

Background

Figure 1: Vocal fold cross section, open and closed at 3 conditions. normal, unilateral paralysis, and bilateral paralysis. [1] Laryngeal diseases are difficult to diagnosis non-invasely.

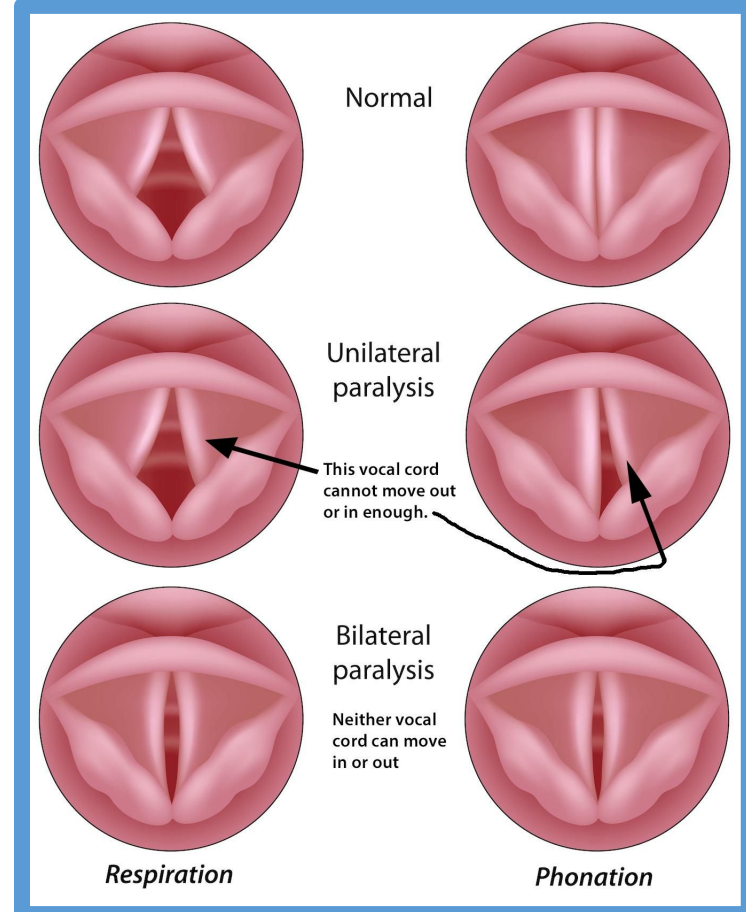
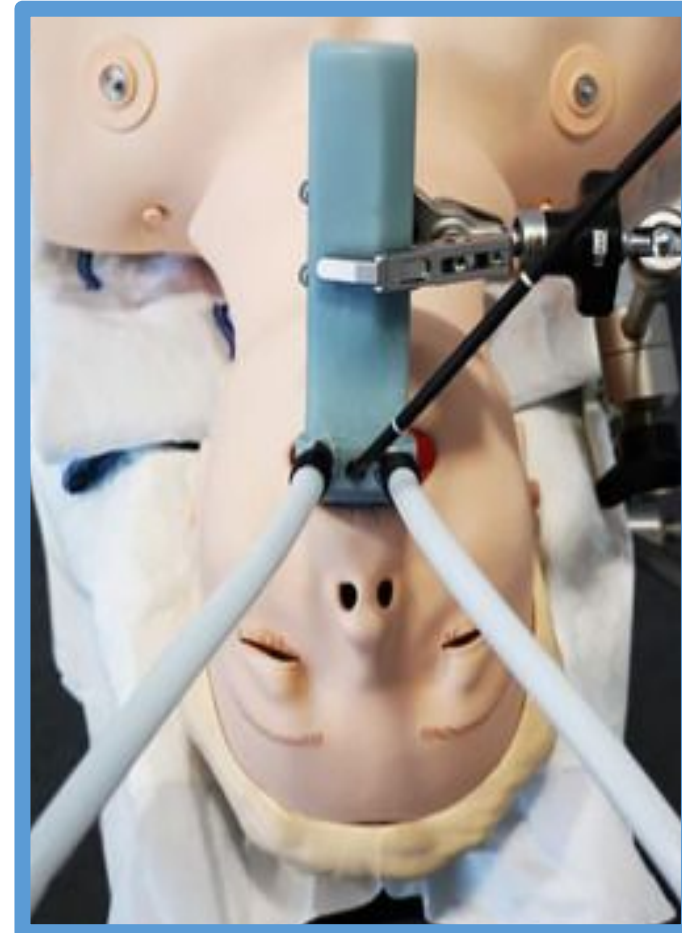


Figure 2: An experimental setup of a laryngoscope, used to visualize the interior of the larynx in a person. [2] Effective, but highly invasive.



Objectives

Problem Statement:

There is a need for an instrument that is non-invasive, low-cost and can and reliably recognize various phases in laryngeal aperture during speech.

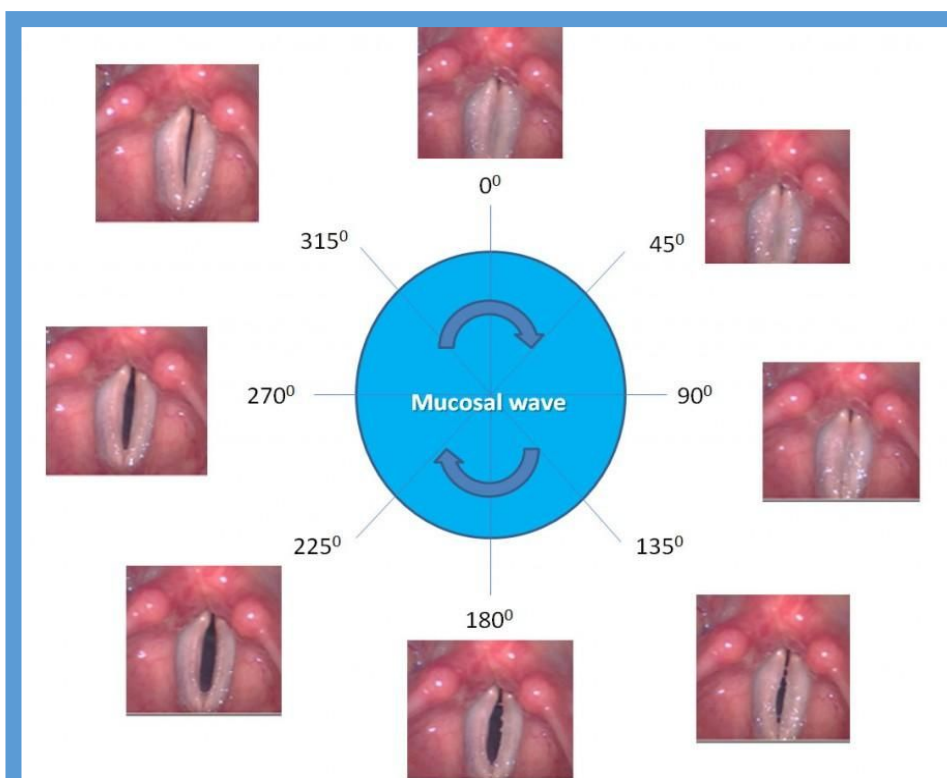


Figure 3: Mucosal phases of the vocal folds. [3]

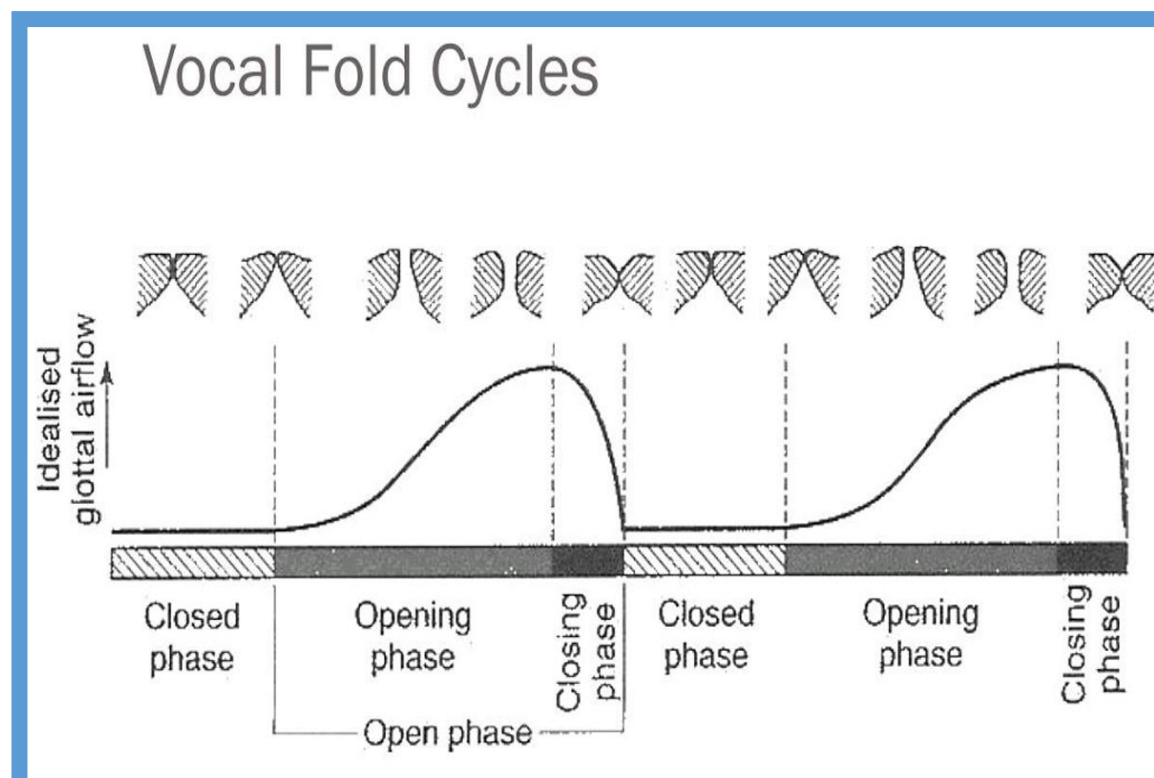


Figure 4: Glottogram waveform, representative of the anticipated signal in our device. [4]

Objectives:

1. Identify glottal opening phases while voicing.
2. Identify glottal closing phases while voicing.
3. Design of a versatile device that works on most individuals regardless of physiological differences.

Device Design

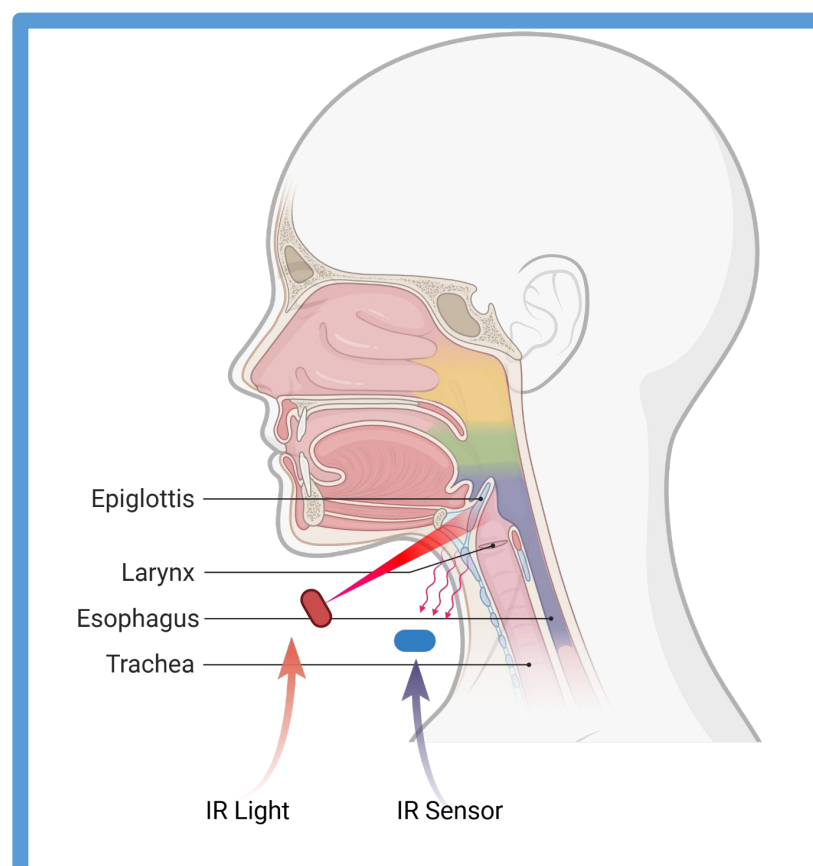


Figure 5: Visual representation of device concept and setup with an IR LED and photodiode.



Figure 6: Old concept of a 3D printed holding device made of TPU to hold the photodiode and LED in the ideal position.

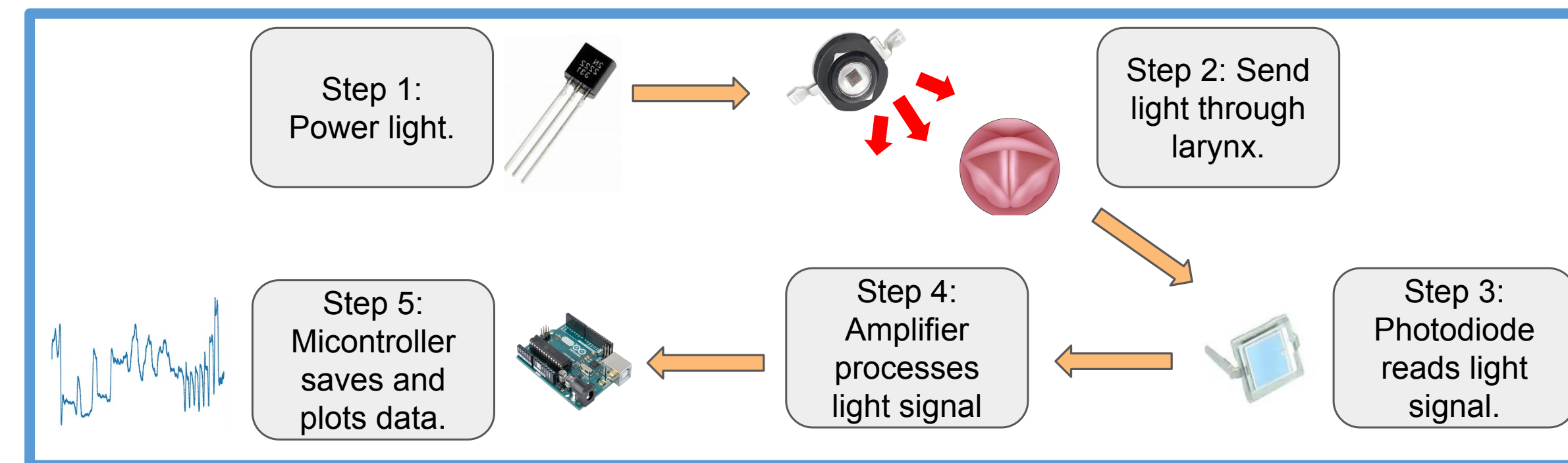


Figure 7: Block diagram workflow of the design setup, showing the purpose of all major components in the system. This summarizes our exact electrical design shown in two circuits below, one for signal amplification/preprocessing and one to power the IR LED lights. [1]

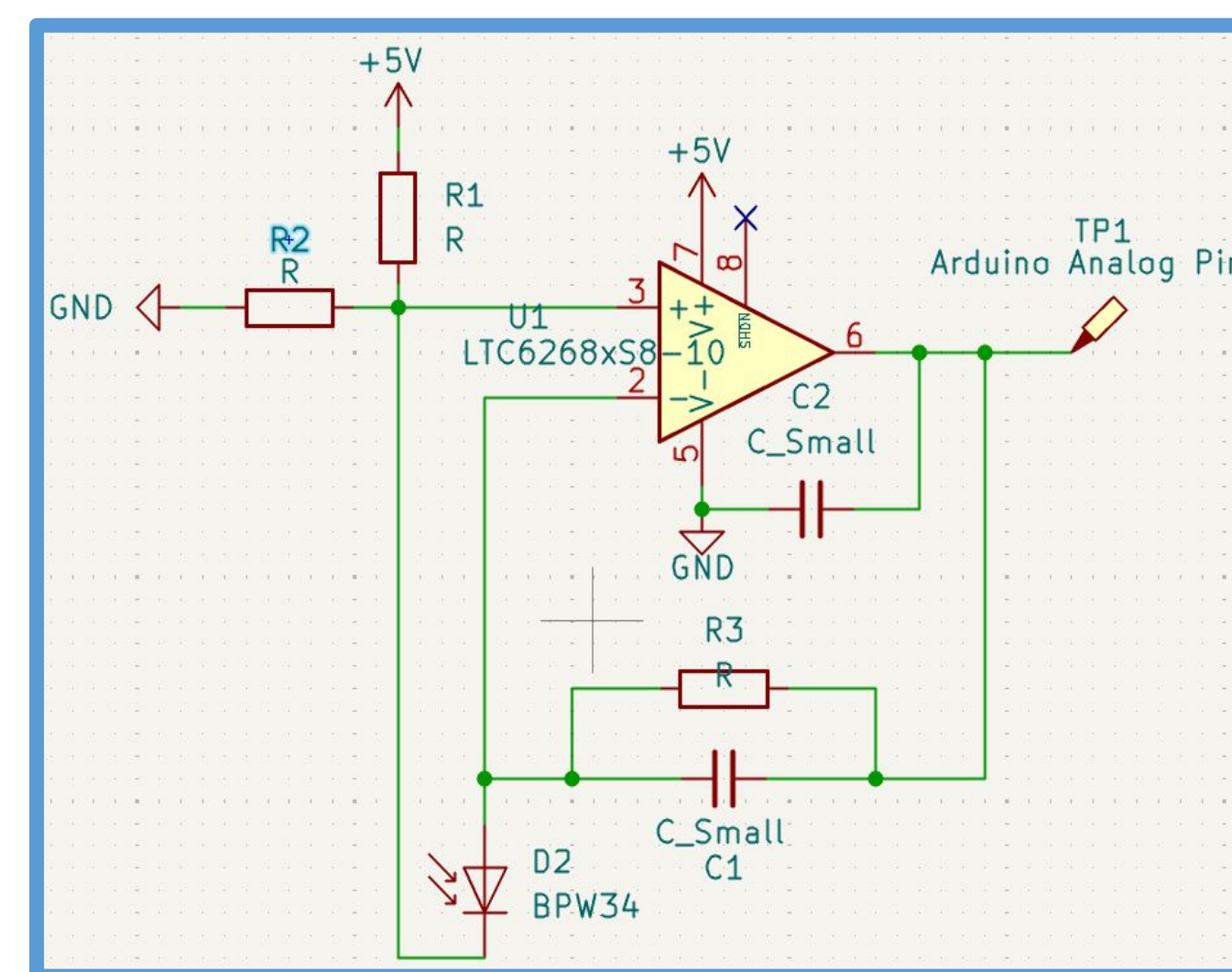


Figure 8: LTC6268 Transimpedance Amplifier circuit connected to a BPW 34 Photodiode sensor. This is amplification/preprocessing circuit.

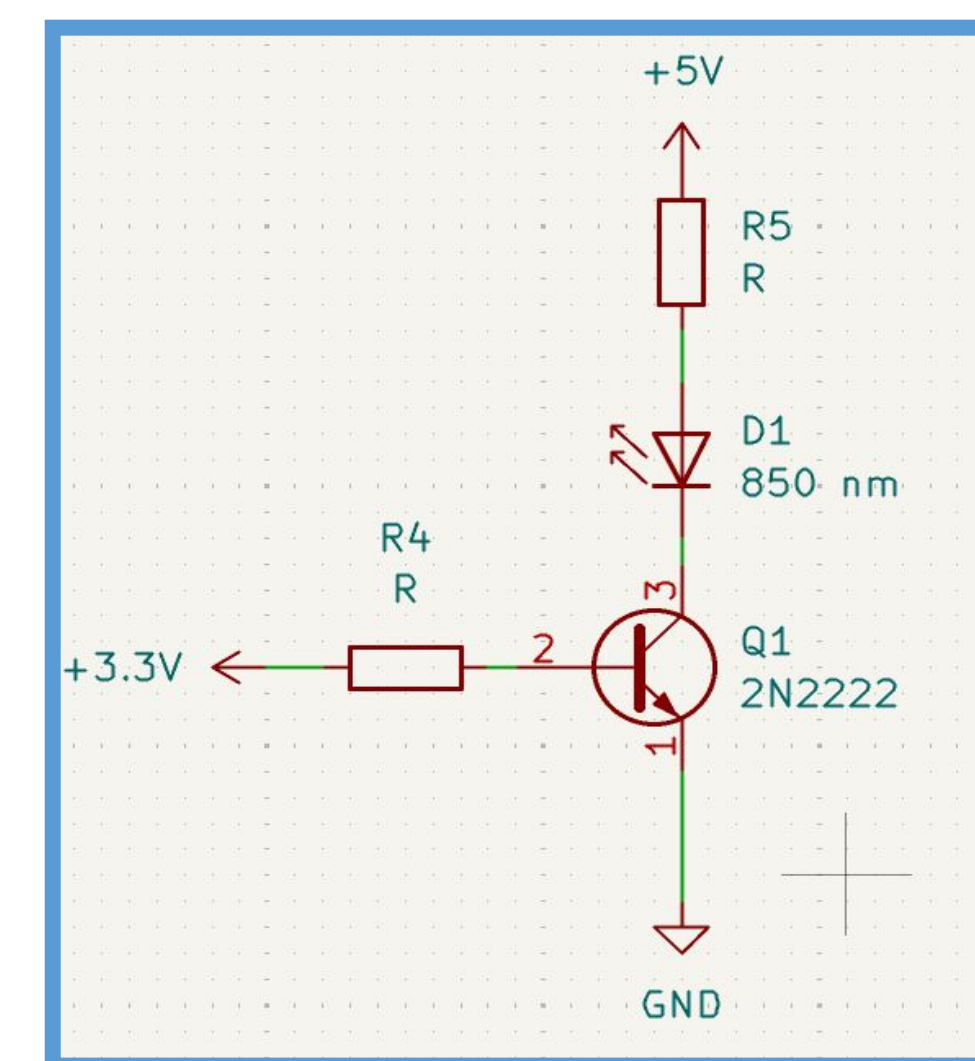


Figure 9: 850 nm LED power circuit, which uses a 2N2222 transistor to supply constant current through the collector pin to power the lights.

Results

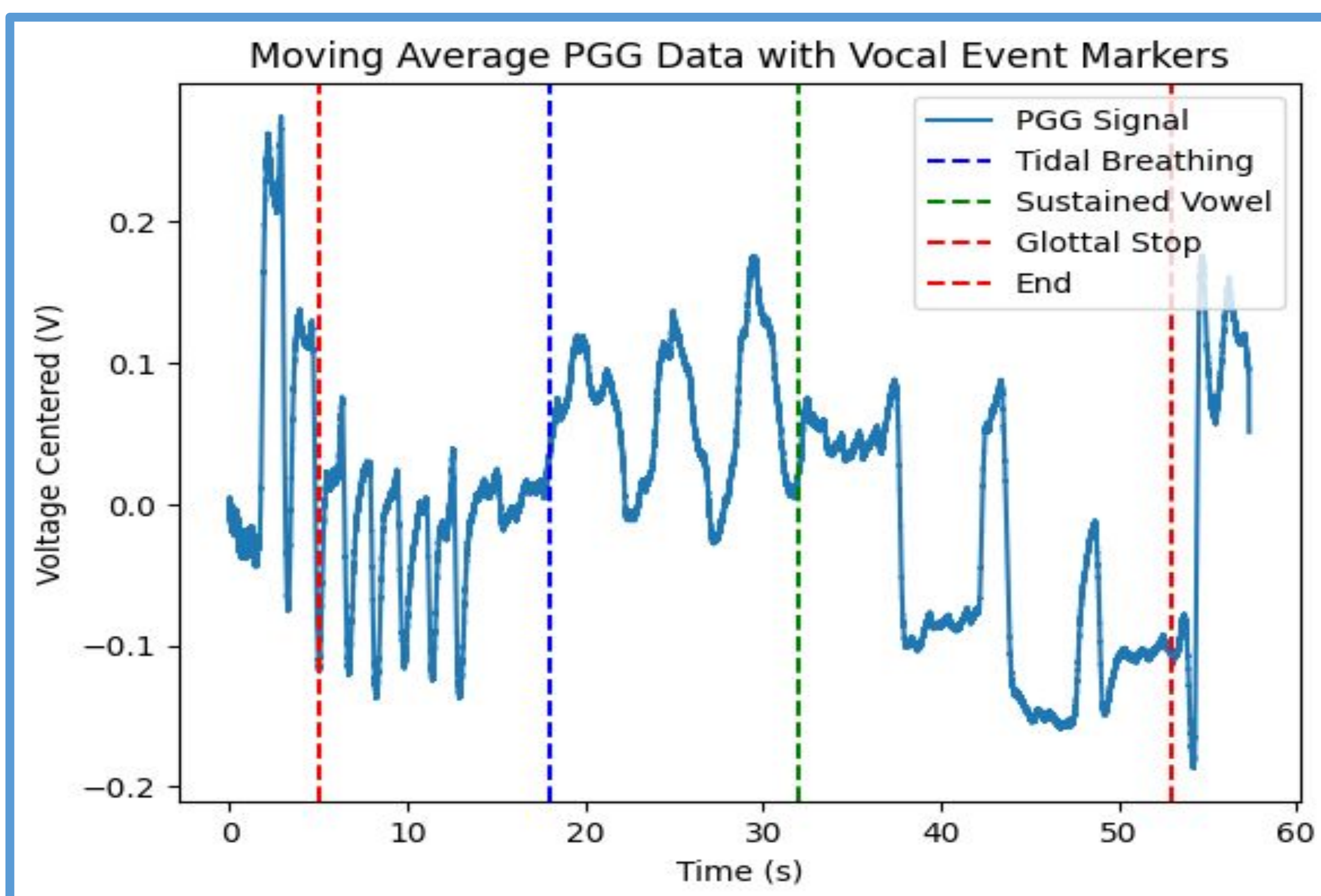


Figure 10: Photoelectroglottography data measured over a 1 minute time frame from voicing. Data was sampled directly from the Arduino analog A0 pin at 500 Hz and the serial monitor values were saved as a .csv file, where it was visualized and analyzed in a Python Jupyter notebook.

Conclusion and Future Directions

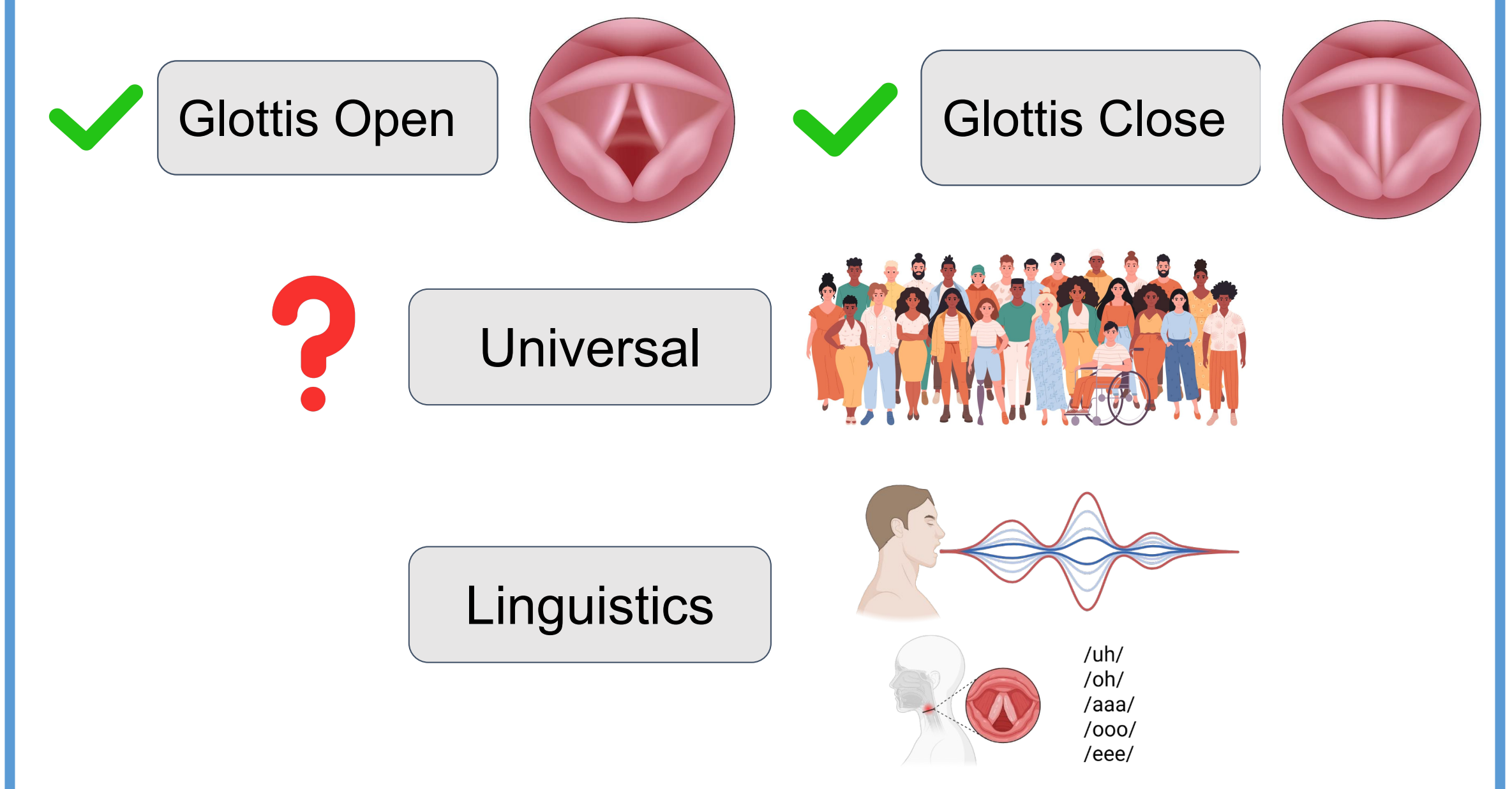


Figure 11: Conclusion and reflection of our project, whether we met our objectives, and future goals.[1]

Immediate Directions:

1. Test with more participants and patients, ensure that efficacy is consistent across demographics, adjust design if not.
2. Record data along with acoustics.
3. Advance breadboard prototype to printable circuit board (PCB).
4. Adapt the design of a holding device so it:
 - a. Fits the necessary components.
 - b. Shields the setup from ambient light.
 - c. Allows for adaptable placement depending on the user needs.
5. Adjust sampling rate, microcontroller used if necessary.

Acknowledgements

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References

- [1] Lansford, J. (n.d.). *Laryngeal nerve dysfunction*. <https://doctorlansford.com/ccv-laryngeal-nerve-dysfunction>
- [2] Kienle LL, Schild LR, Böhm F, Grässlin R, Greve J, Hoffmann TK, Schuler PJ. A novel 3D-printed laryngoscope with integrated working channels for laryngeal surgery. *Front Surg*. 2023 Mar 14;10:906151. doi: 10.3389/fsurg.2023.906151. PMID: 36998594; PMCID: PMC10043209.
- [3] CVT Research. (n.d.). *Understanding laryngeal stroboscopy*. <https://cvtresearch.com/understanding-laryngeal-stroboscopy/>
- [4] Stanford University. *CS224S / Linguistics 285 Spoken Language Processing lecture slides*.