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

**Javier Hernandez[1], Yin Li[2], James M. Rehg[2], Rosalind W. Picard[1]**
**{javierhr, picard}@media.mit.edu – MIT Media Lab[1] - {yli4400, rehg}@gatech.edu – Georgia Tech[2]**

Work supported by the National Science Foundation
Grant No. NSF 1029585 and NSF 1029679

## Motivation

Growing interest in comfortably measuring physiological information during daily life activity

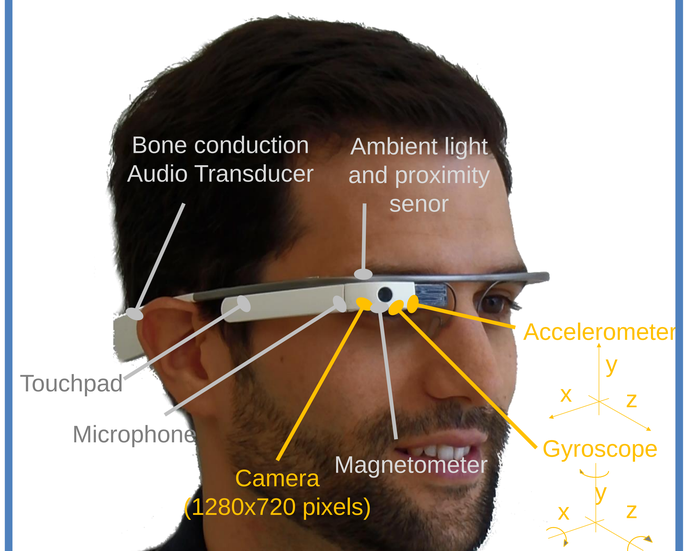
Can we use a head-mounted wearable device to comfortably gather physiological parameters?

Kown et al, 2011
Pahn et al, 2008

Inan et al, 2009

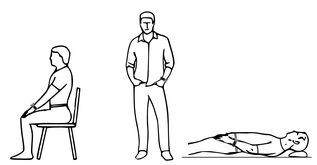
He et al, 2012, 2013

## Google Glass



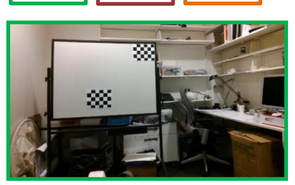

## Experimental Setting

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)



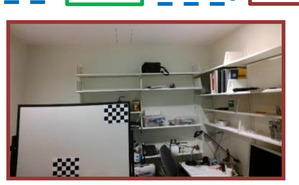
Calm Condition

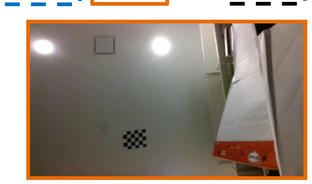
Sit Down → Stand Up → Lie Down



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)

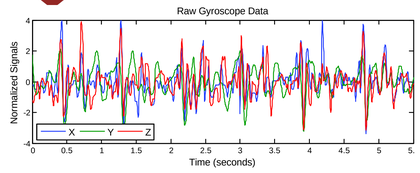
**Preprocessing**
- Enforce uniform sampling rate (256 Hz)
- Remove sporadic peaks

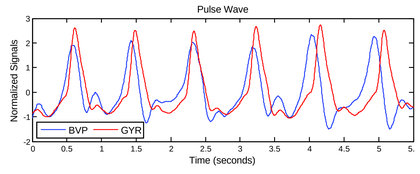
**Heart Rate**
- Filtering: Remove moving average (length: 2); Band pass Butter filter [10-13]Hz (n: 4)
- Aggregation: Square root of the summation of the squared components
- Filtering: Band pass Butterworth filter [0.75-2.5]Hz (n: 2)
- Frequency Analysis: Identify frequency with highest amplitude in [0.75-2.5]Hz

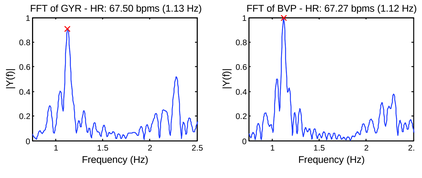
**Respiration Rate**
- Filtering: Compute moving average (length: 256*60/45); Band pass Butter. filter [0.13- 0.75]Hz (n: 4)
- De-noising: Apply Principal Component Analysis
- Selection: Choose component with maximum amplitude in [0.13- 0.75]Hz
- Frequency Analysis: Identify frequency with highest amplitude in [0.75-2.5]Hz

## Results

### Heart Rate

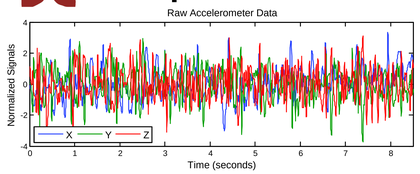


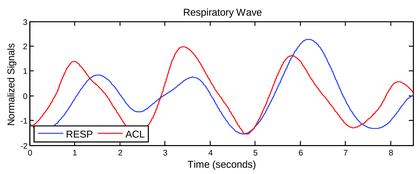



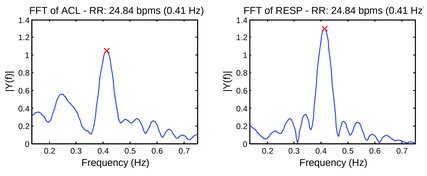




| Sensor | ME | STD | RMSE | CC |
|---|---|---|---|---|
| Gyroscope | 0.83 | 2.02 | 2.19 | 0.99 |
| Accelerometer | 2.41 | 6.45 | 6.88 | 0.92 |
| Camera | 7.89 | 13.35 | 15.50 | 0.59 |
| All | 1.21 | 3.45 | 3.66 | 0.98 |

### 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.