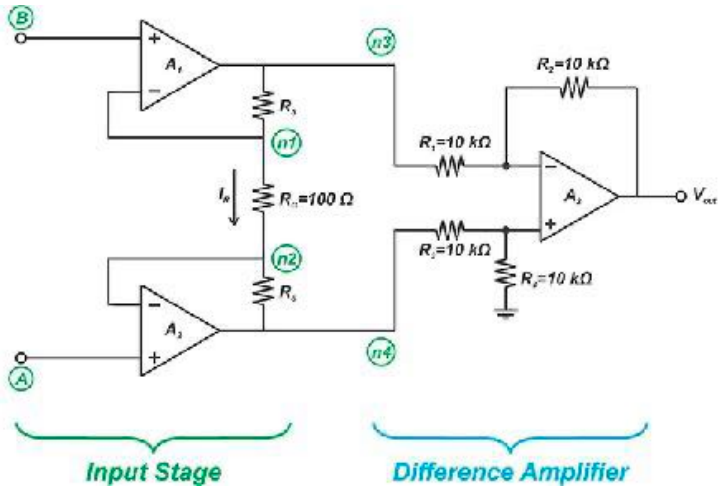


And finally inner is the most important part of auditory. The sound vibration is converted to electric signal in this part. The last bone of ossicles, stapes connect to a snail like, structure called cochlea. Cochlea has three different chamber filled with lymph. Each chamber is separated by membrane. On one membrane there are actual sound receptors called organ of corti. On organ of corti are some special cells having hair structure so called hair cells. Hair cells line up on the membrane. Each line of hair cells will resonate to different frequency sound. Then the organ of corti will convert the signal from hair cells to correspond electric signal and passes to cochlear nerve connecting to it.

• Artificial Alternative

For some deft people, they will choose to have cochlear implant to recover their auditory to some degree. Cochlear implant replaces the function of inner ear in auditory. It consists of a microphone, an audio processor, and a signal transmitter placed in their cochlea The sound wave catches by microphone will be convert to correspond electric stimulus by processor. And signal transmitter will stimulate the cochlear nerve, send audio signal directly to one's brain.

How Does Instrumentation Amplifier Work?



The negative feedback along with the high gain of the op amps will force both the inverting and non-inverting inputs of A_1 and A_2 to have the same voltage. Hence, we have

$v_{n1} = v_B$ and $v_{n2} = v_A$.

The current through R_G, and hence through R_5 and R_6, will be

$$I_R = \frac{v_{n1} - v_{n2}}{R_G} = \frac{v_B - v_A}{R_G}.$$

Therefore, with $R_5 = R_6$, the voltage difference at the input of the difference amplifier will be

$$v_{n3} - v_{n4} = (R_5 + R_G + R_6) \times I_R = (2R_5 + R_G) \times \frac{v_B - v_A}{R_G}$$

which simplifies to

$$v_{n3} - v_{n4} = (\frac{2R_5}{R_G} + 1) \times (v_B - v_A).$$

We know that the gain of the difference amplifier is

$$v_{out} = \frac{R_2}{R_1}(v_{n4} - v_{n3}).$$

Hence, we have

$$v_{out} = \frac{R_2}{R_1}(\frac{2R_5}{R_G} + 1) \times (v_A - v_B).$$

Therefore, the total differential-mode gain of the circuit is

$$A_d = \frac{R_2}{R_1}(\frac{2R_5}{R_G} + 1).$$

Research Plan Proposal

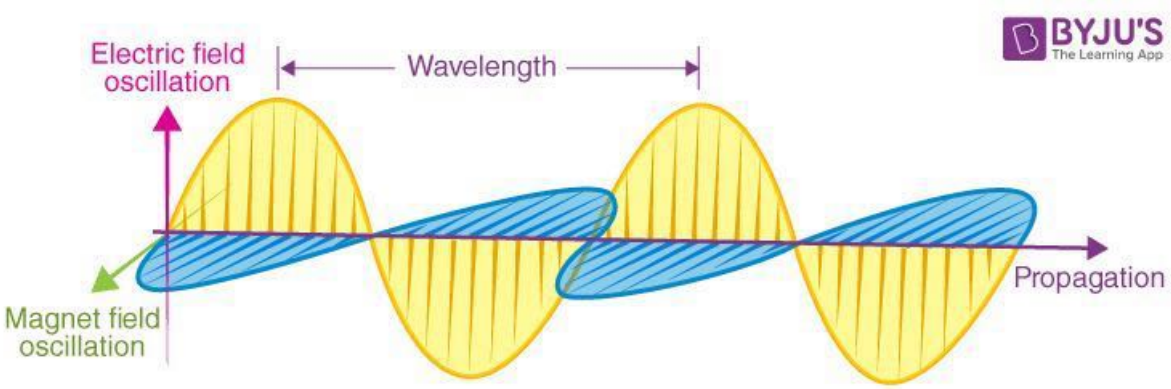
- Background

In these days, there are two main ways to catch the brain activity. One is invasive methods like implant, the other is non-invasive methods like EEG. These two methods have one thing in common, they can only passively record the brain activity and have some precision problem in either space or time. If we can have a new method which can fix all the mentioned problem and can interact with brain. I think that the development of BCI (Brain Computer Interface) and neuroscience will advance rapidly.

- Objective
  - Provide a new non-invasive way to inspect, interact with brain or neuron.
  - Develop a feasible daily use BCI based on the new method.

- Method and Equipments

All the non-invasive method that we use to record brain activity nowadays has some defects. You need to put gel and electrode on your head which makes you feel bad when using EEG. People cannot bring a fMRI with them because it's definitely larger than their car. If we can have a headphone-size or even smaller device that provides higher time and spatial precision and can interact with neuron to replace those big things, it'll be a real daily-use BCI and also largely advance neuroscience.



We all know neural signal is electric current in our brain. Electric current will generate electromagnetic field. The radiation is also an electromagnetic field changing in time. Electromagnetic field will effect each other, so I think we can use radiation to control neuron. Microwave is one kind of radiation can pass through our skull. So if we can build a small microwave device and use beamforming tech to interact with neuron cells.