Non-Contact Respiration Monitoring Through Light Wave Sensing

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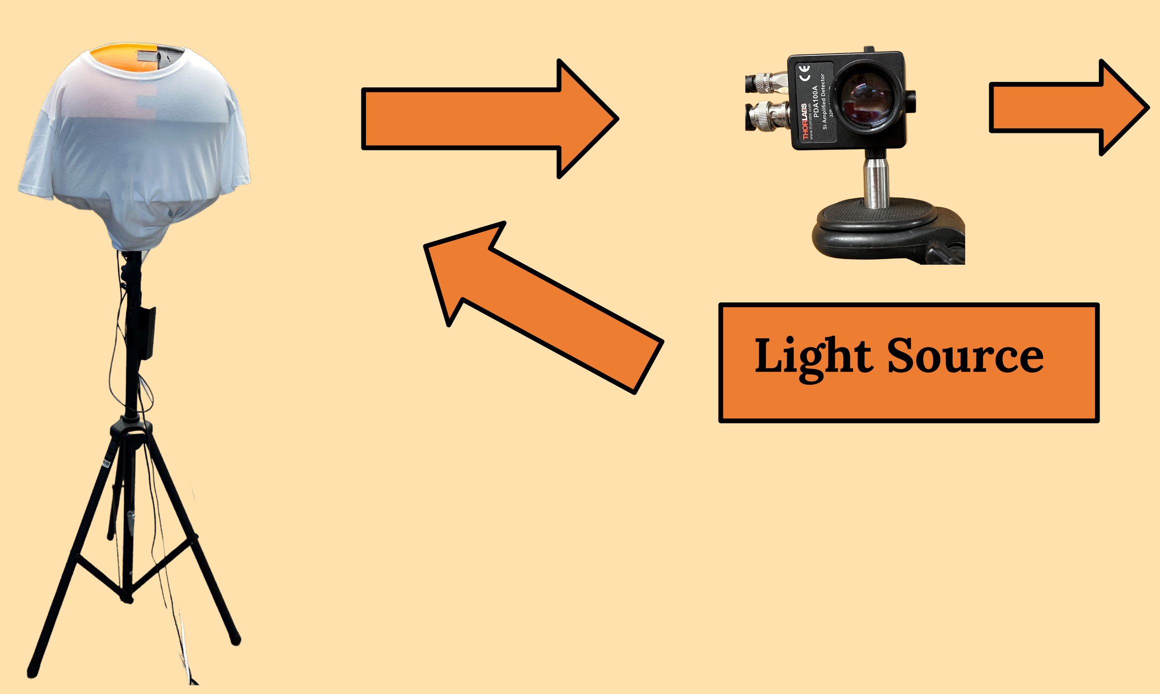
Introduction

The standard method for obtaining a person's breathing pattern is through contact-based sensors, however this comes with several challenges. The primary one is awareness; a person's respiration changes when they are conscious of the ongoing measurement. Another is availability; contact-based respiration sensing is typically only available in a medical facility or through the use of expensive, custom take home tests. Thus, new research has sought methodologies to measure human vitals via non-contact methods, such as cameras, and radio-frequency (RF) or WiFi signals. These methods raise important concerns such as privacy, cost, distance limitations, electromagnetic interference and bodily safety. Our proposed method uses non visible infrared light to measure the movement of a patient's chest.

Methodology

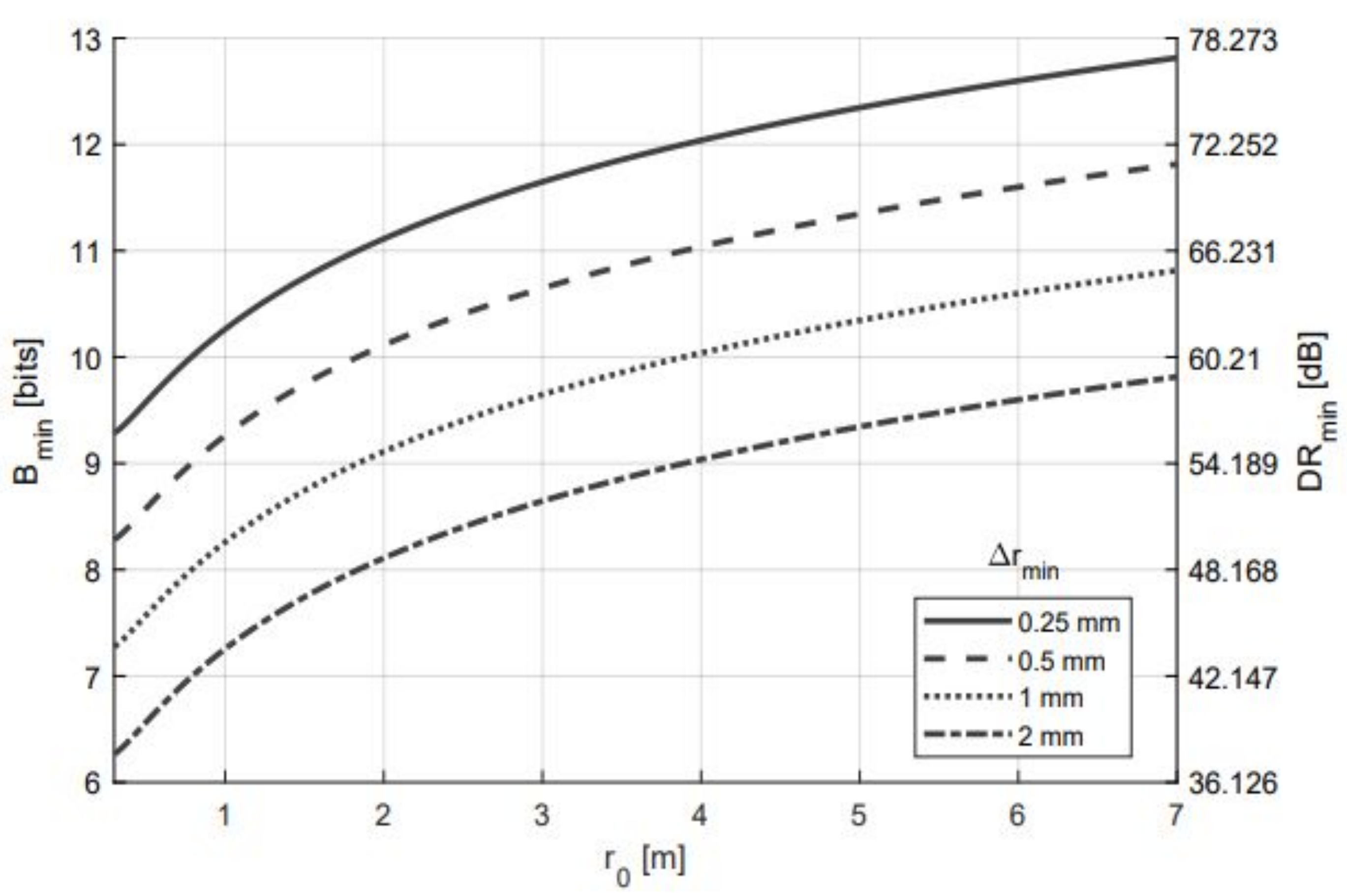
- An infrared light is emitted and modulated to illuminate a breathing phantom (robot) with non-coherent light.
- The reflected signal, which shows the amount of scattered light provided by the source, varies as the robot undergoes a breathing motion. A photodetector then outputs voltage proportional to the amount of scattered light collected. The reflected signal is stored onto a microprocessor.
- In order to reduce the surrounding noise, the photodetector is modulated along with the light source through a Lock-in Amplifier.
- The Lock-in Amplifier accepts all modulated light and rejects anything that is not of equal frequency.
- The recovered signal is sent through MATLAB for signal processing and frequency analysis.



Applications

- Monitoring Sleep Apnea
- Monitoring Epilepsy
- Monitoring vitals for truckers and bus drivers
- Easy at home testing for a variety of respiratory related illnesses
- Detecting and monitoring SIDS

Dynamic Range Minimum

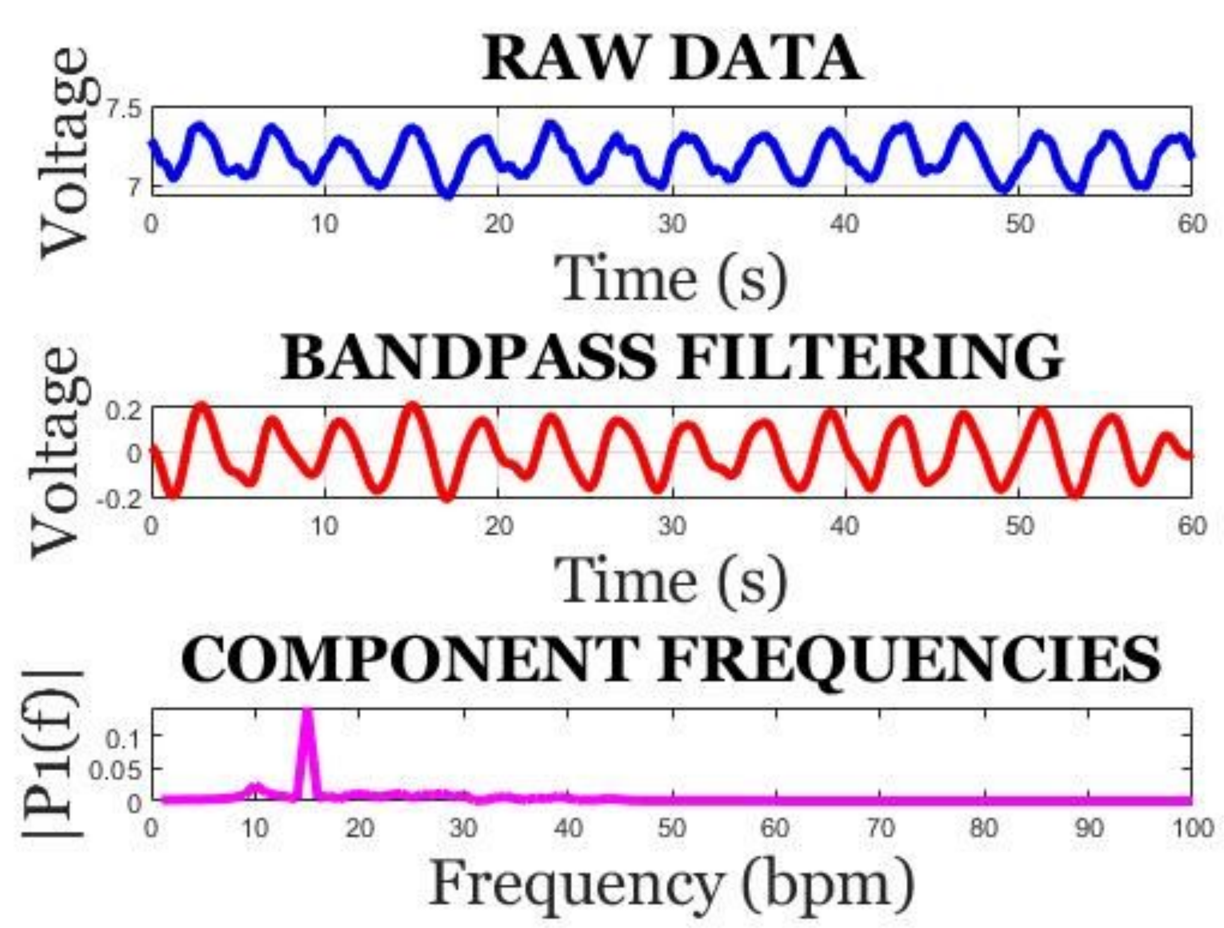


The graph shown displays the minimum movement needed for the signal to be accurate. The dynamic range is limited by the ADC bits and noise (ambient and temperature). Our system is easily capable of producing results for the minimum average depth of breath.

Impact and Benefit

- Low costs
- No privacy concerns.
- No adverse health effects.
- Lower difficulty inserting this system into computer based systems with effective microcontrollers.
- Uses infrared light which is not harmful to the body
- Prevents RF spectrum interference
- Exhibits the limits of light wave sensing

Results and Conclusion



The system has proven to be a reliable method for obtaining a person's respiration. The parameters we were testing for were: BPM, depth of breath, distance, ambient light conditions, and shirt color. The success of the method depends heavily on the light source used. When the system used coherent light the acceptable distance more than doubled. This was regardless of BPM, depth of breath, ambient light condition, and shirt color. When using an LED there is a greater spread in what is captured. This leads to more noise and a shorter allowed distance. Similar to the coherent light, this was regardless of BPM, depth of breath, ambient light condition, and shirt color.

References/Acknowledgments

H. Abuella and S. Ekin, "Non-Contact Vital Signs Monitoring Through Visible Light Sensing," *IEEE Sensors Journal*, vol. 20, no. 7, pp. 3859-3870, April 2019, doi: 10.1109/JSEN.2019.2960194.

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❑ Award number: 2050062, I-Corps: A Low-cost and Noncontact Respiration Monitoring Method for COVID-19 Screening and Prognosis