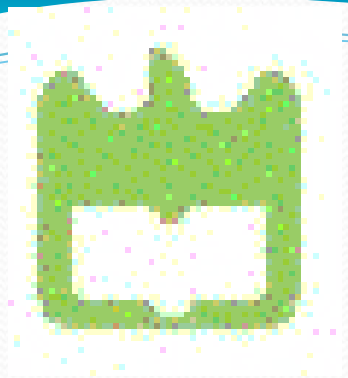
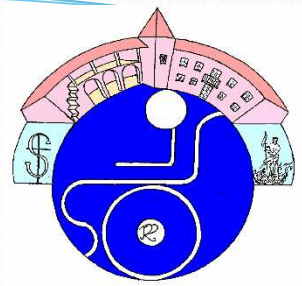


# Evaluating the use of GSR sensors for tetraplegic patients


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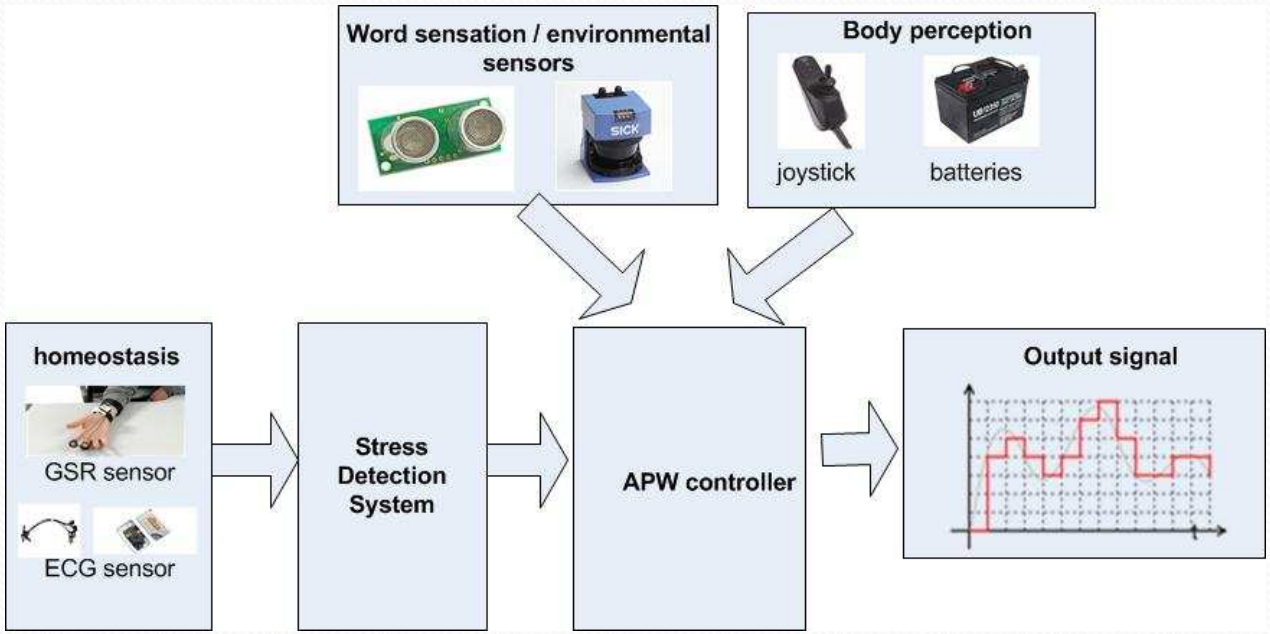
# Motivation

- Tetraplegic patients need a commercial powered wheelchair (CPW).
- *Centro de Medicina e Reabilitação Região Centro-Rovisco Pais* (CMRRC-RP) is the major rehabilitation center in the north of Portugal.
- In collaboration with the Center we are adapting a CPW for people without enough strength to operate the joystick.
- The preliminary work was performed using the Stage simulator and tested by real patients.
- We verified that the patients learned well the mode of operation but, after some time, started to be tired, nervous, and begun to fail.
- The patients are exposed to a significant stress level, due to their limited physical abilities.

# Solution

- The psychic condition affects and is affected by the way the wheelchairs users interact with their wheelchair.
- So, the control system used in the wheelchair must have the capacity of:
  - processing sensors' data, in real time,
  - reacting on unknown environmental situations and
  - reacting to the eventual changes of the wheelchair user's welfare.
- According to these attributes, our adapted wheelchair is considered as an embodied autonomous agent.
- In this work, the plan is to introduced the user's physiological state in the APW control unit.
- The goal is to estimate the patients' emotional / comfort state and use this knowledge to assiste in the navigation of the wheelchair.

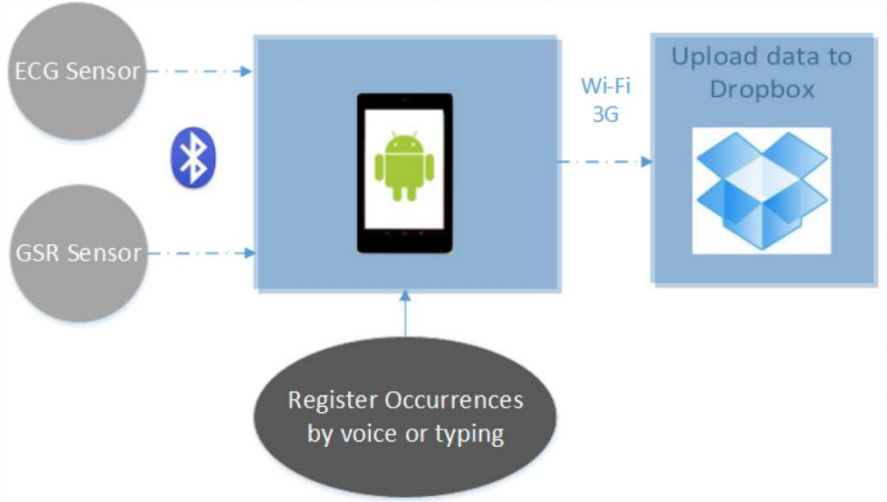
# The hardware configuration




- A stress detection system can provide a solution to avoid situations where the stress can be harmful, like wheelchair or vehicular navigation, avoiding possible accidents.
- APW – Adapted Powered Wheelchair

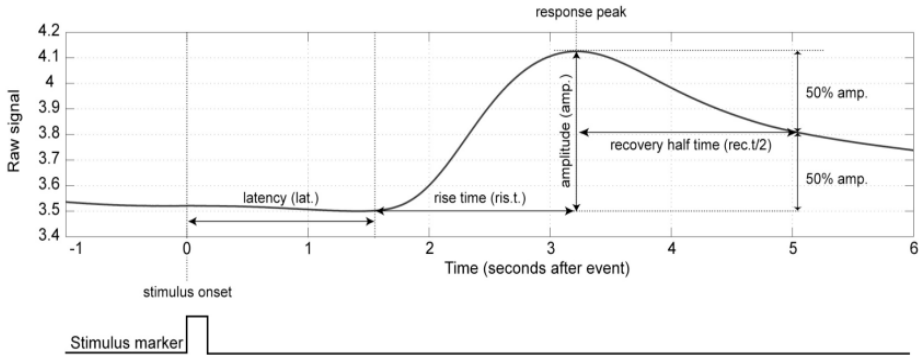
# Stress Detection System

- The stress detection system developed is a non-invasive wireless system capable of:
  - acquiring simultaneously cardiac changes (ECG) and the galvanic skin response (GSR) signal.
  - register, in a friendly way, occurrences which can lead to changes in the stress level of the persons under observation.
  - send all acquired data to a database.
  - memorizing all user emotional profiles in a database.

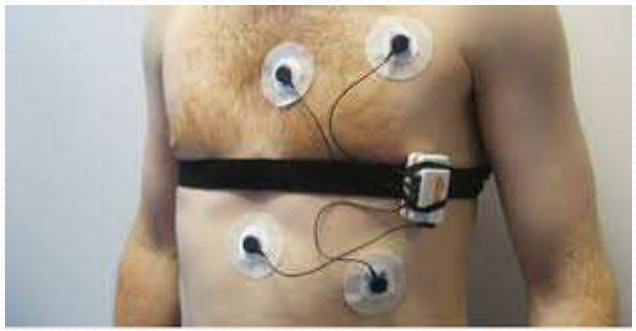


# Sensors Application and signals

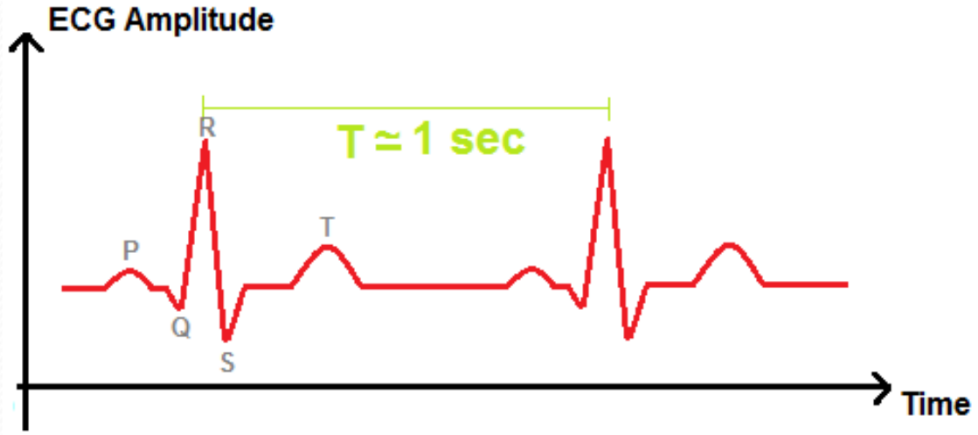

GSR sensor application




Typical GSR signal: stimulus and peak



ECG sensor application




Typical ECG signal

# Centro de Medicina de Reabilitação da Região Centro- Rovisco Pais (CMRRC_RP)

- Is a centre of rehabilitation for disabled persons, most of them with a spinal cord injury (SCI).

- The clinicians of this centre are not only concerned with the rehabilitation but also with the adaptation of the patients to their new way of life: patients are trained to use adapted facilities and assistive devices.

- They have accepted and allowed that this study could be made with their patients.

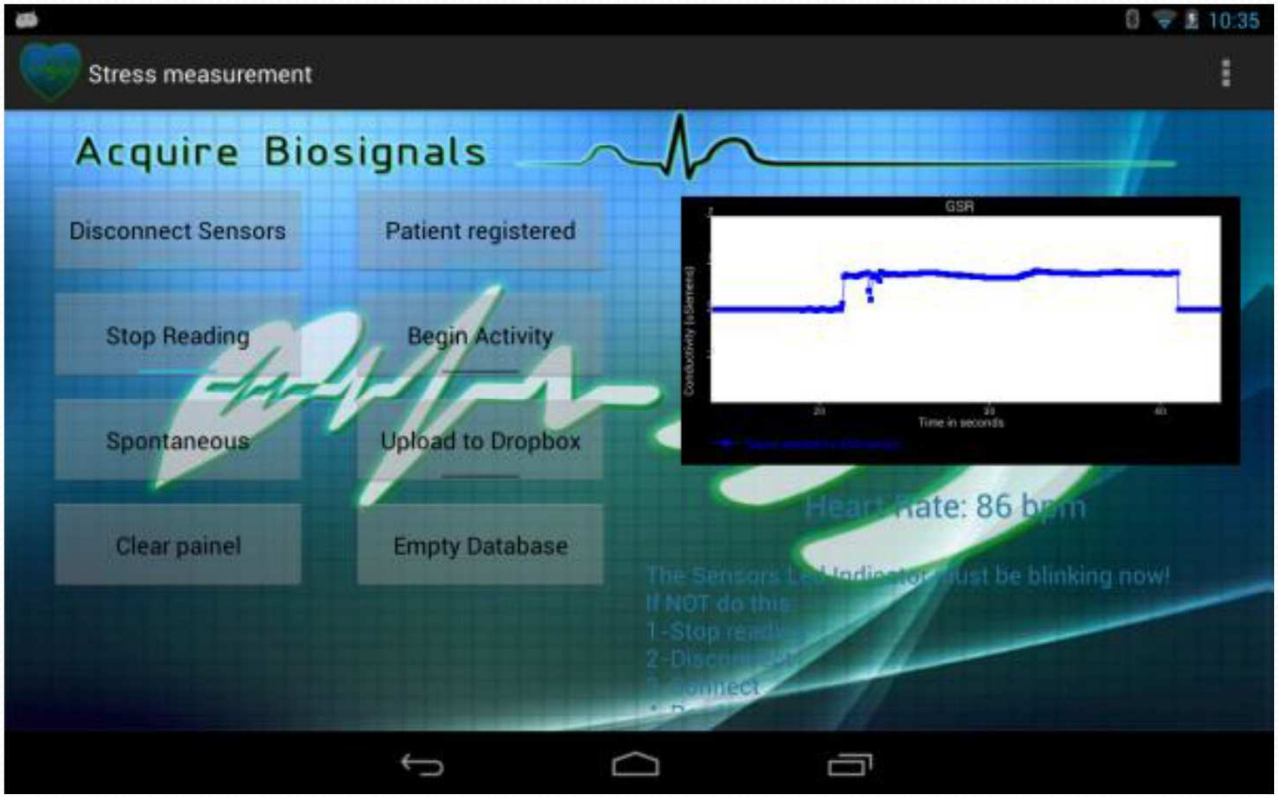
# Patient Experimental Test Protocol

1. Staying 5 minutes in rest.
2. Navigating the wheelchair along a corridor  5 minutes.
3. Navigating the wheelchair 10 minutes:
   - inside a dinning room, bypassing tables, chairs.
   - driving parallel to a  wall.
   - entering and exiting an lift.
4. Navigating the wheelchair along a corridor.
5. Staying 5 minutes in rest.

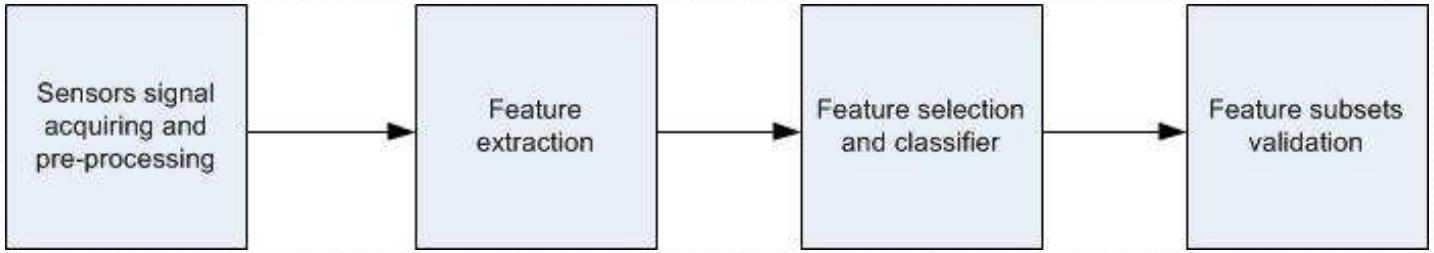
# Stress measurement Android Aplication

During the experimental test:

- Acquires simultaneously cardiac changes and the galvanic skin response.
- Someone registers the occurrences.



# Feature selection



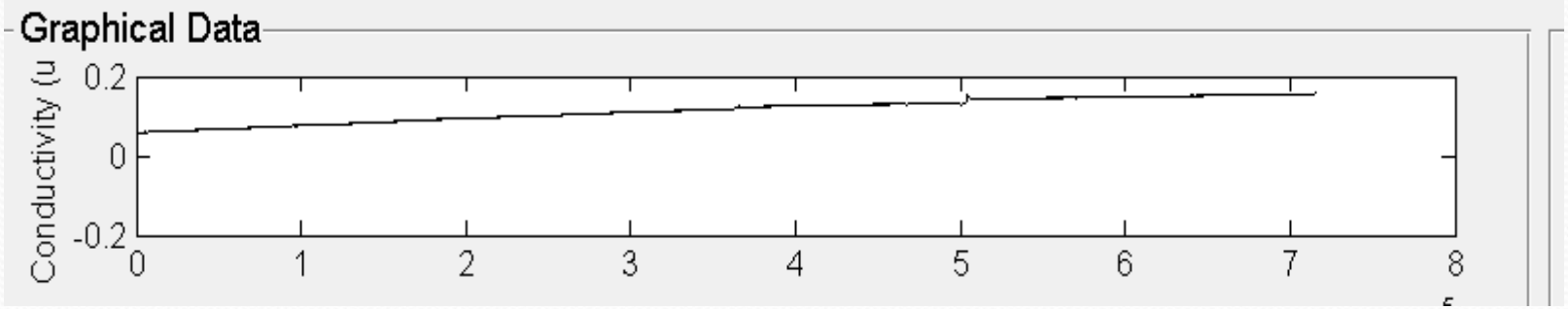

Steps to recognize emotion with physiological signals.

The offline feature extraction of ECG and GSR biosignals is done in a MatLab interface specifically developed.

| — |
|---|
| Mean HR $(bpm)$ |
| Maximum HR $(bpm)$ |
| Minimum HR $(bpm)$ |
| Mean Conductivity $(\mu S)$ |
| Maximum Conductivity $(\mu S)$ |
| Minimum Conductivity $(\mu S)$ |
| Number Peaks Detected |
| Mean Peaks Amplitude $(\mu S)$ |
| Mean Peaks Rising Time $(s)$ |

# Prelimary results

- After the first experimental test (with a C3/C4 patient), it was decided to apply, in future, the GSR electrodes on the forehead
- This decision was based in the type of the GSR signal acquired: it is different from the GSR signal of a person without deficiency: does not show peaks.




first experimental test GSR signal

# Prelimary results

- This can have different reasons:
  - one of the symptoms of this injury is the failure of the sweating function, i.e., patients can not sweat below the level of injury, and some even above.
  - As the patient in the test has three years of experience in navigating his wheelchair, he does it very well without any kind of emotional change.

- Although the GSR signal has no peaks, its instantaneous value increases as the test is advancing.

# Prelimary results

- Two more experimental tests were made with the GSR electrodes apllied in the forehead:
  - patient 2 was a C3/C4 with one month of experience in the navigation of his powered wheelchair
  - patient 3 was a C5 with less of one month of experience in the navigation of her powered wheelchair.
- The GSR signal has the same behavior as the previous one.

# Conclusions and work in progress

- We proposed to incorporate a set of additional sensors in the wheelchair controller, deriving environmental and homeostatic states.
- The stress detection system informs the APW controller of the user emotional state.
- The GSR features selected, when dealing with tetraplegic patients must be different from those selected when dealing with patients with no deficiency.
- More experimental tests will be made as also a user profile will be created based in the implementation of different classification algorithms.
- A new version of the stress measurement application will be developed trying to predict the user different emotional states for the case of these patients.