WiFi Sensing of the Environment

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Introduction to the Problem

- Our generation is advancing towards an extensive use of smart devices
- **Smart Watches/Bands** are already an integral part of our body
- These wearables are our virtual doctors and keep track of health metrics including **Heart Rate, Breathing Rate and Sleep Patterns.**

Problems surrounding smart watches

- **Accurate measurement of health metrics**
- **Discomfortness faced by continuously wearing these devices even during sleep**
- Limited battery life, thus requiring daily charge

Idea

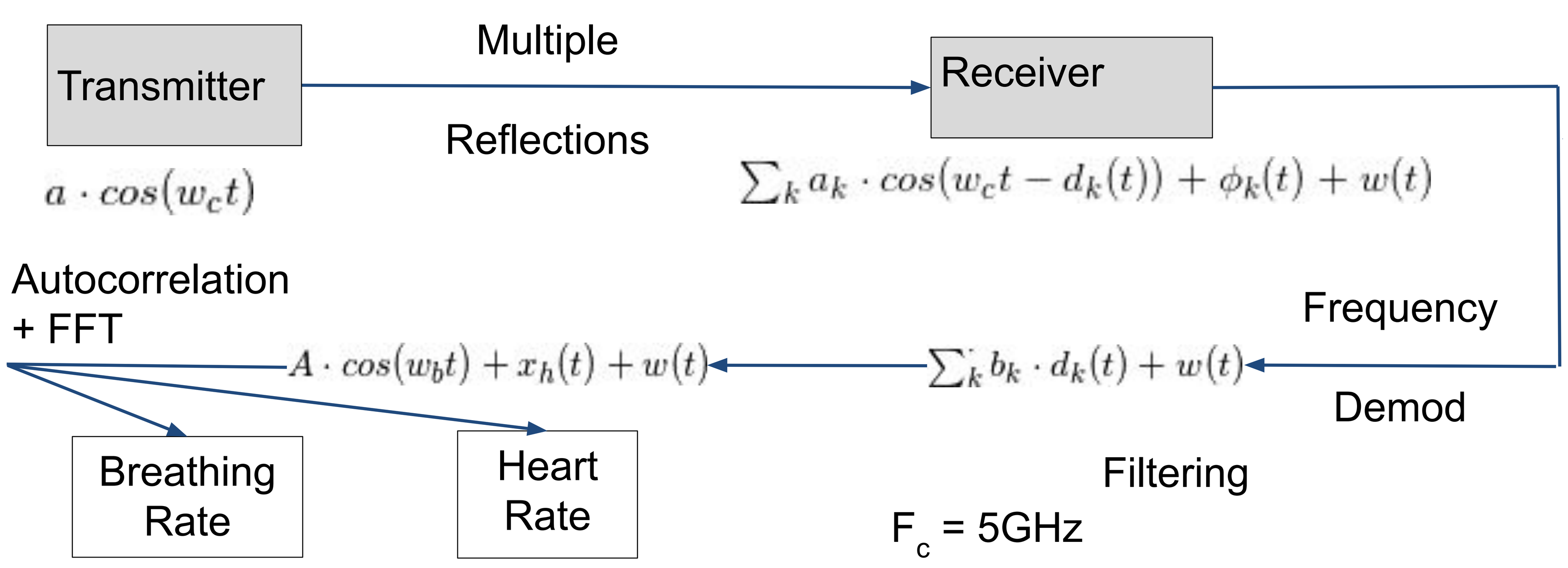
Yes!

We think it is possible to measure the health metrics wirelessly and get accurate results!

Basic Concept

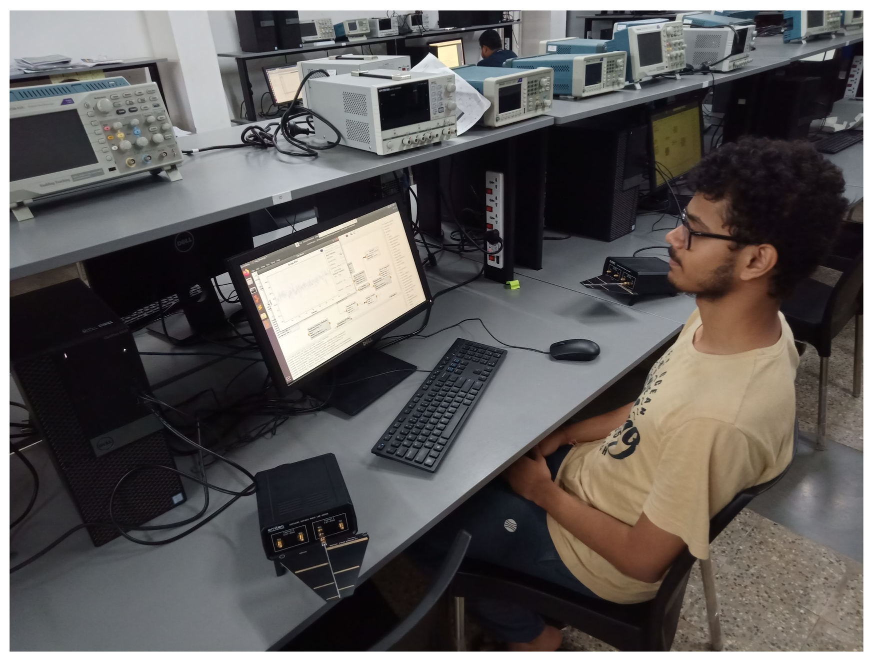
- Use of high frequency signals, along with the algorithms of signal processing to get 2 vitals:
  - **Breathing Rate** (approximately accurate)
  - **Heart Rate**(with an error)

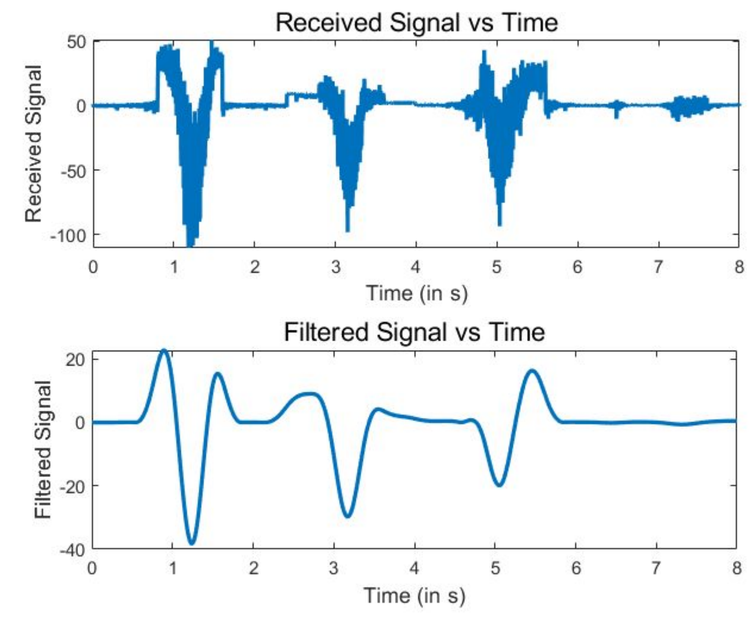
Theory Behind Approach



- **Transmitter Side**: A high frequency (here, 5GHz signal) is sent from the transmitter, which after multiple reflections, including the one from the human, is received
- **Receiver Side**: Delayed version of signal, with $d_k(t) = \tau_k(t) * w_c$, with the assumption that $\varphi_k(t) \sim 0$ for all paths 'k' as the phase is very slow varying
- **Low Pass Filtering**: From our experiments, we found that moving average[averaging over a block and shifting by a window] gives exact results as a FIR/IIR low pass filter (Output- $y_f[k]$)
- **Processing**: Additional downsampling by selecting every m^{th} sample, thus extracting very low frequency in an easy manner (Output- $y_{fd}[k]$)
- **Output**: Autocorrelation, $\Psi_{y\_f} = \Sigma y_{fd}[k] * y_{fd}[k+n]$ + Power Spectral Density calculation to get frequencies related to breathing/heart rate

Experimental Setup

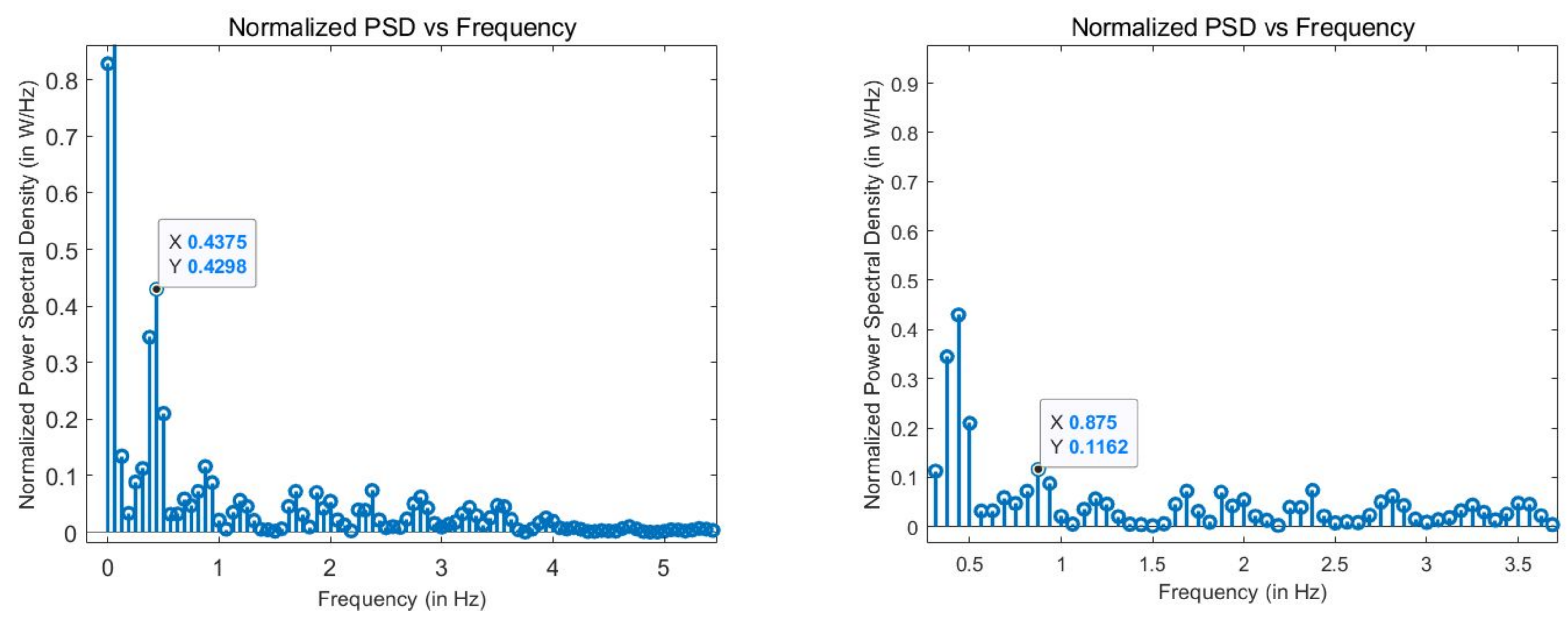




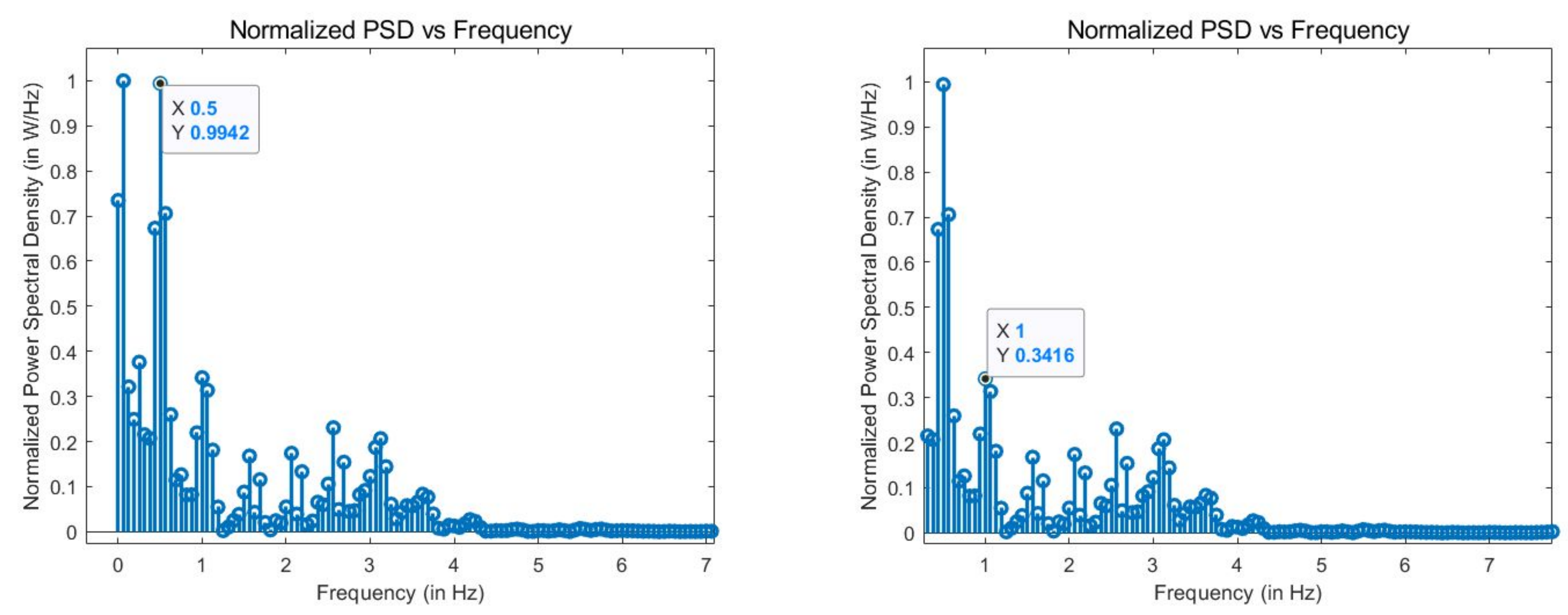
- Data was collected and logged from **SDR-GNU Radio** Interface and processed offline using **MATLAB/Python**

Results

Breathing Rate and Heart Rate in Normal Conditions



Breathing Rate and Heart Rate after Running



Theoretical vs Practical Calculation of Breathing & Heart Rate

Category	Actual Breathing Rate (breaths/min)	Actual Heart Rate (beats/min)	Breathing Rate - Our Method (breaths/min)	Heart Rate - Our Method (beats/min)
Normal - 1st	25	65	~ 26	~ 53
After Running	29	78	30	60
Normal - 2nd	20	70	~ 19	~ 57
After Running (Controlled Breathing)	24	92	~ 25	~ 82

Conclusions & Future Work

- We can conclude that we can measure the breathing rate almost accurately but the heart rate with some error
- **Future Work:** Accurate measurement of heart rate using better hardware, estimating the sleep pattern using Machine Learning algorithms and performing multi-user health metric calculation

References

- http://witrack.csail.mit.edu/vitalradio/
- https://www.youtube.com/watch?v=QyYl28znEgI
- https://ubicomplab.cs.washington.edu/publications/wibreathe/

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