Invention Convention Questions

1. What problem are you trying to solve? The more specific you are in describing the problem, the better your solution will be. How did you come up with the problem?

- Developing countries lacking trained medical professionals makes it difficult for patients with asthmatic conditions travel to the doctor. Also, people with asthma don't necessarily know if they are suffering from some of the symptoms such as minor wheezing, pneumonia, or chest tightness.
- Because I am very experienced with recognizing the symptoms of my asthma, I am able to identify when I start wheezing. My doctor told me that others aren't able to notice these symptoms easily and often visit the doctor when the symptoms worsen and are harder to treat.

2. What is the result you are trying to achieve? The more specific you are in describing the result you want, the better your solution will be.

- I hope to create an affordable medical device that can help patients with asthma to identify their symptoms such as wheezing before the symptoms worsen to the point where they are hard to treat.

3. What are some possible solutions? Which one did you choose to pursue? How did you decide which solution to try? The more specific you are in describing the solution you will create, the better your invention will be. How did you come up with the solution?

- Some possible solutions include owning a stethoscope and listening to your own lungs
    - This is slightly inconvenient and isn't very accurate to the untrained ear
- Another solution is having an AI listen to your lungs through a stethoscope
    - The AI will be more accurate than an untrained ear and the device will be able to track your conditions over time without user input. The only inconvenience is plugging the device into the computer to view results over time. The device will have a stethoscope attached to your chest and the raspberry pi boxed in your pocket. Over time I will try to find more user convenient solutions.
- I came up with this solution because I read about AI software that can identify the differences between audio clips. Because I can create a neural network that can do this, the AI will be able to identify the symptoms. For people with diabetes, a tracker is kept on the person's body to monitor the patient's symptoms. I can also use this idea for my device.

4. Has this solution been done before? If it exists, how is your approach different and better? What research did you do to see if this invention had been done before? Who did you talk to? Where did you look? What website did you search? You should show 4 pieces of evidence of different types of research – talking with experts, searching the internet, interviewing friends and family as to how useful this would be, etc.

Where I looked to see if my idea is new:

1. Diabetes monitors are able to track a person's blood sugar level at any time and is able to give alerts when irregularities occur. My friend who has this device for his diabetes and he explained to me how the device works from the perspective of the user. I can use a user's perspective to make my device more user friendly.

1. I talked to my pediatrician about what doctors listen to when listening for symptoms of asthma. She told me that different sounds can be heard at different parts of the lung and that doctors check each area of the lung to determine where the symptoms occur.

1. I looked at webmd to research the level of severity asthma based off of the sounds of the symptoms. From this research, I have concluded that

the amplitude of the sound waves, or the average amplitude, can determine the symptom severity or its level of progression.

1. From my own experience, I sometimes forget to take my medication on time, which delays my medication cycle. I can try to add a feature to the device that will remind the user to take medication and will keep track of the medication cycle in order to make sure that time gaps between medications stay constant.

Document any similar inventions you found, describing how yours will be different:

- A similar invention that I found was a diabetes blood sugar tracker that tracks the user's blood sugar level over time. The device also alerts the user if there are irregularities in the blood sugar level. My device will be different because it will track the symptoms of asthma rather than diabetes. My device will alert irregularities, but it will also identify the types of irregularities, such as wheezing, pneumonia, or chest tightness.

5. Draw a model (a sketch or drawing) of the invention you are thinking about building. Label all the important parts and features. Explain how the invention will work. If you need more space, use another blank page.

- The model is shown at the bottom of the page with the pseudo-code designs

6. What problems or issues might you encounter with this design? Is this design compatible with the principle of sustainability? Who did you talk to about this design (another student, parent, teacher, etc.)? What were their comments about your design?

- I will need to find many audio samples in order for the neural network to be able to identify the aspects of the specific lung irregularity
- There will need to be user input as the user must apply the stethoscope to their chest

7. How can you fix those problems or address those issues?

- I can also try to attach a tape that can be applied to your body that will secure the stethoscope on the user's chest.
- I can also try to get samples from people with pre-identified irregularities for the neural network to learn from.

8. Repeat steps 5 to 7 until you have a design that you think will work. You may have to make multiple copies of a blank page until you have a good design.

- The pseudo-code designs are located at the bottom of the page with the model sketch

9. What parts, materials, and tools will you need to make the invention and how much will they cost?

- The Raspberry Pi will cost $50
- The Sound Card and microphone are $20
- The stethoscope is $15
- The software, Python is free to download and use
- The total cost is $85

10. Where will you get those parts and materials?

- My dad already owns a raspberry pi and a sound card
- I can download Python online
- I can purchase a stethoscope off of amazon

11. What additional skills or abilities will you need to make the invention?

- I will need to learn how to create a neural network in python and how to create a display that can analyze an audio sample

12. Who can help you build the invention?

- My dad is very experienced with python and can point me in the right direction to create a neural network and how to make the network learn about the difference between regular and irregular airways.

Design Constraints:

- The detector will contain a stethoscope like device attached to an audio receiver

- I will use a raspberry pi, a microphone, a sound card, and a stethoscope

- Ideally the device should within 5inx5inx2in

I will use the raspberry pi software and a raspberry pi sound card

- I will assemble the project by inserting the microphone within the stethoscope, connecting the microphone to the sound card and connecting the sound card to the raspberry pi

- I hope to create an affordable medical device that can help patients in poor areas of the world to identify the severity of asthma symptoms in order to determine if they really need to go to a doctor.

- The device will be for asthmatic people in developing countries

- The device must be able to test the severity of asthmatic symptoms

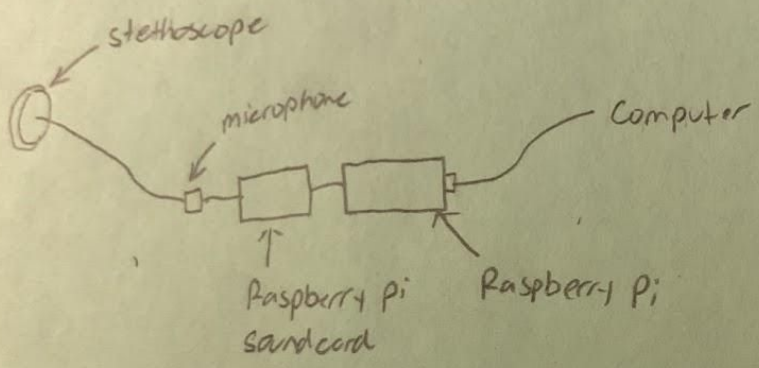
- The project will cost around $100 to make, but I can make innovations in order to make it cheaper

- I would sell it for the same cost used to make it since global health has more value than money

- I do not plan to make profit or losses

Model Sketch and Description

Model



The stethoscope will be attached to the user's chest and will send vibrations to the microphone, which will translate the vibrations into audio samples. The sand card is able to take this audio sample and send it to the raspberry pi where the program can analyze the sample. The computer is for display of symptom outputs.

Design 1

Design 1 (graph correlation)

1.) Input Audio sample

2.) Calculate Linear regression values for each possible curve

3.) Determine best linear regression value

4.) Creak equation of the curve

5.) Analyze amplitude, period ...etc

6.) compare graph aspects to aspects of previous audio samples

7.) Determine best match for the graph comparison

8.) Provide Output Asthma symptom (Print symptom)

Design 2

Design 2 (process of elimination)

1.) Input Audio Sample

2.) Identify areas of extrema pitch or highest amplitudes

3.) a.) Calculate the frequency of highest amplitudes iff number of "crackles" is relatively high

b.) Narrow options down to pneumonia-like symptoms

c.) compare audio sample to previous, known, pneumonia samples

d.) Provide output for pneumonia (print pneumonia)

4.) If relatively high amount of areas with high/low pitch

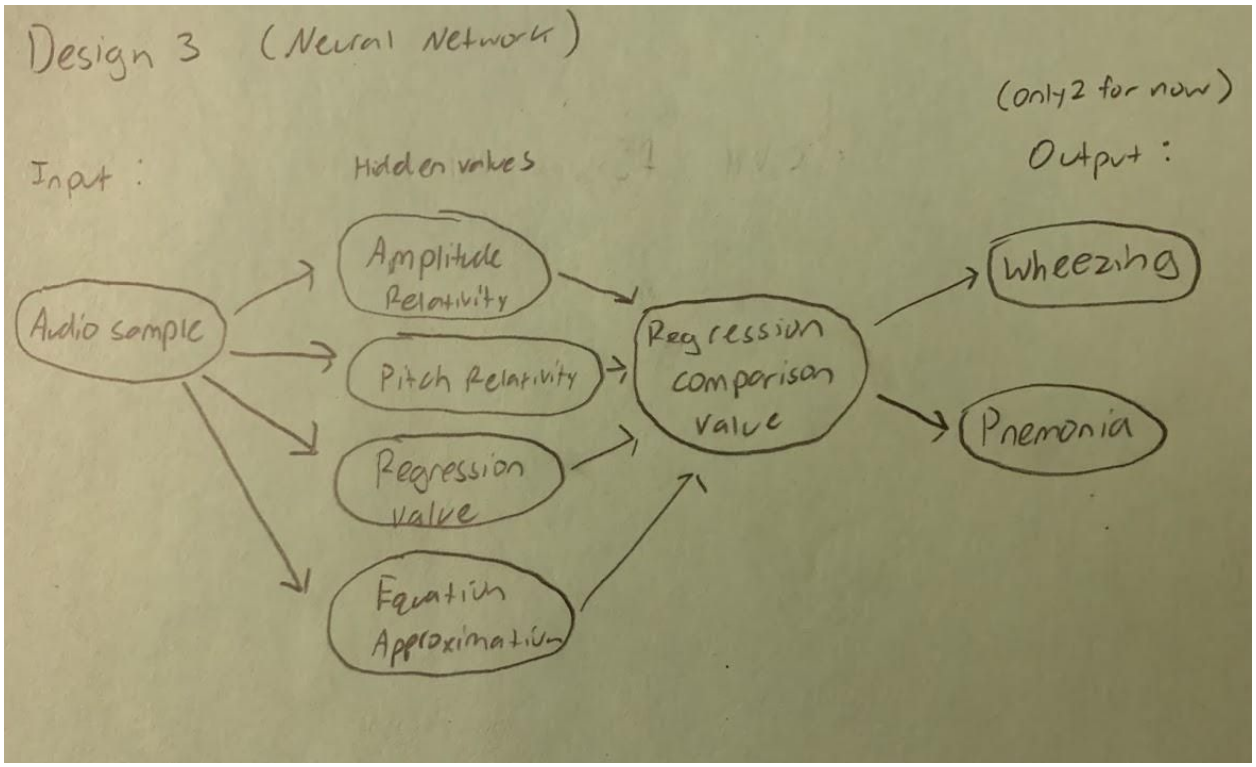
a.) Eliminate options to wheezing

b.) compare sample to known wheezing samples

c.) Calculate closest match to correct wheezing symptom

d.) provide output for wheezing (print wheezing)

Design 3



Decision Matrix

- Values are scaled from 1- 10,
  - 10 is the best and 1 is the worst

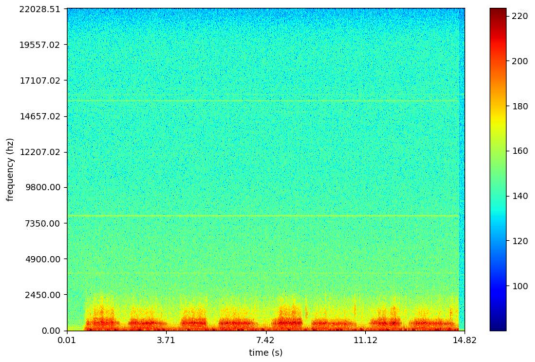
	Ease of Pseudocode Implementation	Time to Create	Use of Prior Knowledge	Total
Idea 1	**6**	**5**	**6**	**17**
Idea 2	**4**	**7**	**3**	**14**
Idea 3	**9**	**8**	**7**	**24**

Research

Spectrogram

A 3-dimensional visual image conversion of an Audio Sample

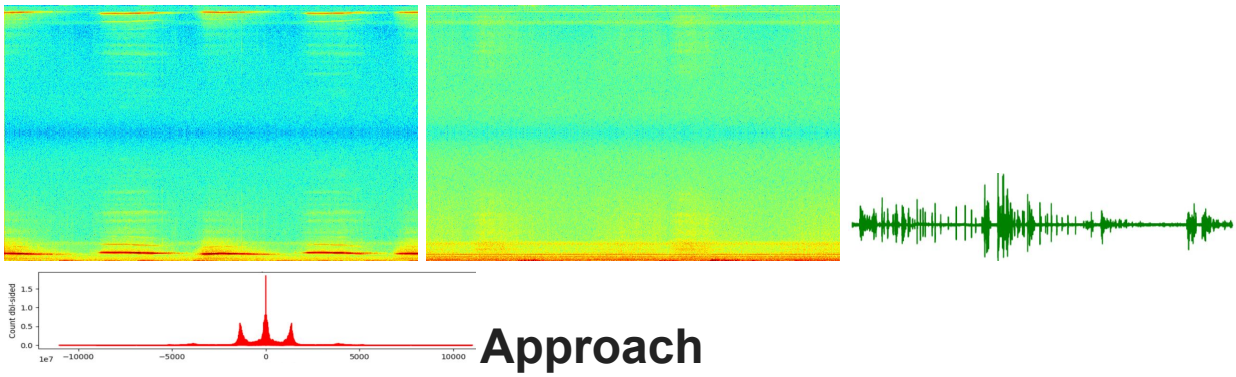
a. X axis represents Time,
b. Y axis represents Frequency;
c. Z axis representing the Amplitude of a particular frequency at a particular time shown by the Color of each point in the image



Created by converting Audio sample recorded as Amplitude (sound pressure) over Time to Frequency over Time using *Fourier Transform*

Wheezing Spectrogram
Normal/Healthy Lung Spectrogram
Audio Amplitude over Time

Fourier Transform



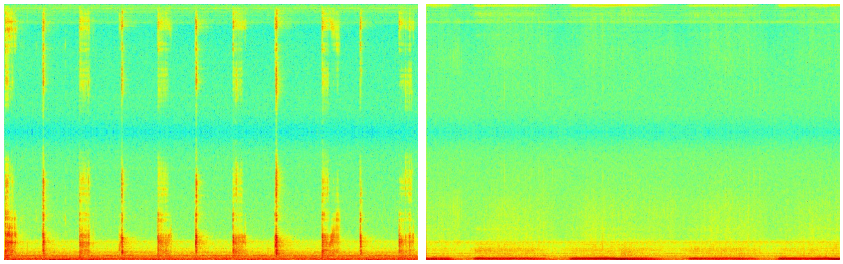
Approach

Lung Sound Spectrogram visually represents a distinct frequency patterns produced by breath sounds for different lung ailments.

A neural network (just like the human brain) can be trained to identify the different visual patterns of the lung sounds and help identify the underlying ailment

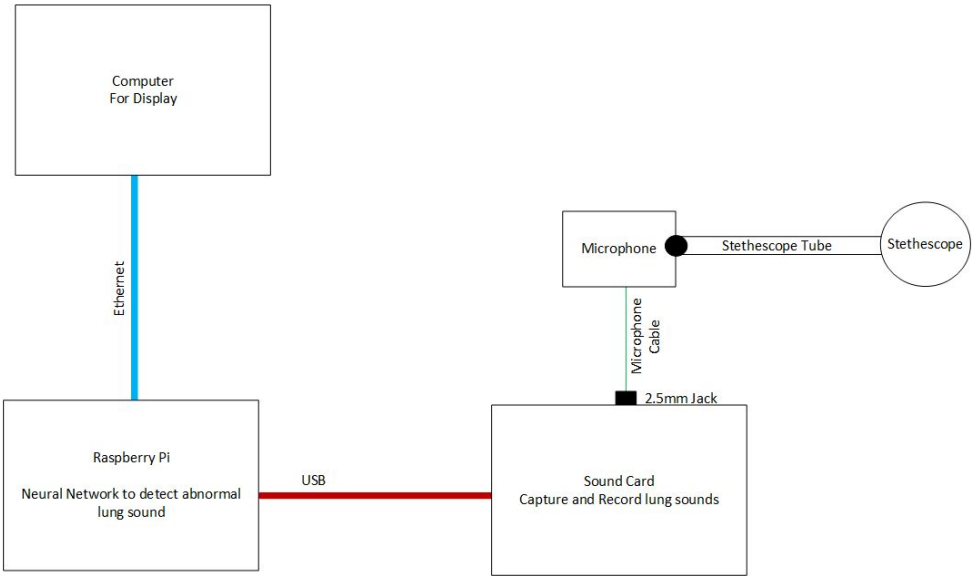
Pneumonia Spectrogram

COPD Spectrogram



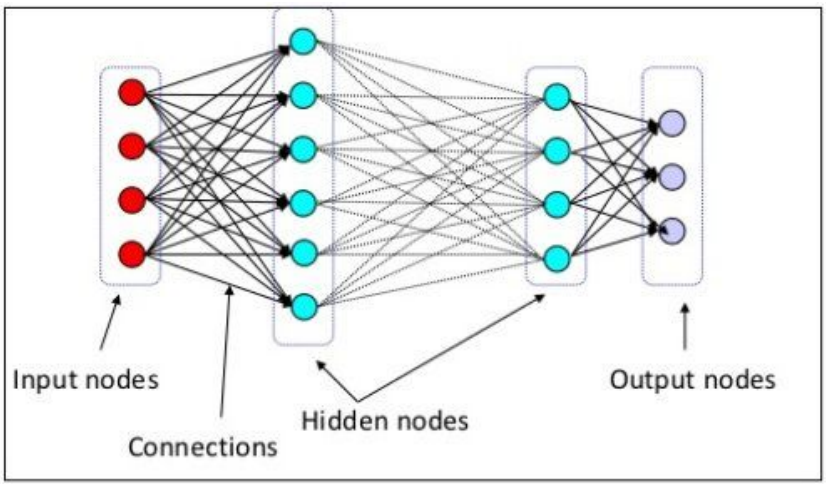
System

1. Stethoscope with rubber tubing hear lung sounds
2. Microphone to convert lung sounds to electrical signals
3. Sound Card to digitize, capture lung sounds
4. Raspberry Pi - Small processing device to record, train neural networks and analyze digital lung sounds
5. Computer for graphical display



Deep Learning Neural Network

1. Using mathematical neural networks to imitate how human brain neurons communicate with each other to recognize patterns
2. Mathematical neural networks are a collection of nodes or functions (to mimic brain neurons or nerve cells) linked to each other by connections of different strengths or weights (to mimic synapse)
3. Three types of nodes or functions -
    a. Input layer for sensing incoming information
    b. Hidden layer nodes connected to each other by different weights
    c. Output layer for predicting results



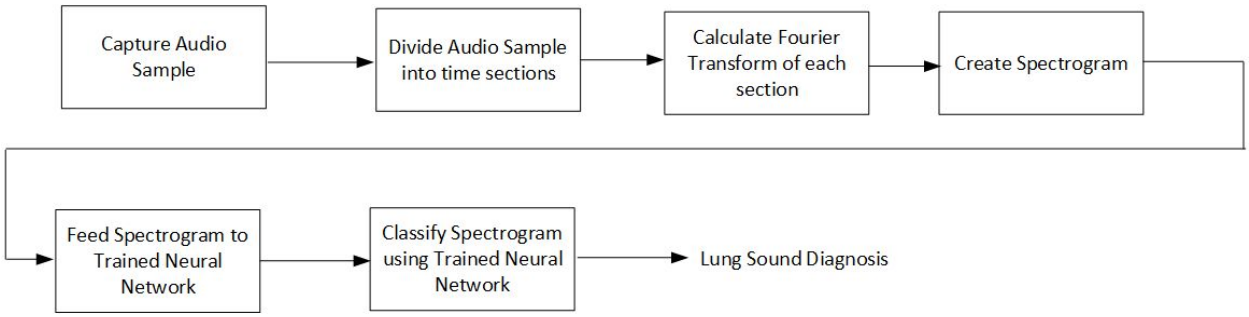
Testing:
Test 1

Prediction Inputs	COPD	Crackle	Normal	Wheeze
COPD	8	0	0	0
Crackle	5	5	0	0
Normal	2	0	8	0
Wheeze	5	0	0	5

Test 2

Prediction Inputs	COPD	Crackle	Normal	Wheeze
COPD	8	0	0	0
Crackle	5	5	0	0
Normal	2	0	8	0
Wheeze	5	0	0	5

Design:


Capture Audio Sample
Divide Audio Sample into time sections
Calculate Fourier Transform of each section
Create Spectrogram
Feed Spectrogram to Trained Neural Network
Classify Spectrogram using Trained Neural Network
Lung Sound Diagnosis