Stress Monitoring and Detection using Physiological Sensors

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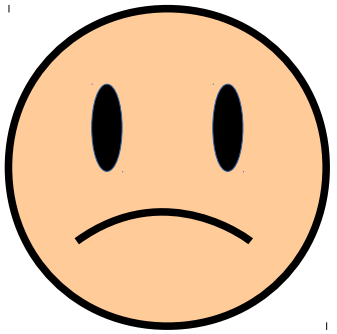
Motivation

- Problems in developed countries:
    - Increasing population
    - Increasing stress / anxiety -> Depression
- Consequences:
    - Decreasing the quality of life of people
    - Low productivity at work and daily life
    - Personal problems / relationships / family

Facts about depression in elderly

- Depression affects 12% of the elderly in EU (11.3 million) and 31% in Japan (10.7 million) and it is the main illness in older people ahead of dementia.
- Untreated depression negatively affects the outcome of other diseases like heart conditions, lupus, or AIDS.
- Finally, and mostly important, depression is the main cause of suicide for older people in western countries and Japan.



Example: Costs in UK

- In the UK around 12 million adults visit the doctor with stress related problems.
- Stress generates 13.3 million lost working days in UK.
- Stress has a cost of ~8.4 million pounds to UK companies
- Current doctor appointments for therapy have waiting time of 3-6 months → dangerous cumulative stress

Sensors for Stress

- How to monitor and detect stress?
- In this work we use wearable physiological sensors.

Recorded Signals

- Pulse plethysmograph (PPG): volume of blood in the tissue
- Electro-dermal activity (EDA): skin sweating activity
- Heart Rate Variability (HRV): heartbeats
- Correlation of PPG and HRV (PPG)
- Signals were sampled at a 10 Hz
- For eat time t the feature vector was:

$$x_t = \{ \mathrm{PPG}_t, \mathrm{EDA}_t, \mathrm{HRV}_t, \mathrm{PPG}_{\mathrm{corr}} \}$$

- Each time *t* we classify the feature vector x_t into "stressed" and "not stressed" using a Support Vector Machine

Trier Social Stress Test (TSST)

- In TSST people carry out stressful and neutral tasks
- Neutral tasks: Talk about the weather, personal info, etc...
- Stressful tasks:

    1) Presentation of 5 minutes in front of 2 examiners

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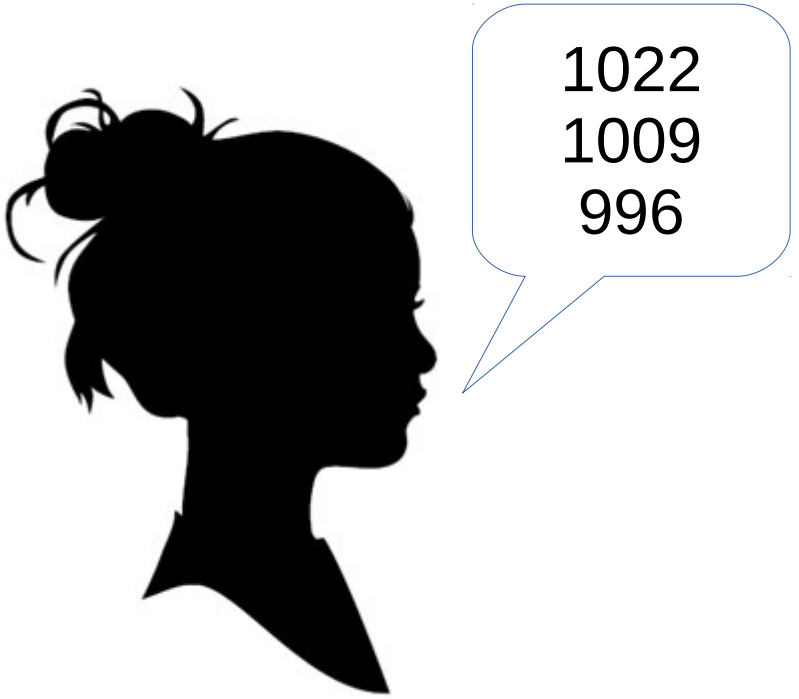


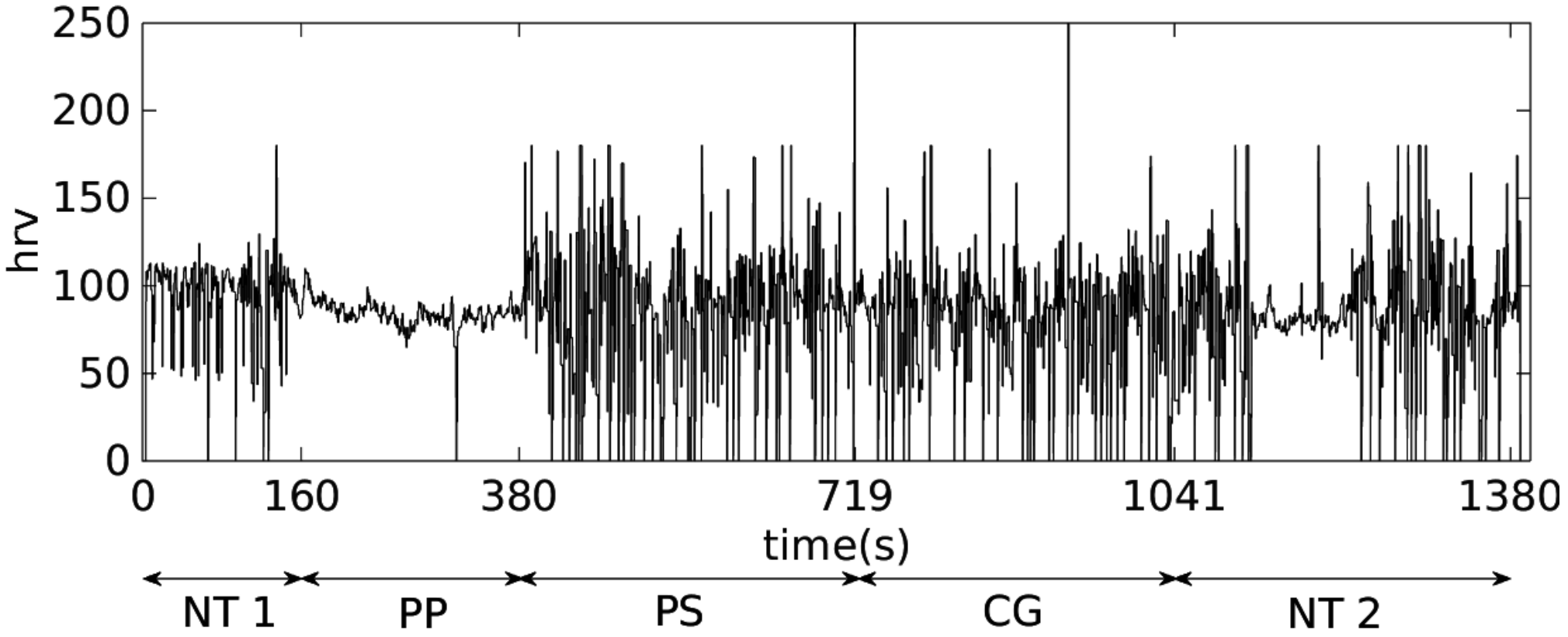
Dataset Recording

- During the TSST the physiological measurements are recorded together with the corresponding label (x_t, l_t)

$$x_t = \{ PPG_t, EDA_t, HRV_t, PPG_{corr} \},$$

$$l_t \in \{\text{“stressed”}, \text{“not stressed”}\}$$

Example Recorded Signals



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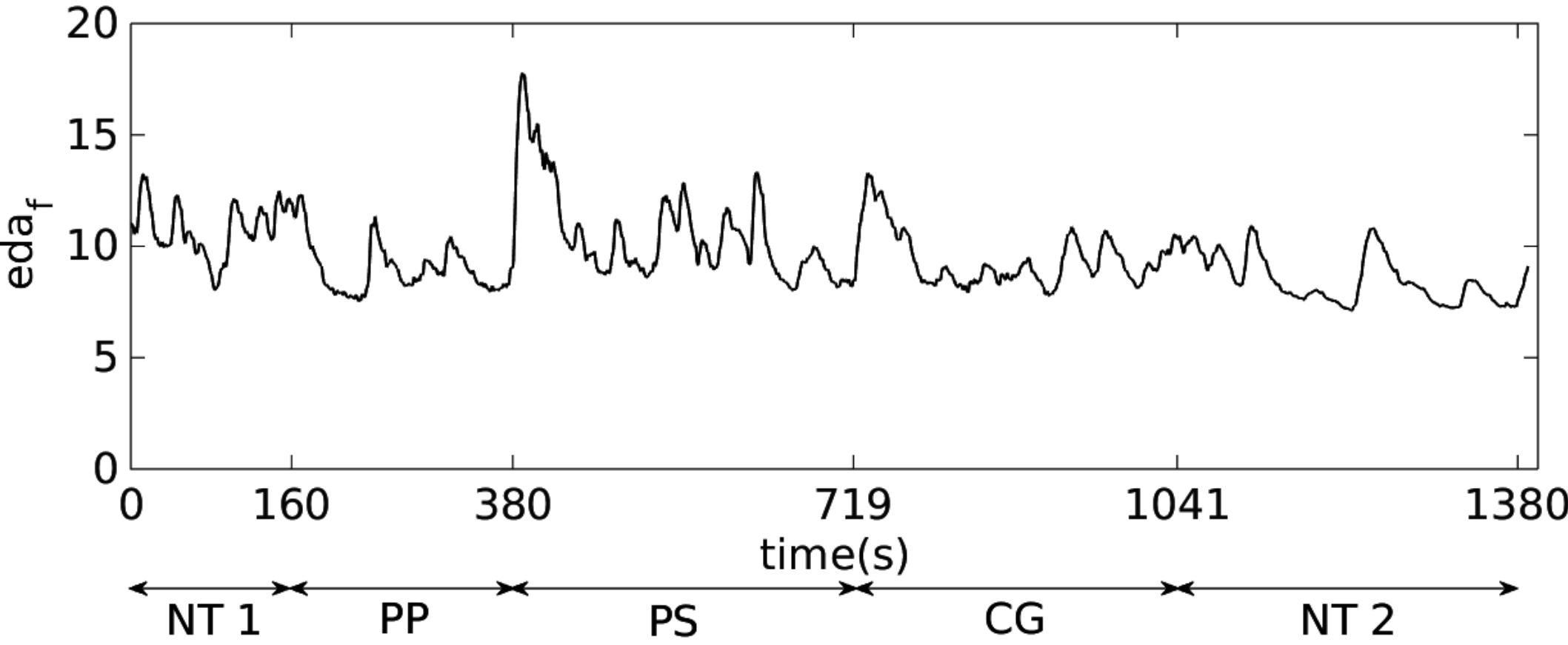
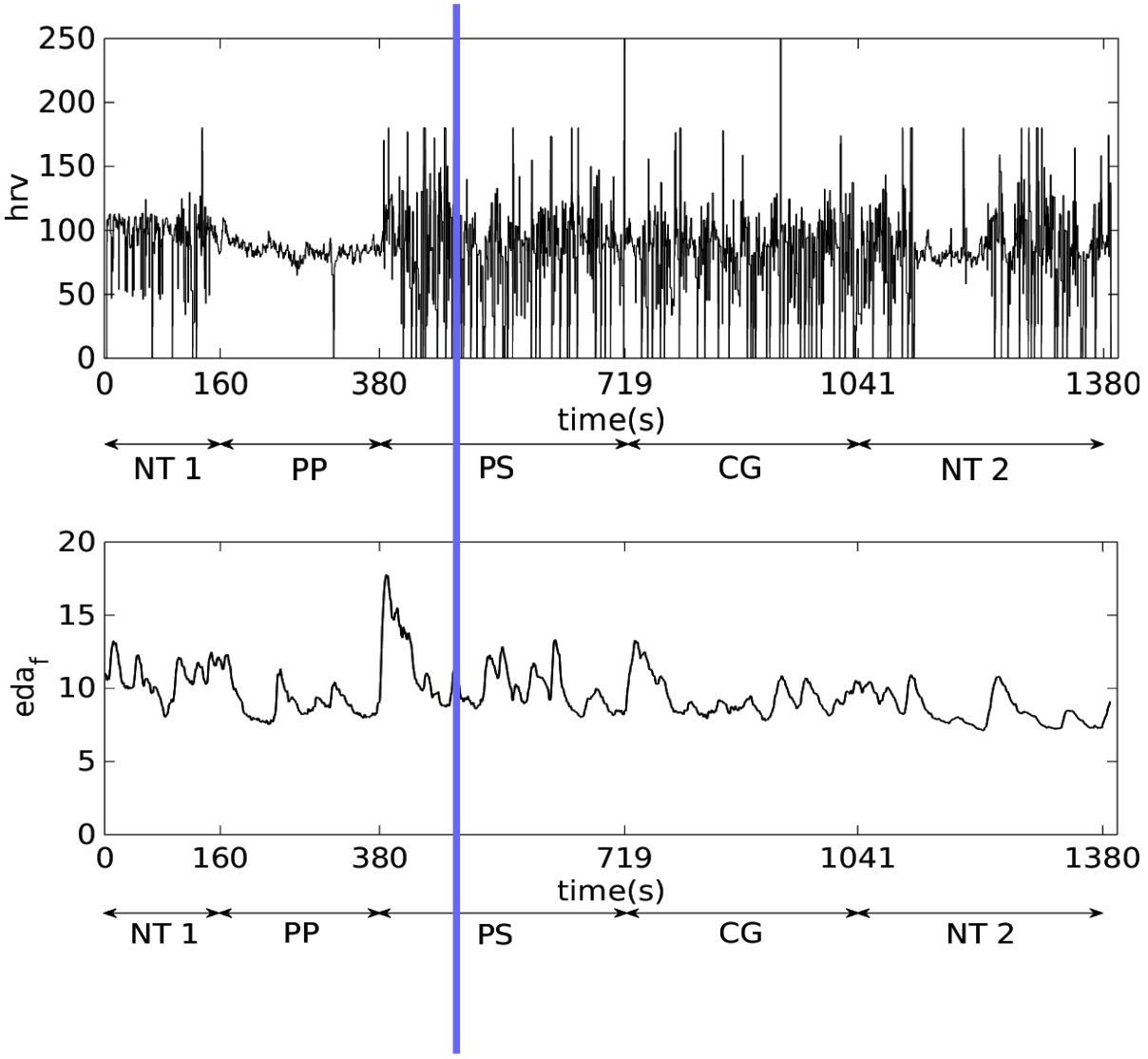


Feature vector for time t



$x_t = \{ HRV_t , EDA_t \},$

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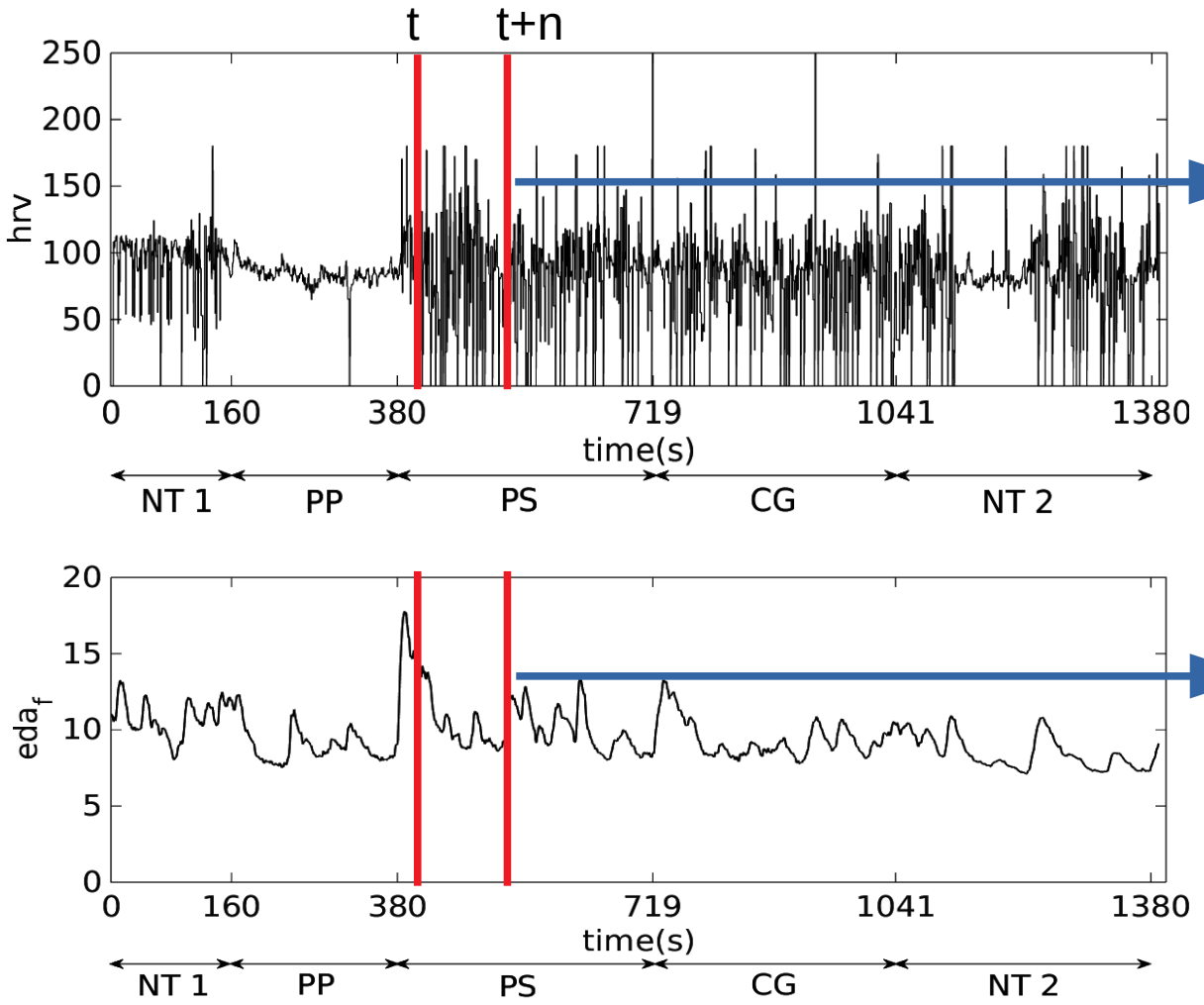


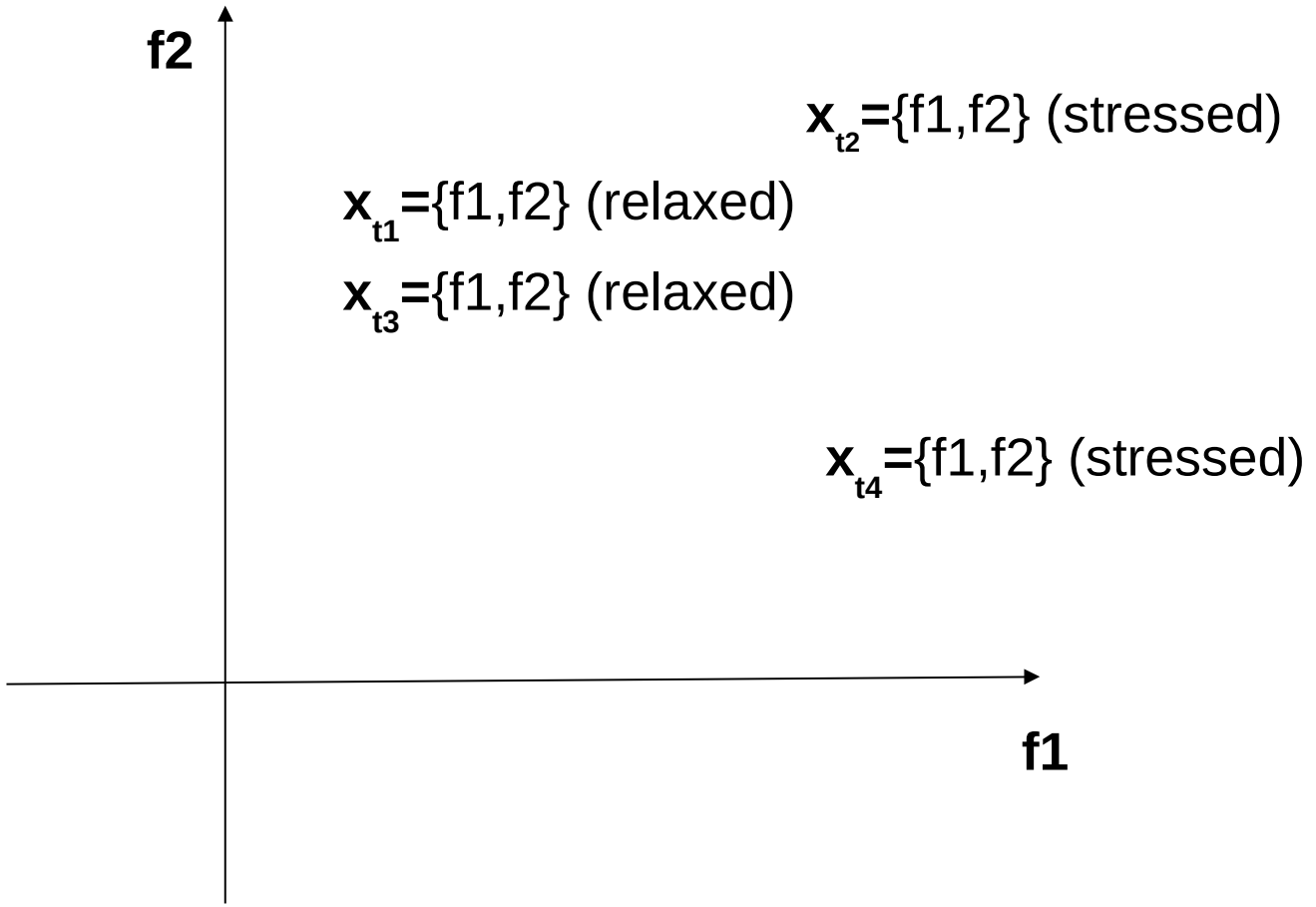
$f1 = \sum_{t}^{t+n} hrv_t$

$f2 = \sum_{t}^{t+n} hrv_t$

$x_t = \{ f1_t , f2_t \},$

Feature space

- We plot the feature vectors into the feature space which will be used by the classification algorithms.



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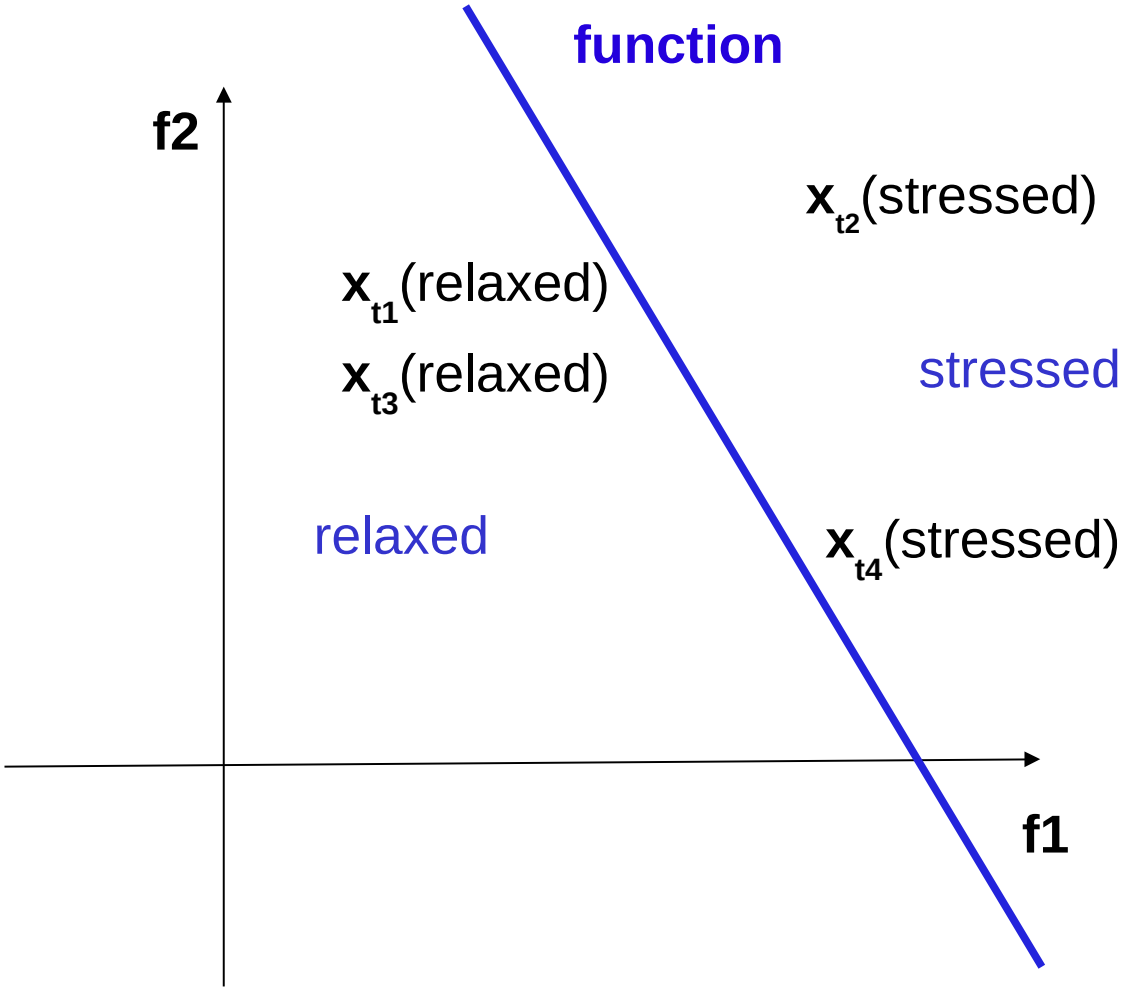
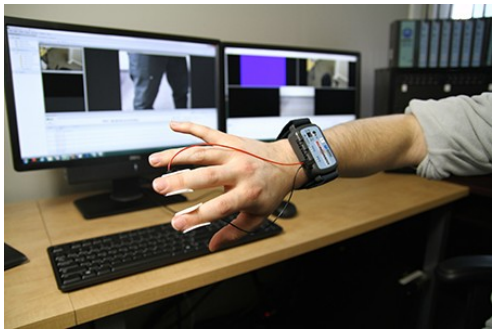
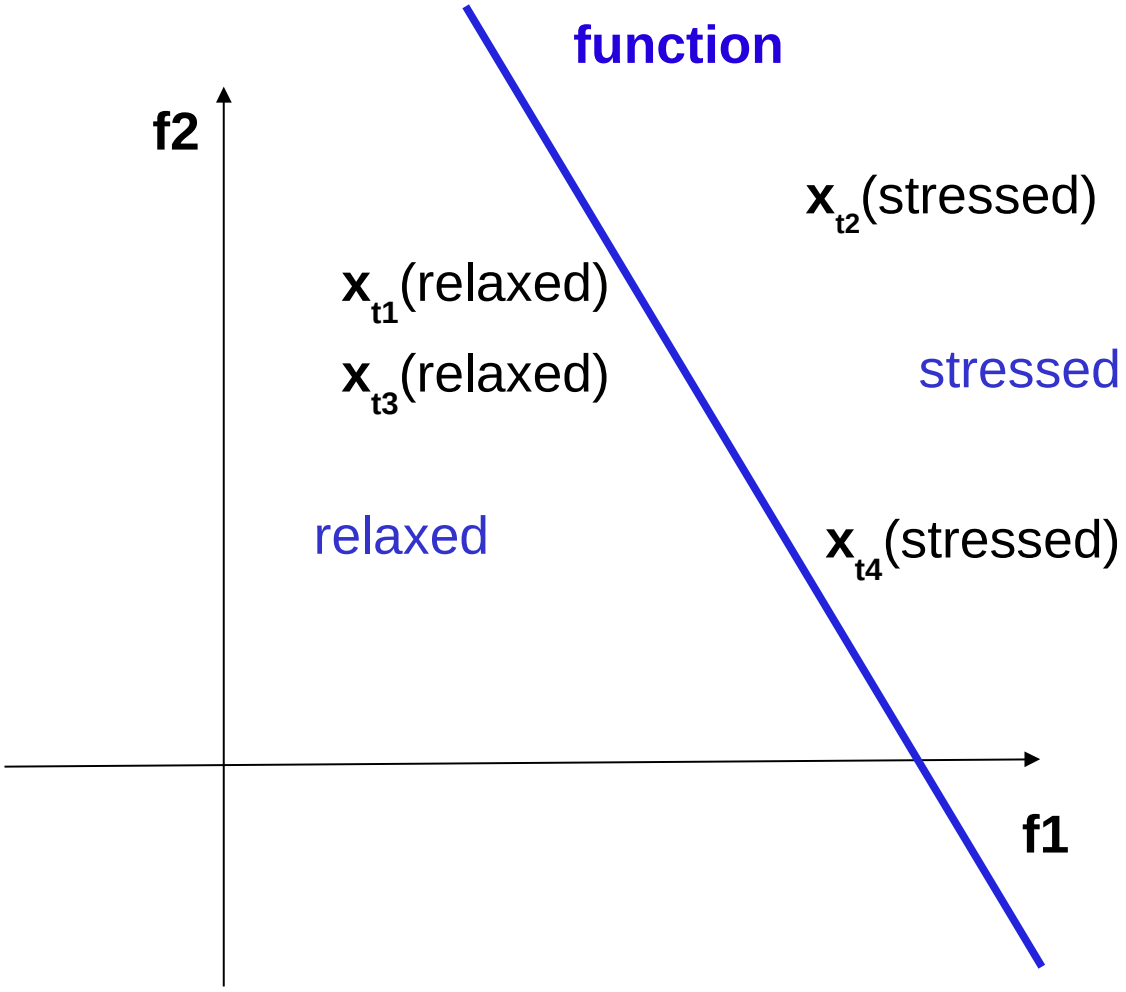


New measurement



x5 ={ f1, f2 }



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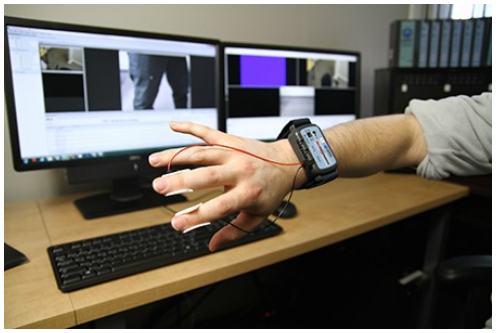

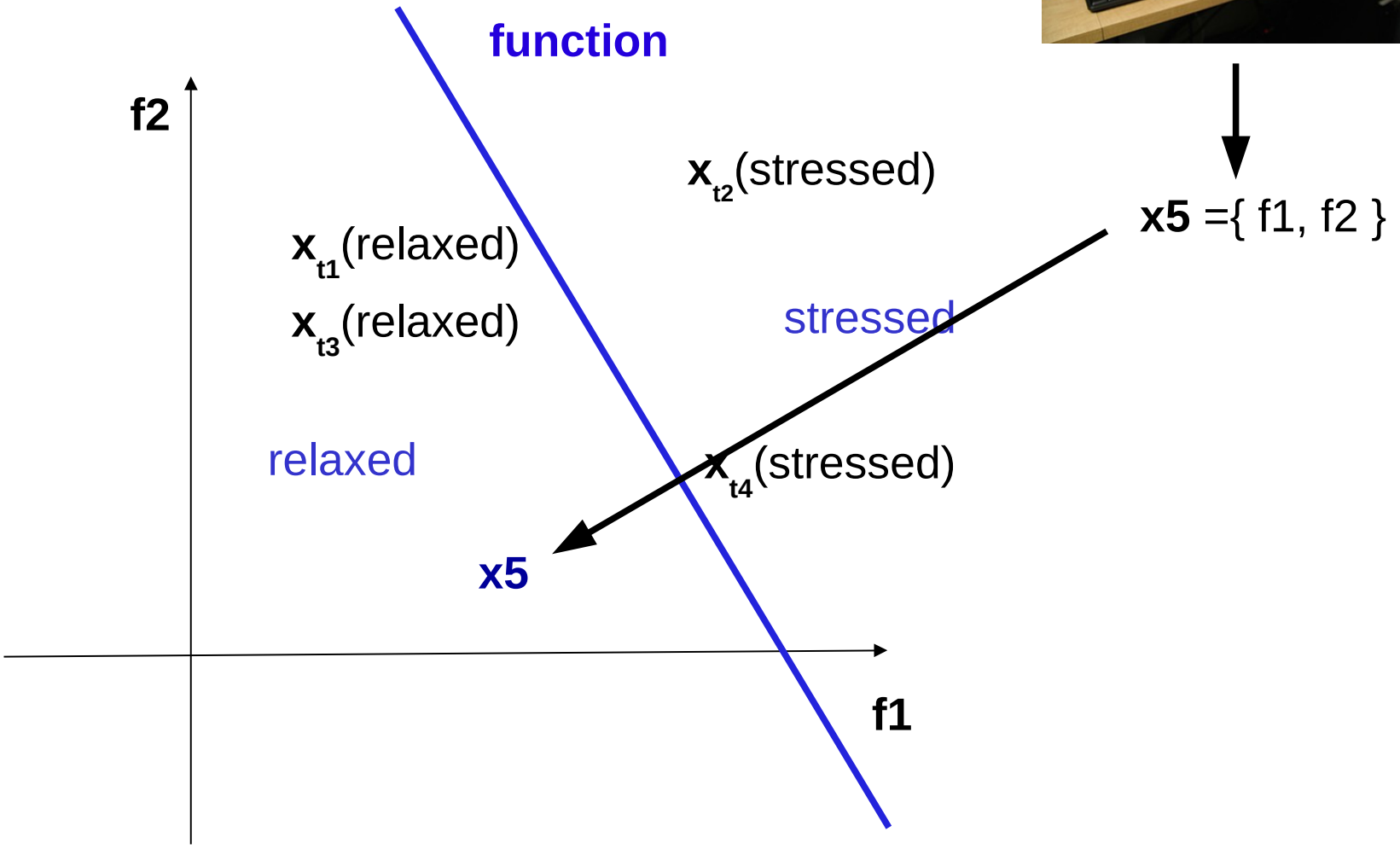

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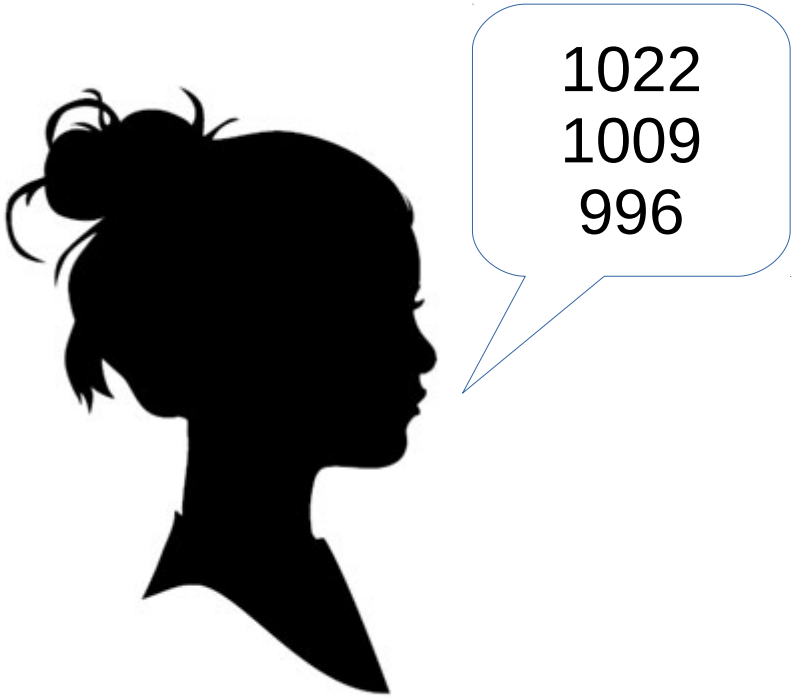

Experiments

- 5 persons participated in the TSST
- Each experiment around 20 minutes
- Dataset sizes:

|D 1 | = 11620, |D 2 | = 13450, |D 3 | = 13740,

|D 4 | = 13740, |D 5 | = 13000

- We train one individual SVM for each person (adaptation)
- 75% for training, 25% for testing

Results

Participant No.	Accuracy [%]	Precision [%]
P1	78.90	80.19
P2	73.26	73.61
P3	83.08	83.87
P4	82.82	83.20
P5	76.83	76.67

$$Accuracy = \frac{TP + TN}{TP + TN + FP + FN}$$

Positive=stressed

$$Precision = \frac{TP}{TP + FP}$$

Results

Participant No.	P1		P2		P3		P4		P5	
	stressed	not stressed	stressed	not stressed	stressed	not stressed	stressed	not stressed	not stressed	stressed
stressed	**94.04**	5.95	**88.21**	11.79	**90.50**	9.50	**91.55**	8.44	**91.62**	8.38
not stressed	60.62	**39.38**	50.73	**49.27**	29.49	**70.51**	32.53	**67.47**	49.36	**50.64**

- Bias to positive class “stressed”
- Double check if the person was really stressed or not

Discussion

- Difficult to stress people. Each person has a different behaviour.
- Difficult to get ground truth.
- Difficult to measure stress levels (how stressed are you?)
- How well does the stress classifier generalize to other people? → global vs individual