IPDPS 2020 New Orleans

RAW Reconfigurable Architectures Workshop

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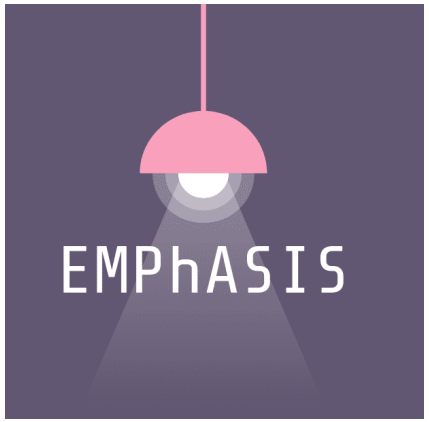

An EMbedded Public Attention Stress Identification System

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Context & Problem Statement

70% — **Of Americans regulary experience** physical and psychological symptoms caused by **stress**, and this trend is constantly increasing[1].

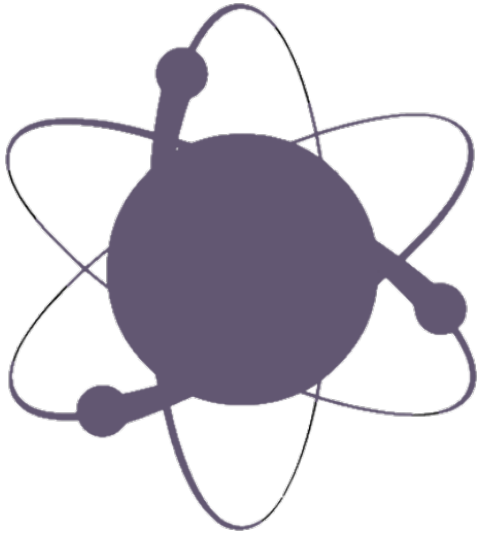
300$ Bilion — **Cost to the United States** every year due to absenteeism, employee turnover, diminished productivity, and direct medical charges **caused by stress[2]**.

25% — **Of American people experience stress and anxiety in public speaking**. Professions in contact with the public are among the most stressful[3].

[1] https://www.stress.org/daily-life
[2] https://www.apa.org/pi/health-disparities/resources/stress-report.pdf
[3] https://www.cnbc.com/2019/03/07/the-most-stressful-jobs-in-america.html

Current Solutions

In lab experimental setups[4], that requires too many sensors and so are **not applicable in a public speaking scenario**.



On-the-market devices[5,6], paired to a smartphone application that **could not be monitored in a public speaking scenario**.

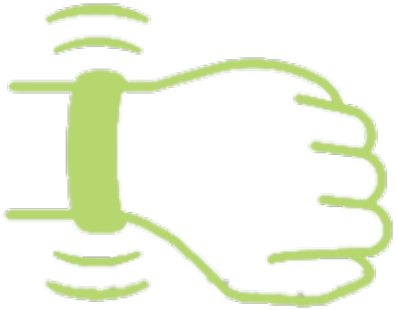
Also, most of these applications **lack of a calibration phase**.

[4] Deng, Yong, et al. "Sensor feature selection and combination for stress identification using combinatorial fusion." International Journal of Advanced Robotic Systems 10.8 (2013): 306.
[5] https://thepip.com/ [6] https://spirehealth.com/products/health-tag-membership

EMPhASIS

An EMbedded Public Attention and Stress Identification System able to **help people prevent and handle stress and anxiety condition** that is

Customizable, according to each user's physiology

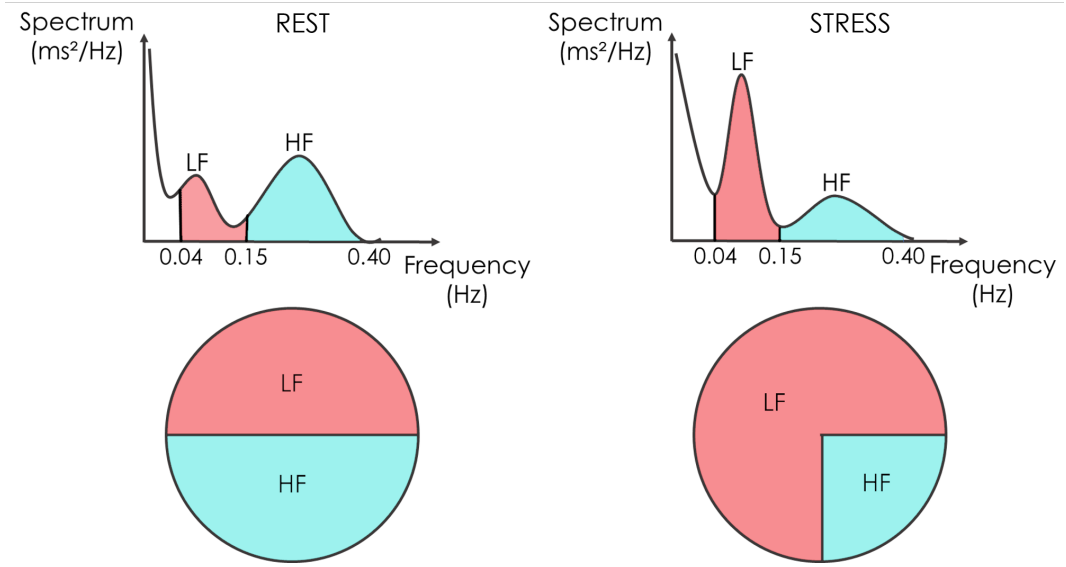


Minimally Invasive, to fit a public speaking scenario

Energy Efficient, although equipped with lightweight batteries

Biomedical Background

The combination of **ECG time and frequency domain analysis is sufficient to accurately perform stress identification[7]**.

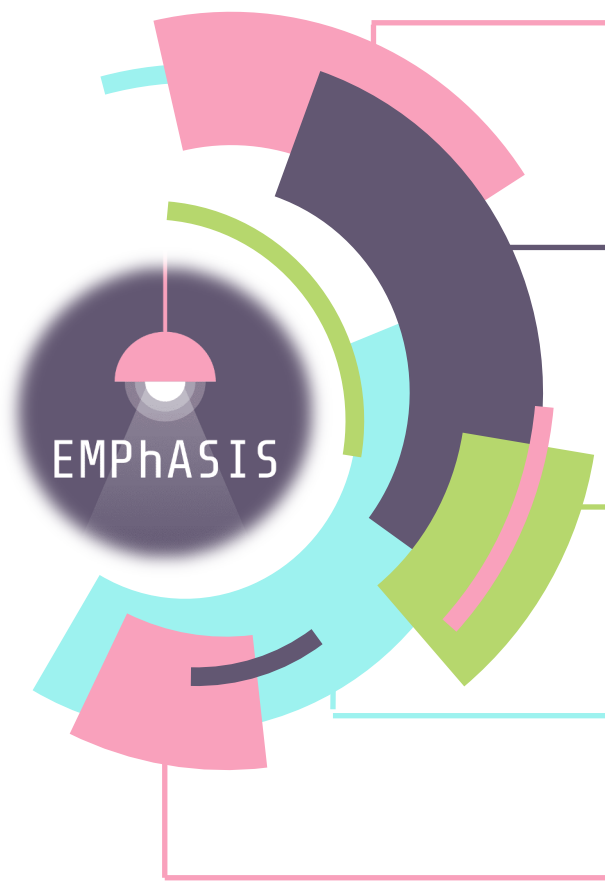


In the **time domain**, we consider the heartbeat duration, the **distance between to consecutive R peaks**

In the **frequency domain**, we consider the **proportion between area underneath the LF and HF**

[7] A. Malliani, F. Lombardi, and M. Pagani, "Power spectrum analysis of heart rate variability: a tool to explore neural regulatory mechanisms." British heart journal.

System Functionalities



ECG ACQUISTION

ECG signal acquired by the sensor. The Zynq Processing System windows the signal and sent it to the FPGA through AXI stream interface

FEATURES EXTRACTION

The FPGA extracts time and frequency domains **features** per each window

STRESS STATUS CLASSIFICATION

Leveraging a **PCA threshold-based algorithm**, the FPGA estimates the stress status that corresponds to each features vector received

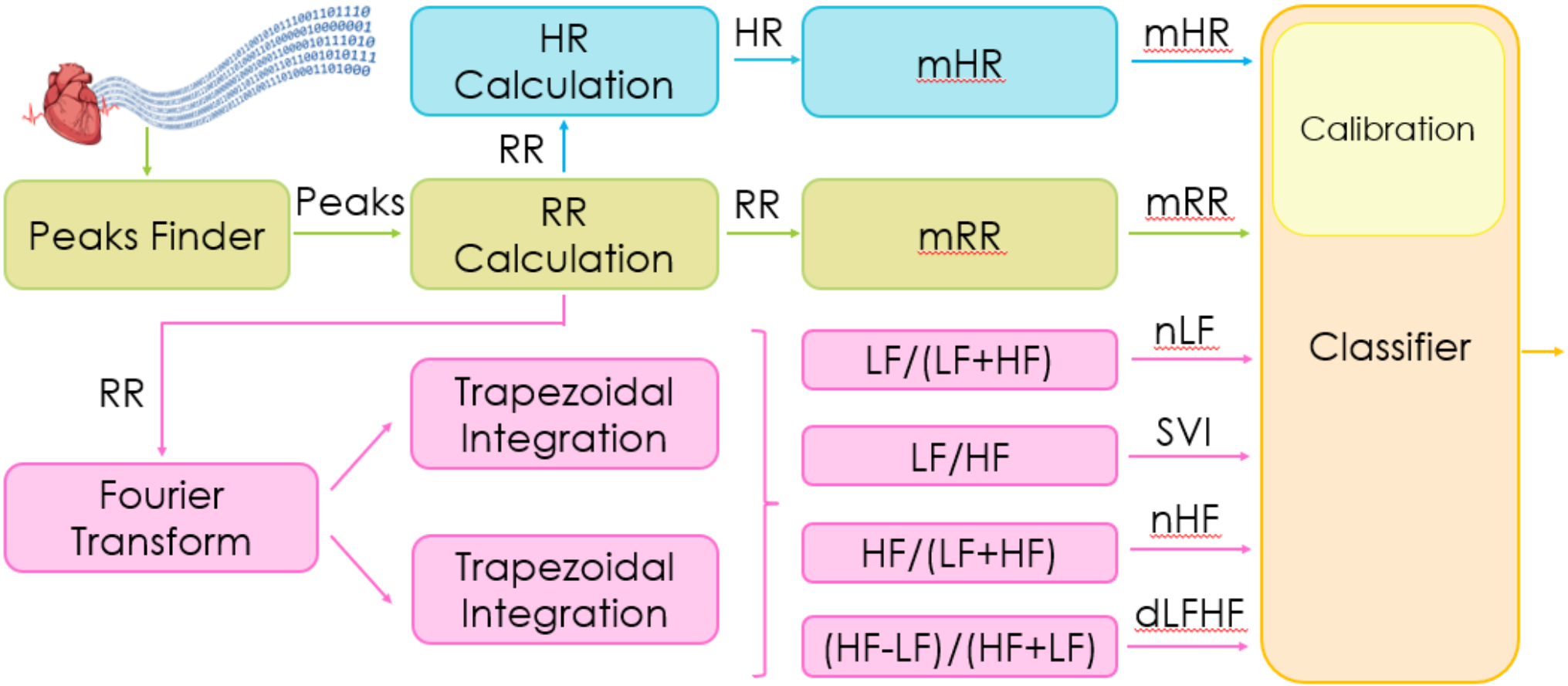
USER NOTIFICATION

Predictions are sent to the Zynq Processing System through AXI stream interface and **reported by the board RGB LED**

FIRST USE CALIBRATION

The first time that a new subject uses the system, **classifier's threshold and weights are calibrated** according to its physiology.

Design Scheme



Main Results

1.7 6Watt

Total Power Consumption,
allowing for covering an entire presentation duration with lightweight batteries.

5 Hours

Minimum Guaranteed Autonomy,
assuming a power bank with a current intensity of 2Ah.

10 Seconds

Input-Output Time,
i.e. total amount of time between ECG signal acquisition and stress status reporting.

Remarks & Future Works

EMPhASIS is an Embedded Public Attention and Stress Identification System **minimally invasive, customizable, and fast**. Moreover, **it does not require any smartphone interaction**, to fit at best a public speaking scenario.

Future directions for the project deal with

Replace the RGB LEDs colour with a **vibrating wristband** for reporting to the user its stress status

Interface the board to the output devices with a **Bluetooth connection**

Replicate EMPhASIS IP to fit all the FPGA resources, to support **multi-user**

Evaluate EMPhASIS also in **other scenarios**, i.e. employees in a office or people in a house

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EMPhASIS

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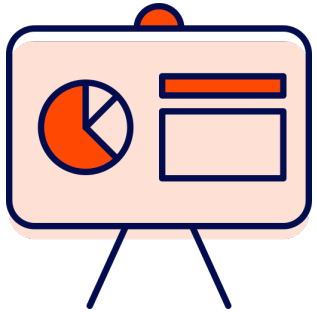
https://necst.it/
https://www.slideshare.net/necstlab



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