Utilizing nano-meter resolution laser Doppler vibrometer to measure small vibration of human skin

運用奈米精度雷射都卜勒測振儀偵測皮膚震動位移

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Advisor: How-Foo Chen

Laser Doppler Technology Application Fields

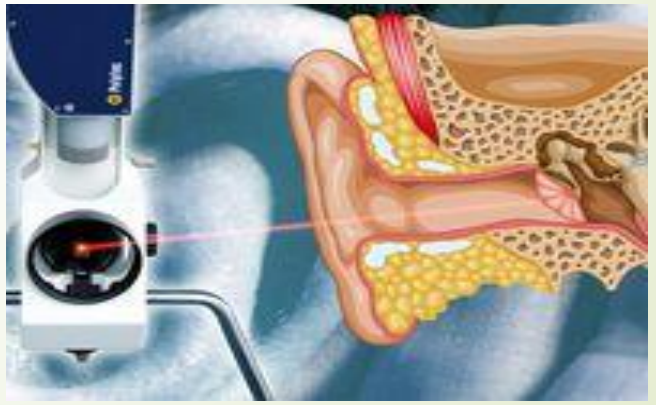
Civil Engineering

Mechanical

Aerospace

Automotive

Biomedical



www.polytec.com/us/

Laser Doppler Vibrometer

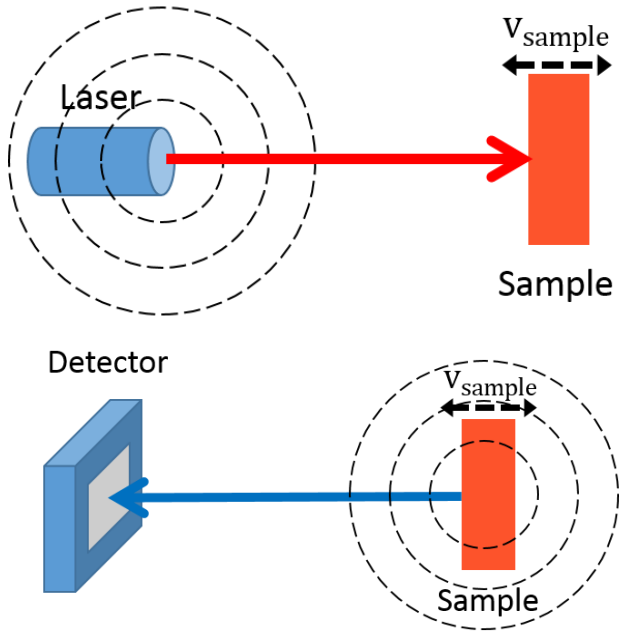
Benefit

- *Remote (non-contact)*
- *High spatial resolution*
- *Reduced testing time*
- *Wide frequency range (near-DC to 1GHz)*
- *Large velocity range (~30m/s)*

www.polytec.com/us/

Laser Doppler Principle

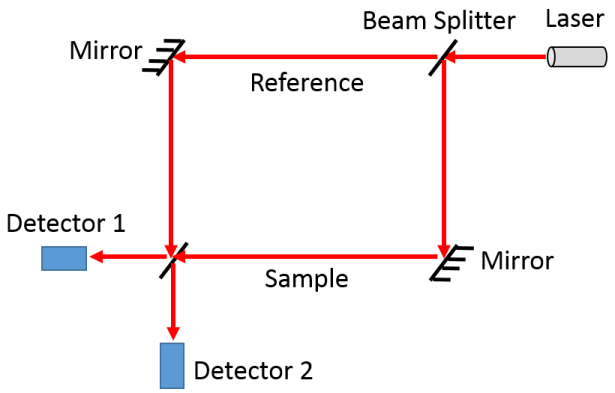
Doppler Effect

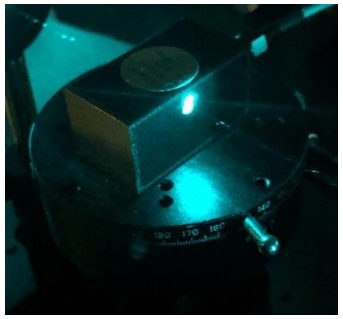


Doppler frequency shift

$$\Delta f = f'' - f_{laser} = \frac{\pm 2 v_{sample}}{\lambda_{laser}}$$

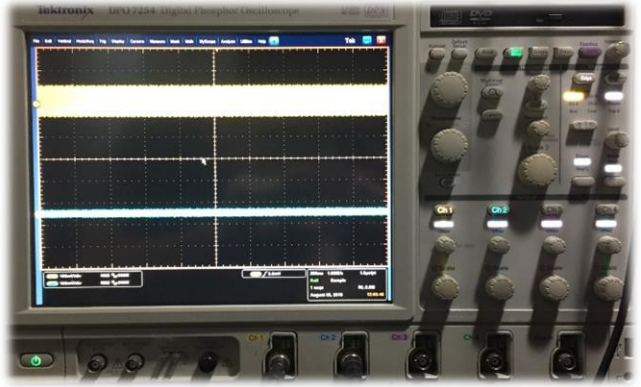
Heterodyne Detection





Acousto-Optical Modulator (AOM)

Data Analysis



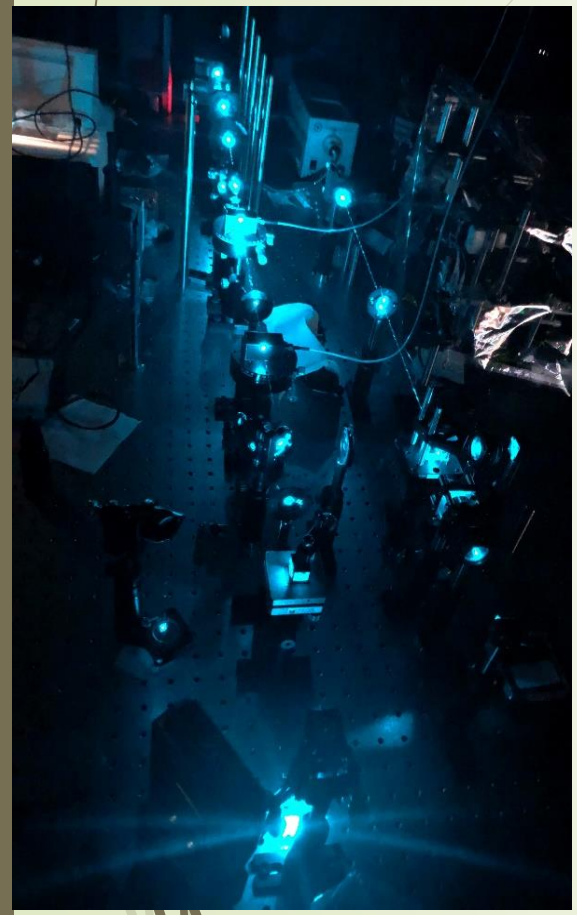
Hilbert-Huang Transform (HHT)

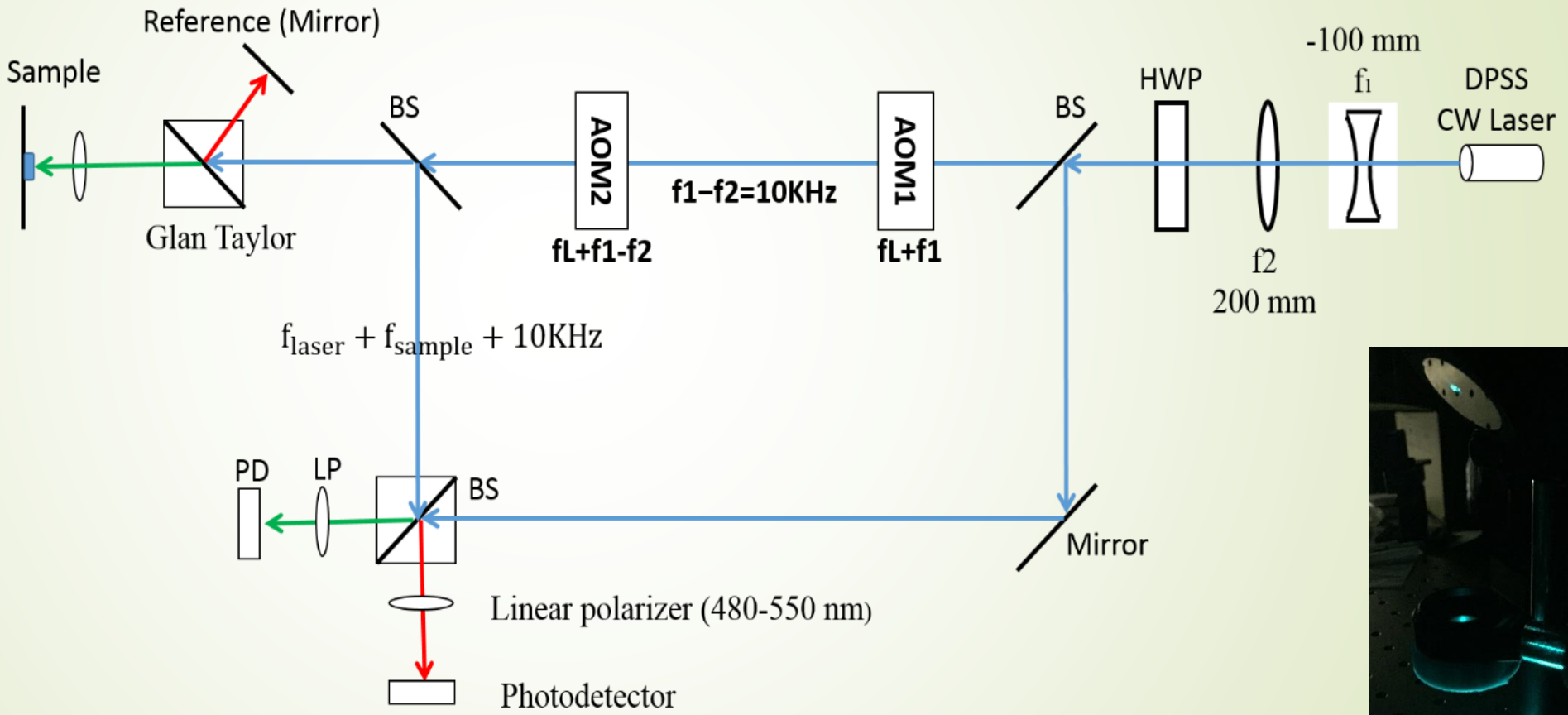
non-stationary nonlinear data

→ *Empirical Mode Decomposition (EMD)*

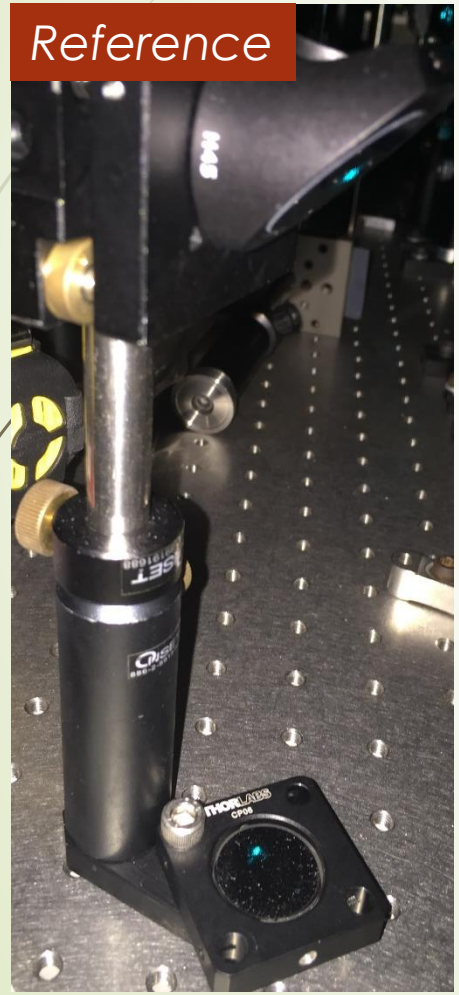
→ *Intrinsic Mode Function (IMF)*

Experimental Setup





Experimental Design



Human skin surface physiological signals

Pulse Test *Pulse at the wrist*

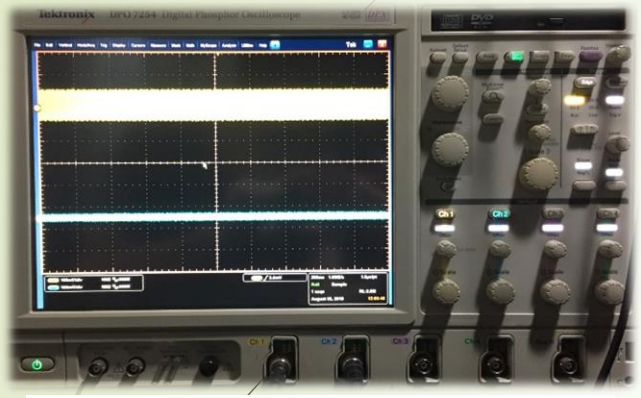
Newborn : 130 - 150 bpm
Children : 65 - 105 bpm
Adults : 60 - 100 bpm

Test Object *25-year-old adult*

Estimated pulse rate range

Adults : *60 - 100 bpm*
1 - 1.67 Hz

Data Analysis - Hilbert-Huang Transform (HHT)



Load Data
Channel 1 & Channel 2
Sample Rate : 1MHz

Matlab

Data Processing
Resample to 100KHz

Empirical Mode Decomposition (EMD)

Hilbert Transform Instantaneous Frequency

Sample Surface Displacement

Intrinsic Mode Function (IMF)

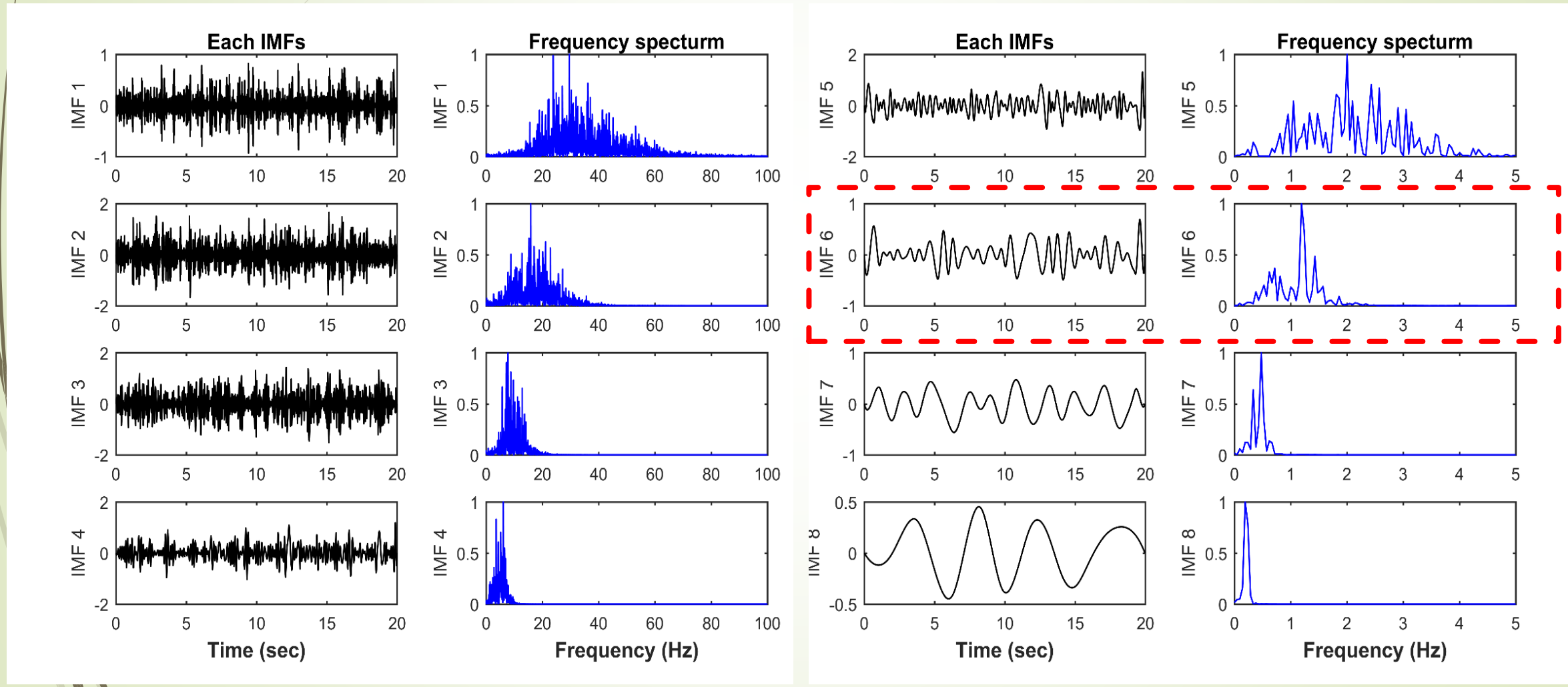
Find results what we expected

Hilbert Spectral Analysis

Data Analysis

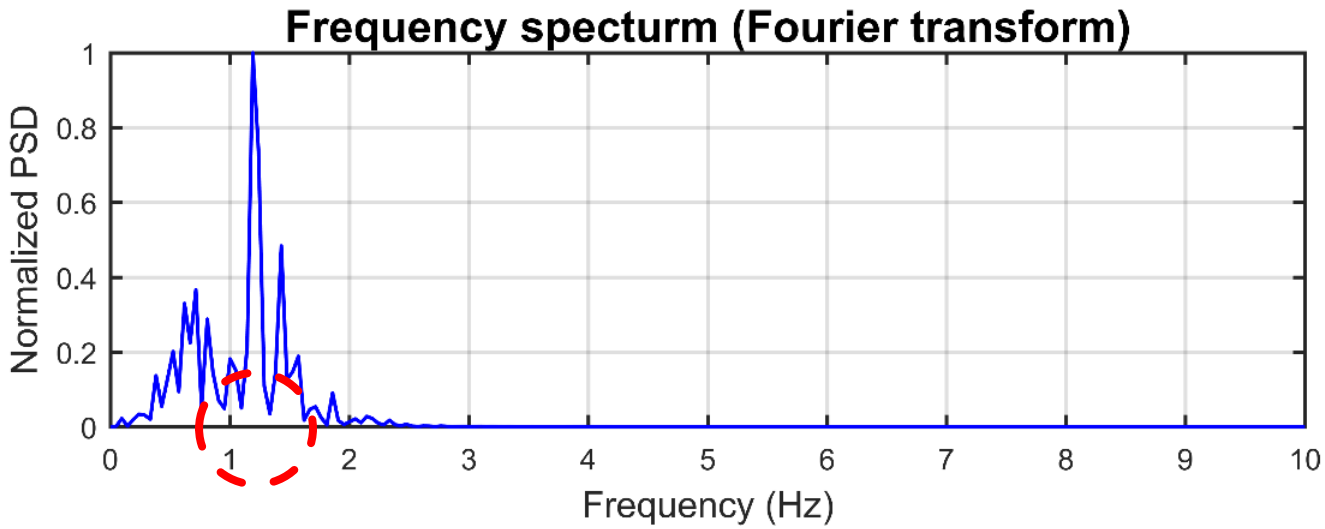
After Empirical Mode Decomposition (EMD)

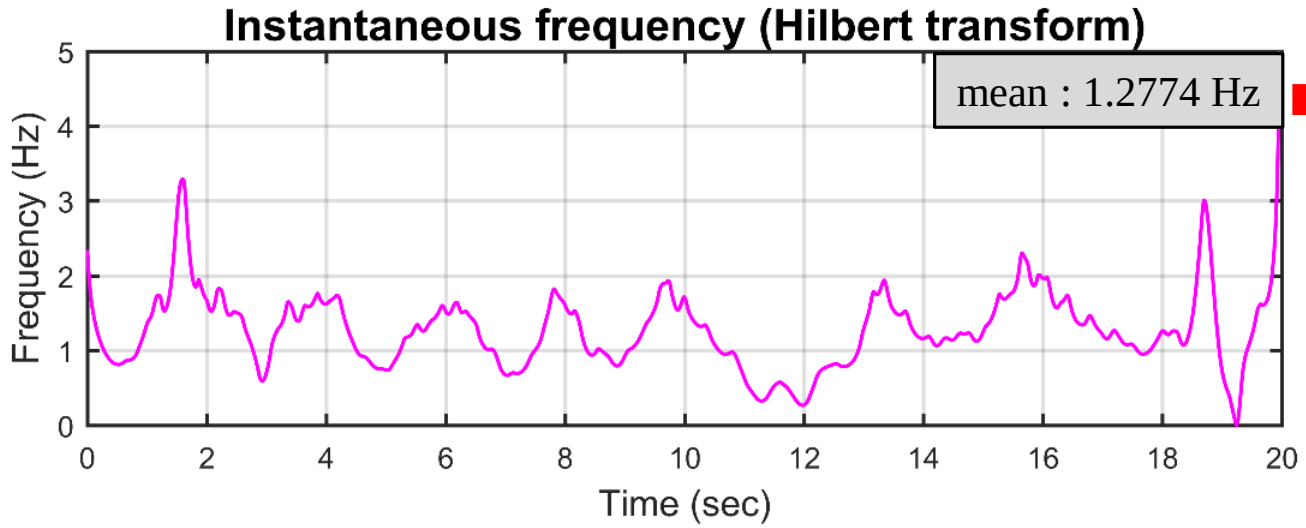
Each Intrinsic Mode Function (IMF)



Data Analysis

Frequency Domain



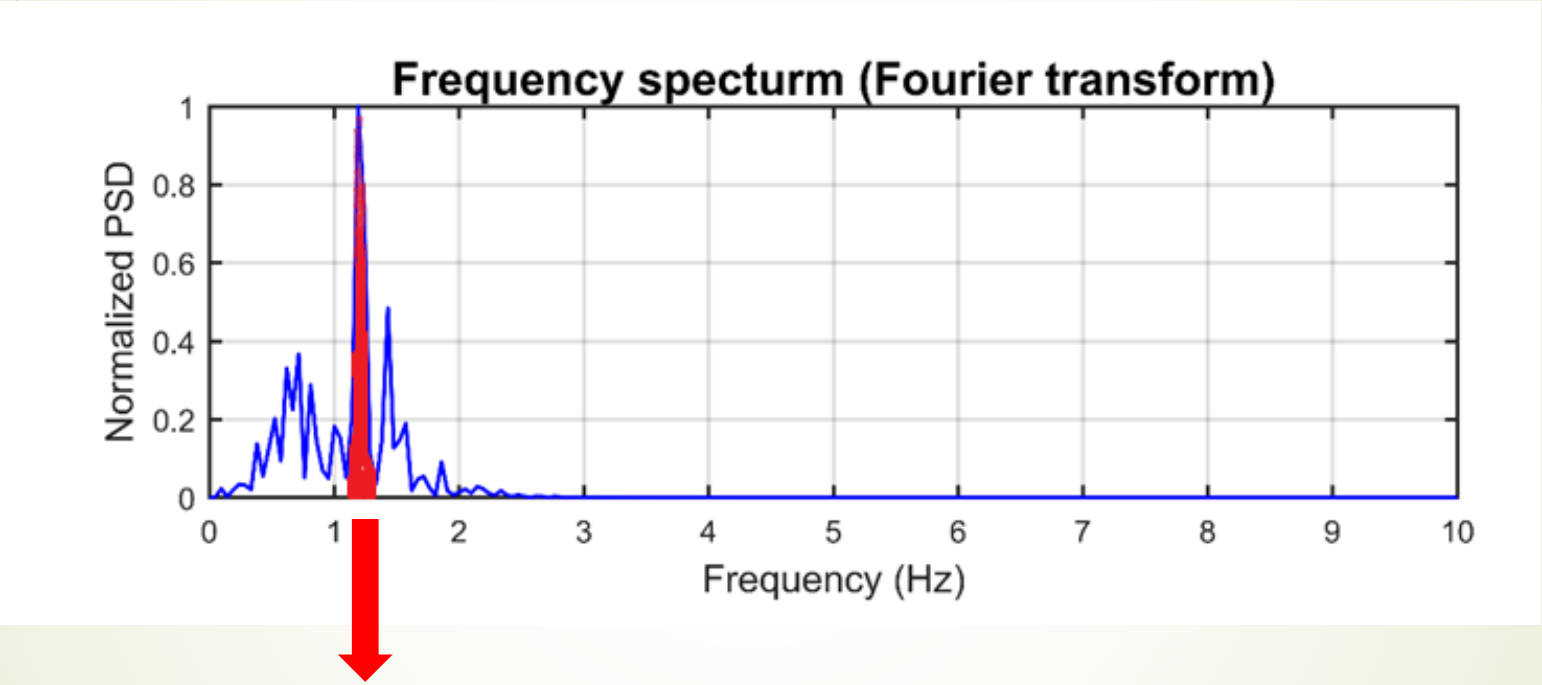


Pulse
1.2774 Hz→77 bpm

Adults : 60 - 100 bpm
1 - 1.67 Hz

Discussion

Calculate the Ratio

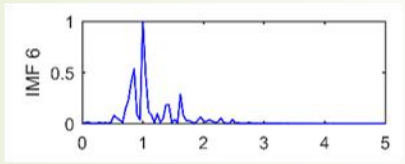


Calculate the ratio of the area of the main peak to the entire spectrum.

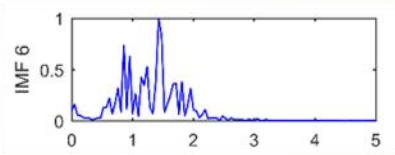
Ratio = 0.3284

Discussion

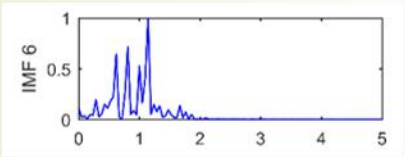
Pulse test



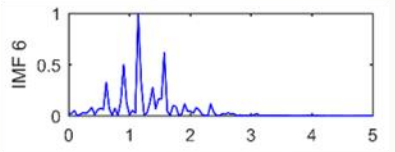
R=0.3343
F=1.0014



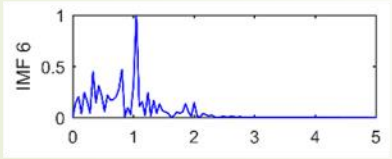
R=0.2314
F=1.4305



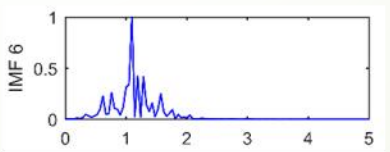
R=0.2645
F=1.1444



R=0.2445
F=1.1444



R=0.2121
F=1.0490

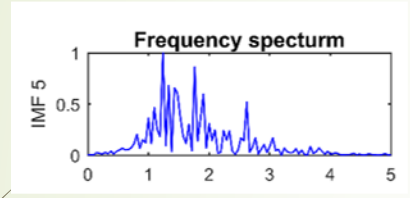


R=0.3603
F=1.0967

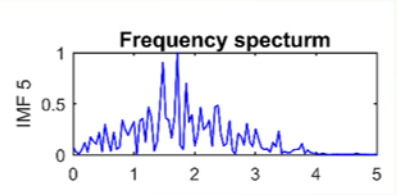
Measuring position

Discussion

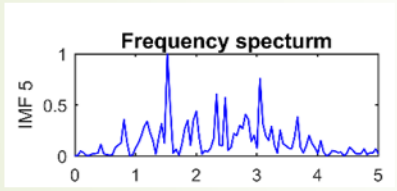
Not on pulse



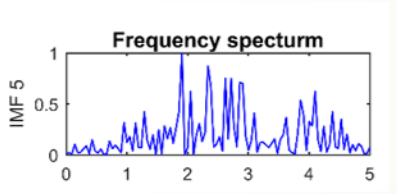
R=0.1012
F=1.2398



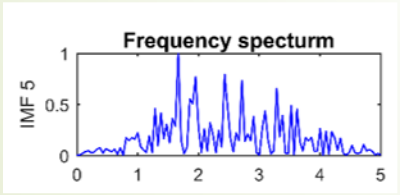
R=0.1007
F=1.7166



R=0.1052
F=1.5259



R=0.0896
F=1.9074



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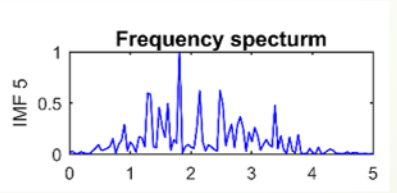
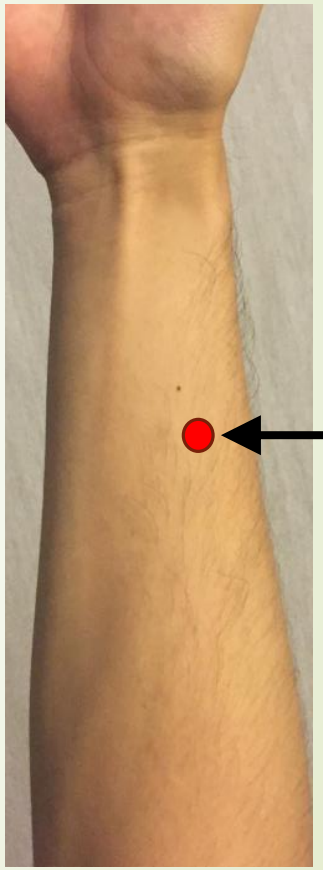
F=1.6689



R=0.0871
F=1.8120

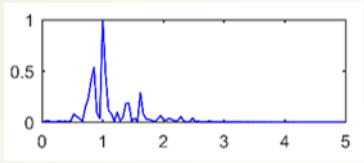


Measuring position

Discussion

Comparison

On pulse



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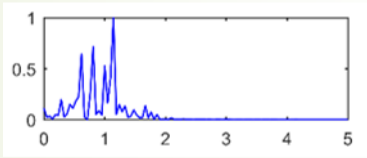

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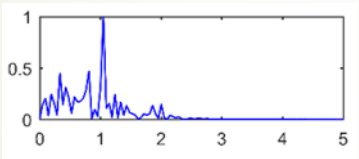
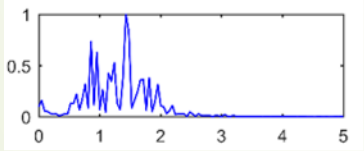
F=1.1444



R=0.2121
F=1.0490



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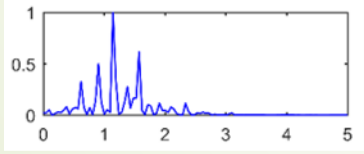
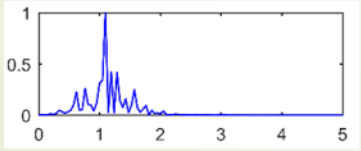
F=1.4305

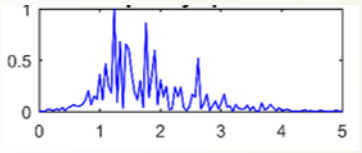


R=0.2445
F=1.1444

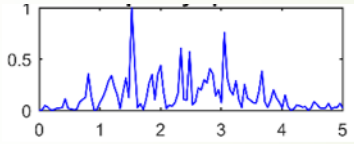


R=0.3603
F=1.0967

Not on pulse



R=0.1012
F=1.2398



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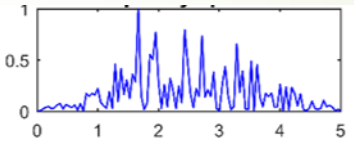
F=1.5259



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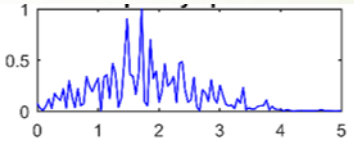
F=1.6689



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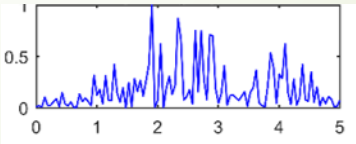

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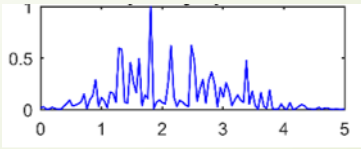
F=1.9074



R=0.0871
F=1.8120

Discussion

Comparison of the pulse and non-pulse signals

- *On the pulse, the ratio can reach 0.2121 to 0.3603.*
- *On non-pulse, the ratio is only 0.0801 to 0.1052.*

In these two cases, the ratio differs by 2-4 times.

Feasibility

- *From the results of data analysis, it verifies the feasibility of physiological signal measurement.*

Thank You for listening