


# BioGlass: Physiological Parameter Estimation Using a Head-mounted Wearable Device


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## Motivation

Growing interest in comfortably measuring physiological information during daily life activity



Can we use a head-mounted wearable device to comfortably gather physiological parameters?

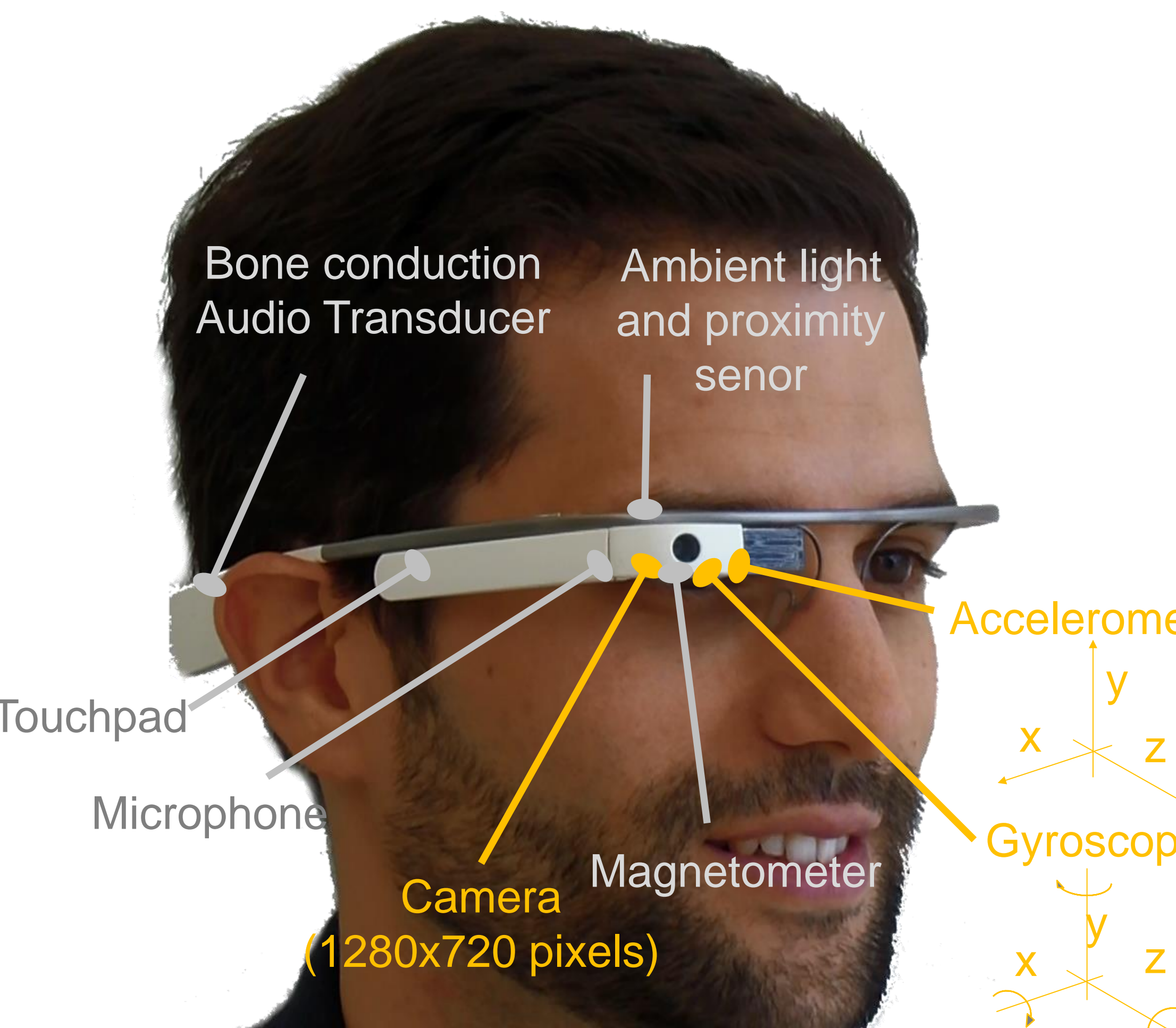


Kown et al, 2011  
 Pahn et al, 2008

Inan et al, 2009

He et al, 2012, 2013

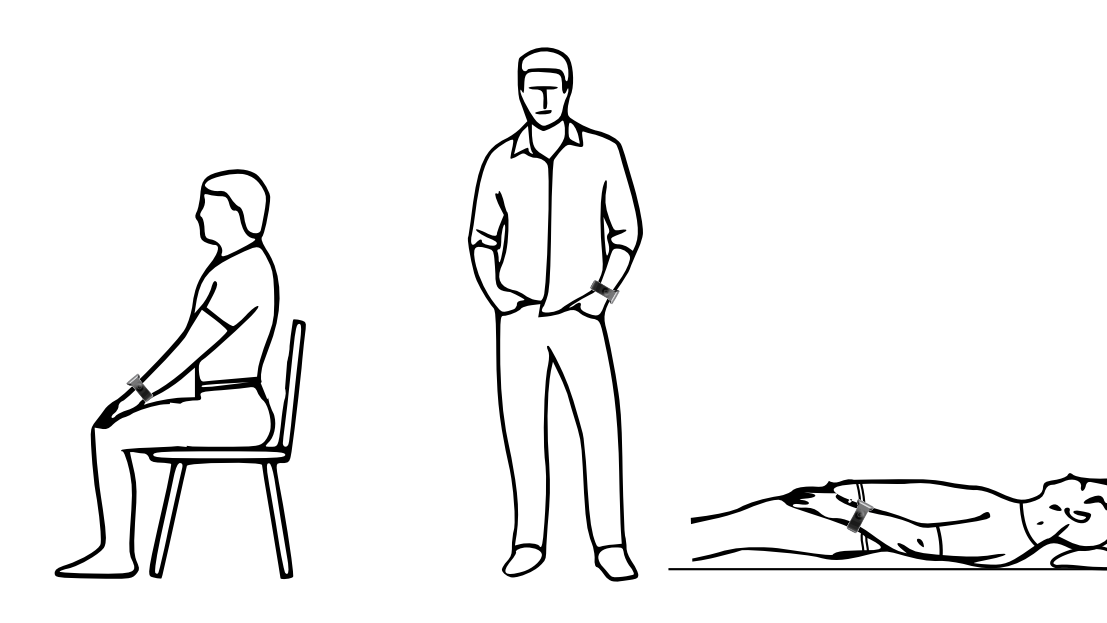
## Google Glass



Bone conduction Audio Transducer  
 Ambient light and proximity sensor  
 Accelerometer  
 Gyroscope  
 Camera (1280x720 pixels)  
 Magnetometer  
 Touchpad  
 Microphone

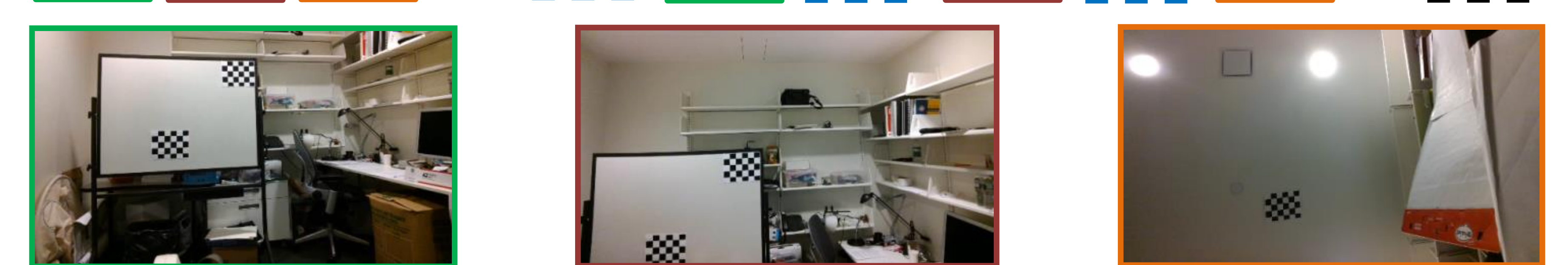
## Experimental Setting

12 participants (balanced gender)  
 3 still positions: sit down, stand up, lying down  
 2 conditions: relaxed and after biking 1 min.  
 Google Glass, FlexComp (BVP and respiration)



Calm Condition: Sit Down, Stand Up, Lie Down

Aroused Condition: Bike, Sit Down, Bike, Stand Up, Bike, Lie Down, Survey



## Physiological Parameter Estimation

Input: Multidimensional Input Data (gyroscope, accelerometer, camera motion, combinations of sensors)

**Preprocessing**

Enforce uniform sampling rate (256 Hz)  
 Remove sporadic peaks

**Filtering**

Remove moving average (length: 2)  
 Band pass Butter filter [10-13]Hz (n: 2)

**Aggregation**

Square root of the summation of the squared components

**Filtering**

Band pass Butterworth filter [0.75-2.5]Hz (n: 2)

**Frequency Analysis**

Identify frequency with highest amplitude in [0.75-2.5]Hz

**De-noising**

Apply Principal Component Analysis


**Selection**

Choose component with maximum amplitude in [0.13- 0.75]Hz

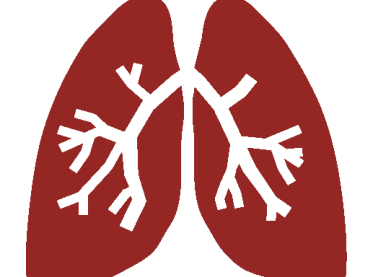
**Frequency Analysis**

Identify frequency with highest amplitude in [0.75-2.5]Hz

**Heart Rate**

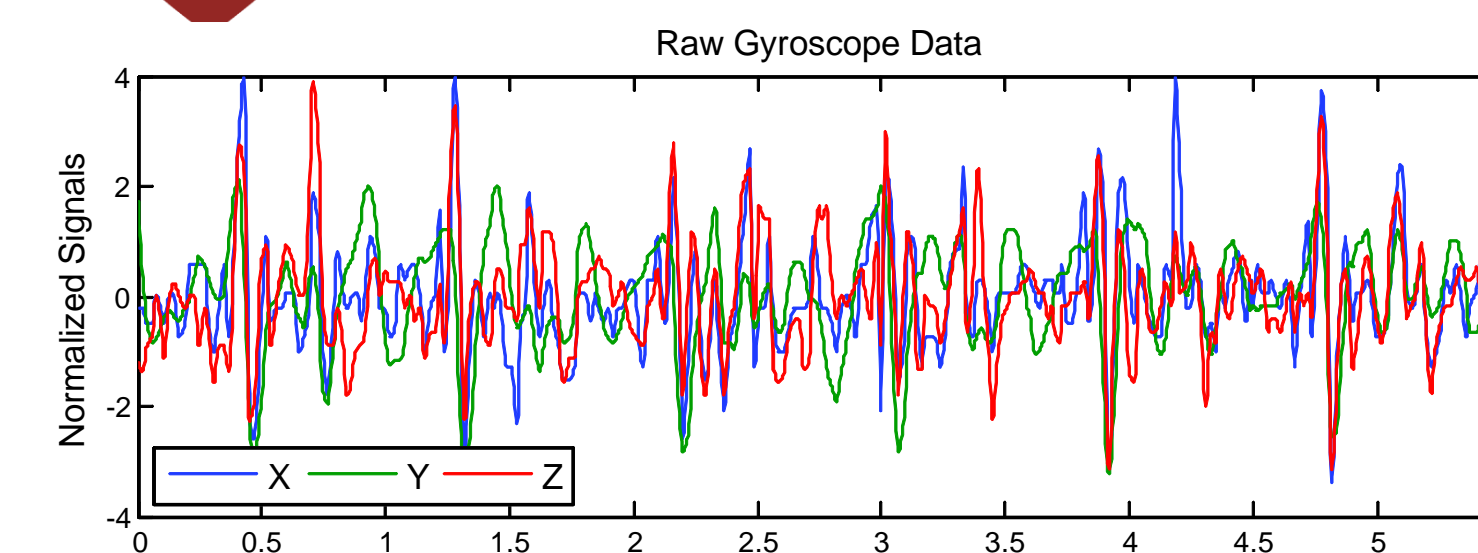
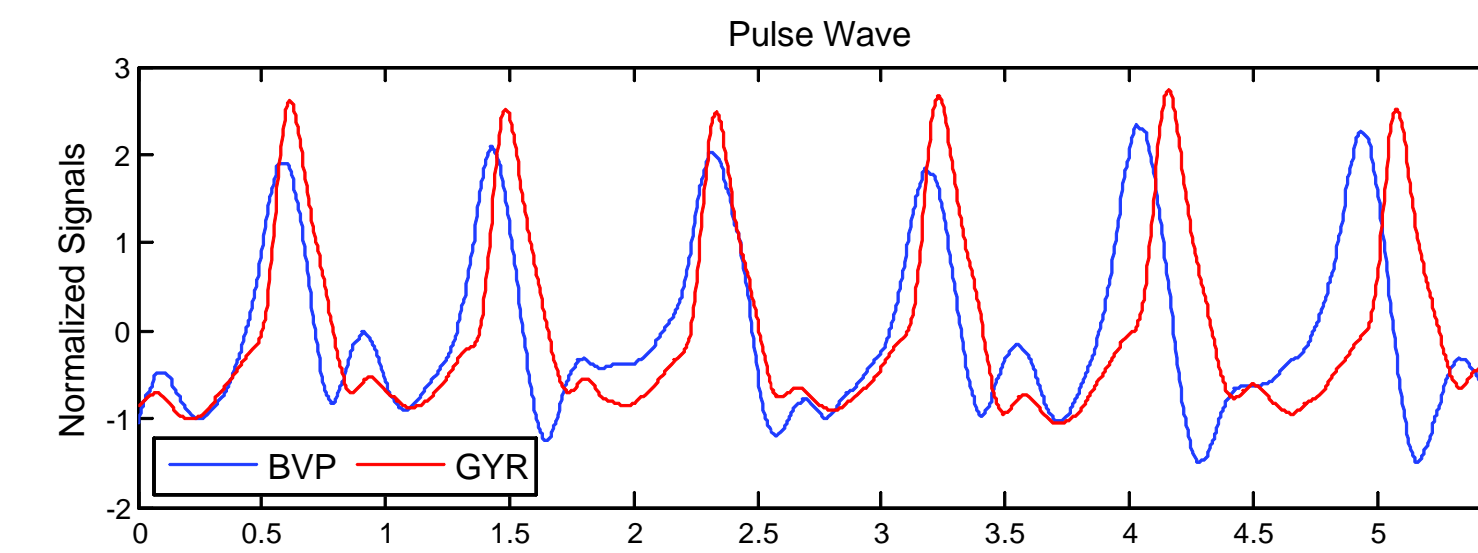
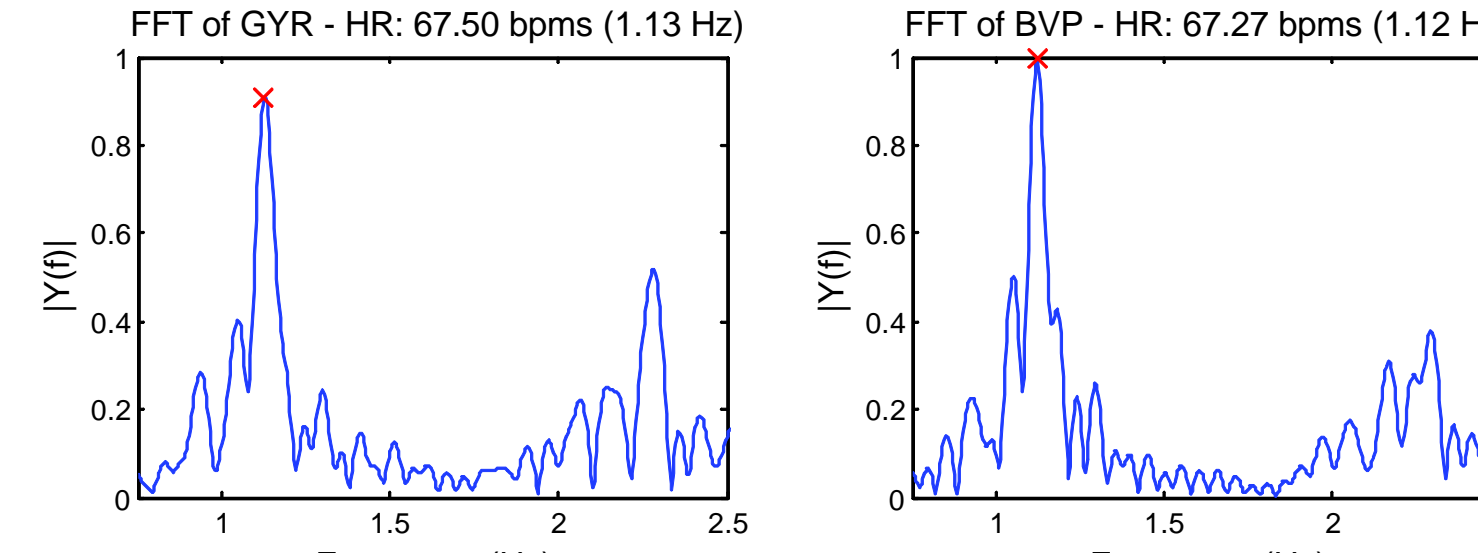


**Respiration Rate**



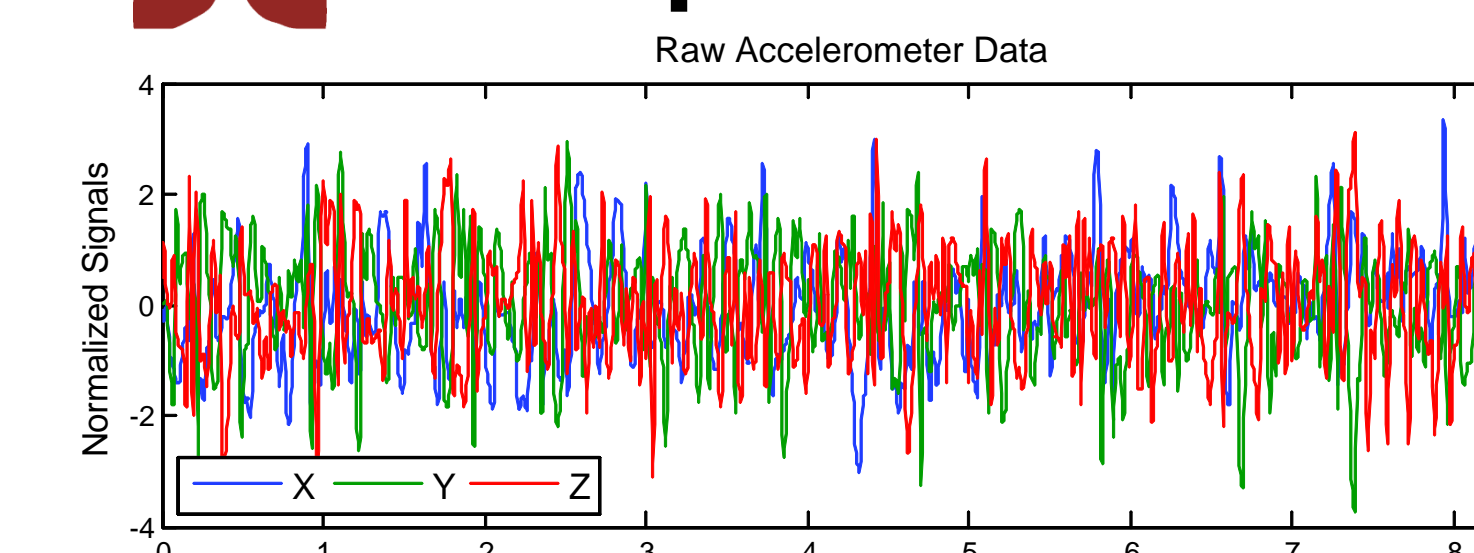
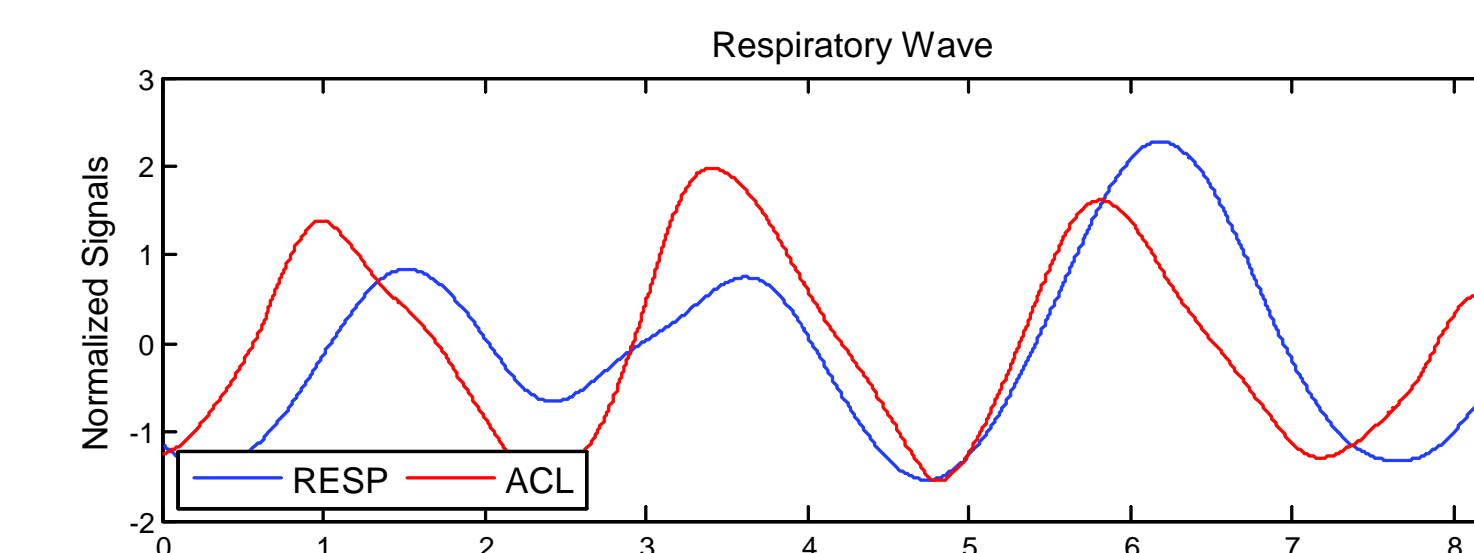
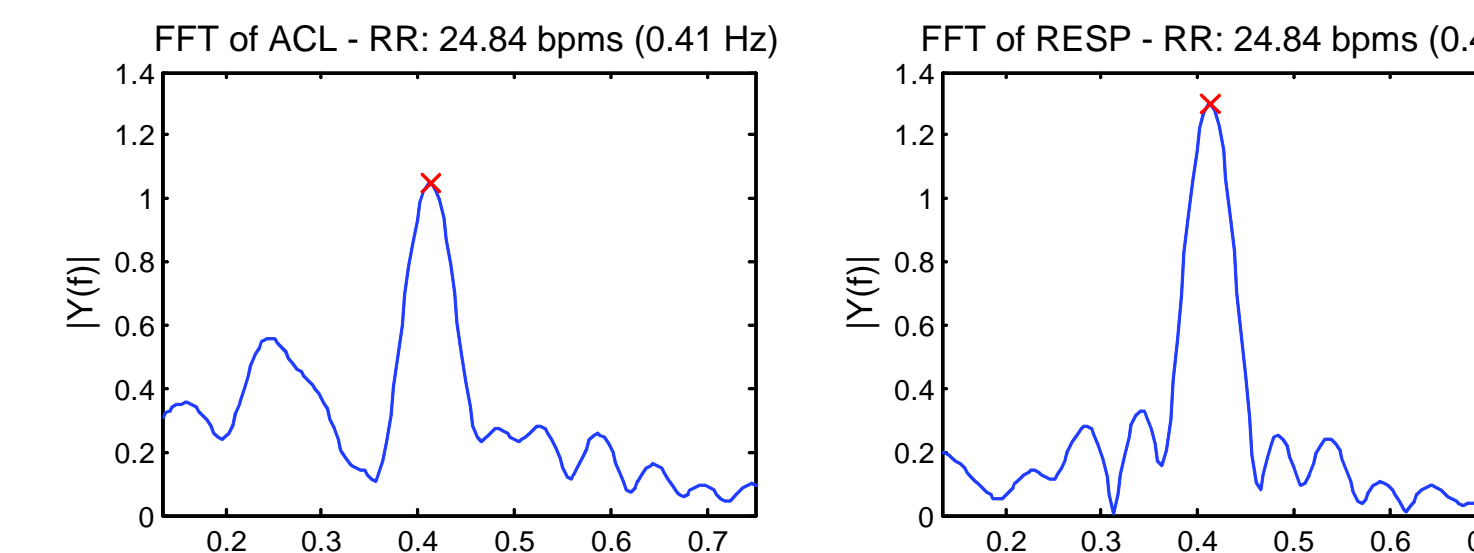
## Results

### Heart Rate

Sensor	ME	STD	RMSE	CC
Gyroscope	0.83	2.02	2.19	0.99
Accelerometer	2.41	6.45	6.88	0.92
Camera	7.89	13.35	15.50	0.59
All	1.21	3.45	3.66	0.98

### Respiration Rate

Sensor	ME	STD	RMSE	CC
Gyroscope	1.39	2.29	2.67	0.75
Accelerometer	2.26	3.38	4.07	0.43
Camera	1.58	2.62	3.06	0.68
All	1.18	2.04	2.36	0.79

ME = Mean absolute error, STD = Standard deviation of the absolute error, RMSE = Root mean squared error, CC = Pearson's correlation coefficient.

Hernandez J., Li Y., Rehg J., and Picard R. W., (2014), BioGlass: Physiological Parameter Estimation Using a Head-mounted Wearable Device. To appear in International Conference on Wireless Mobile Communication and Healthcare.