The use of sensor technology for early notification of stress in people with impaired cognition

Nanda de Knegt, Sylvia Huisman, Lindsey Welling, Nienke Vrenegoor – Prinsenstichting

Jolien Verstegen, Rieneke Dash – Severinus

Hanneke Smaling – LUMC

Jasper Bos, Stefan de Vries, Fransje van Oost, Dwayne Dillen, Can Bikcora, Denise Klep, Reon Smits, Eric Riegen, Erwin Meinders – Mentech

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The challenge

The idea for technology-based emotion sensing to better read and regulate emotions in people with a severe intellectual disability was born within the care organization Severinus. One of our buddies suffered from pain due to a hurting shoe. This pain led to severe discomfort and to challenging behavior, but he was not capable of verbally expressing pain sensation.

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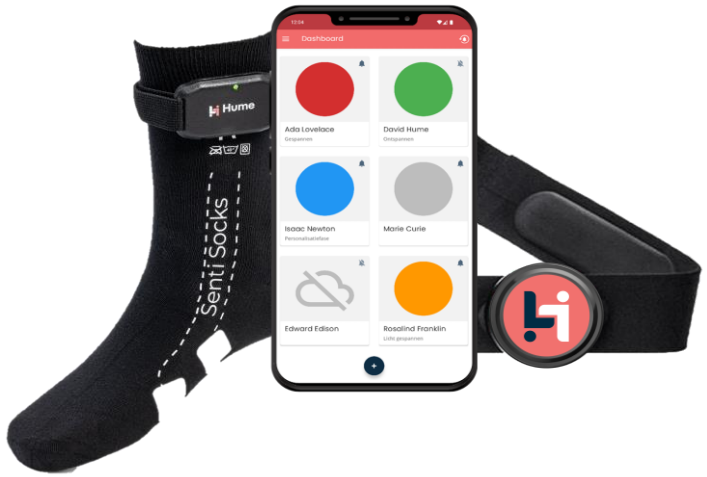
The solution

- Digital emotion detection based on physiology features (from smart wearables) and trained AI models to facilitate behavioral change, to improve self-management, to enhance quality of life and happiness.

- The solution provides the care professional with:
  - An early warning function (a traffic light), for early intervention to reduce the impact of challenging behavior, like auto mutilation
  - Diagnostics function to study the causes of escalations or challenging behavior and effect of possible interventions



Client value

- Reduction of escalations and incidents by early warning of stress and intime interventions to avoid these.
- Better understanding of the emotional wellbeing and thereby provide more efficient care, which leads to more happiness and quality of life.
- Self-management by learning to understand the causes of stress.
- Signal function for under-alertness
- A better trust relationship between the client and caregiver, which leads to better understanding of client's emotions, needs and behavior.

Stress detection with wearables

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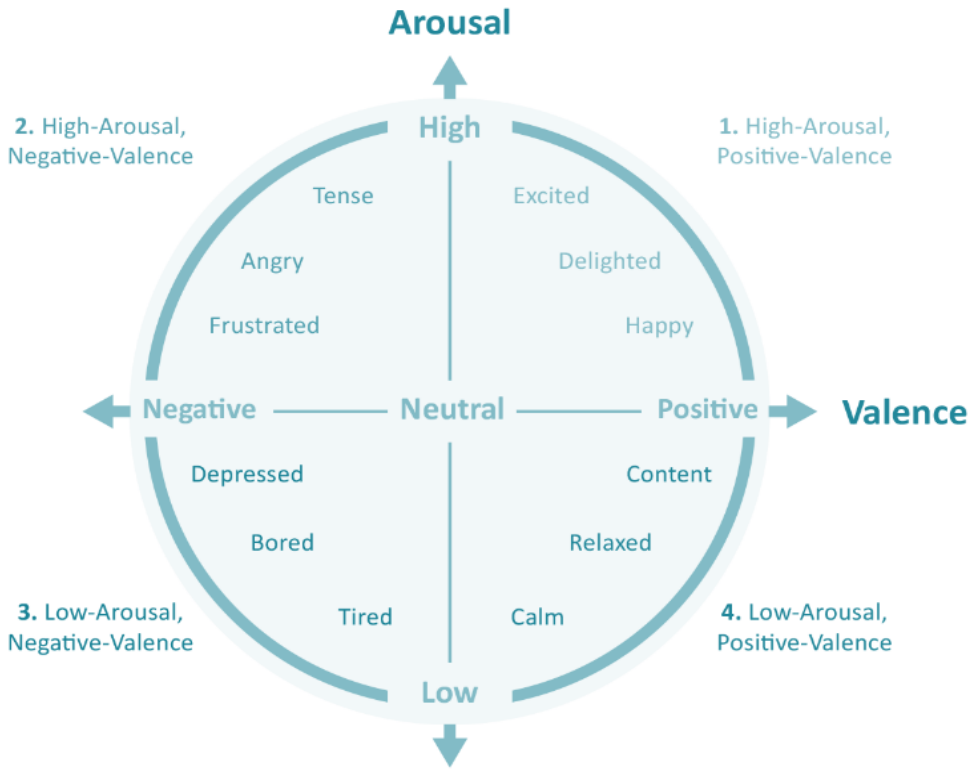
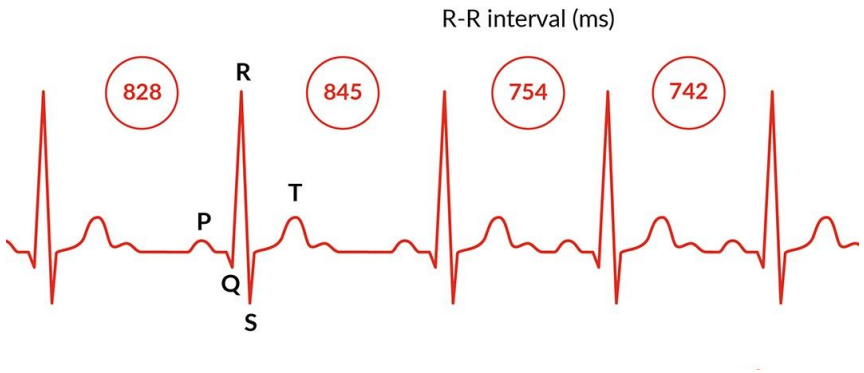
Circumplex model of affect

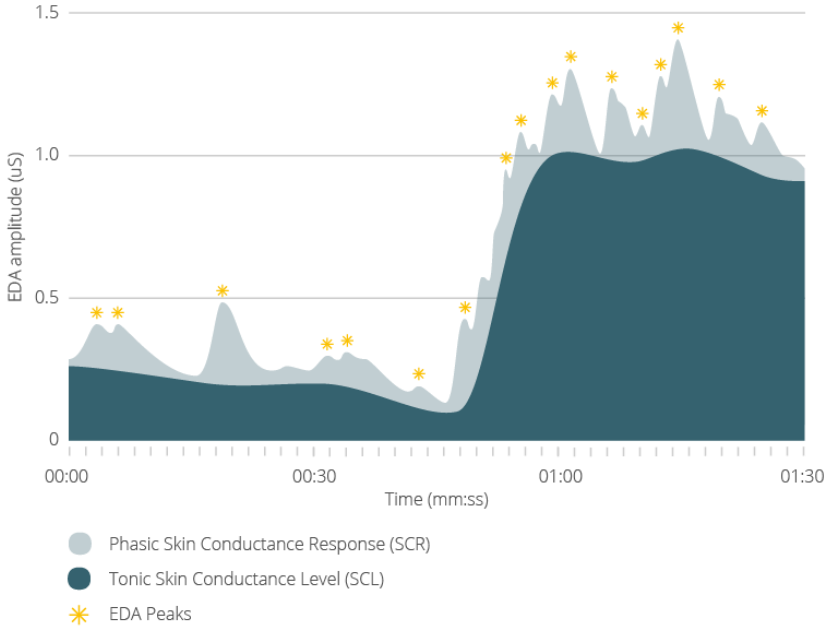
- The stress detection model is based on the circumplex model of affect, a theoretic model developed by Posner and colleagues (2005).
- The circumplex model provides a dimensional framework that can be used to distinguish and categorize emotions based on two physiological and cognitive dimensions: arousal and valence.
- Arousal is described as a mental of physical state that consists of a person's level of activity, and alertness.
- Valence is used to describe the nature or core characteristic of the emotional experience of an individual (that is: to which degree an emotion someone experienced was good, bad, or neutral).



Stress detection with physiology

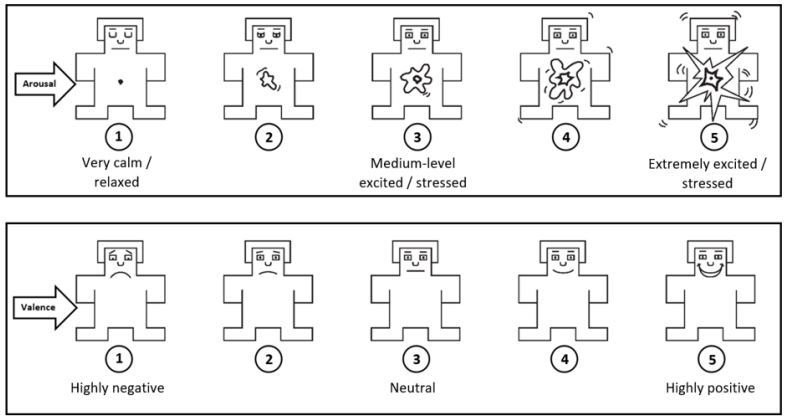
- The stress detection method utilizes the relation between stress and physiology;
- Relevant features include skin conductance (EDA), heart rate (HR) and activity;
- The Skin Conductance signal contains two components 1) the Skin Conductance Response (SCR) and the Skin Conductance Level, SCL);
- The Heart rate signals contains at least two relevant features: 1) inter-beat interval and (IBI) and variability (VAR);





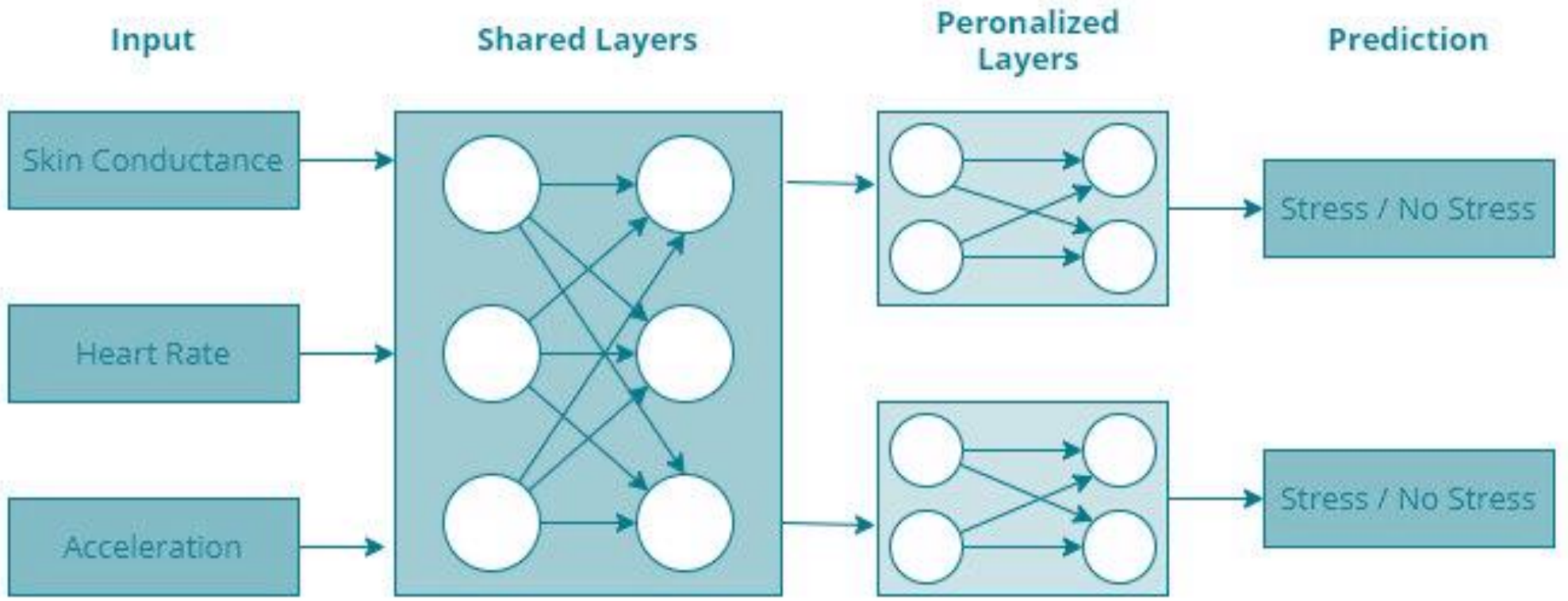
Stress detection with wearables

- A reference database was developed with labeled data of more than 150 test persons (over 200 hours of labelled data);
- The test persons were exposed to emotion content (such as VR video, VR games, mathematical excises, Stroop test) while the physiological response was captured;
- Core aspects of these tests included the balance in stress/non-stress events, relaxation periods and movement related factors;
- The labels were provided via self-annotation of the participants via SAM scoring;



Stress detection with wearables

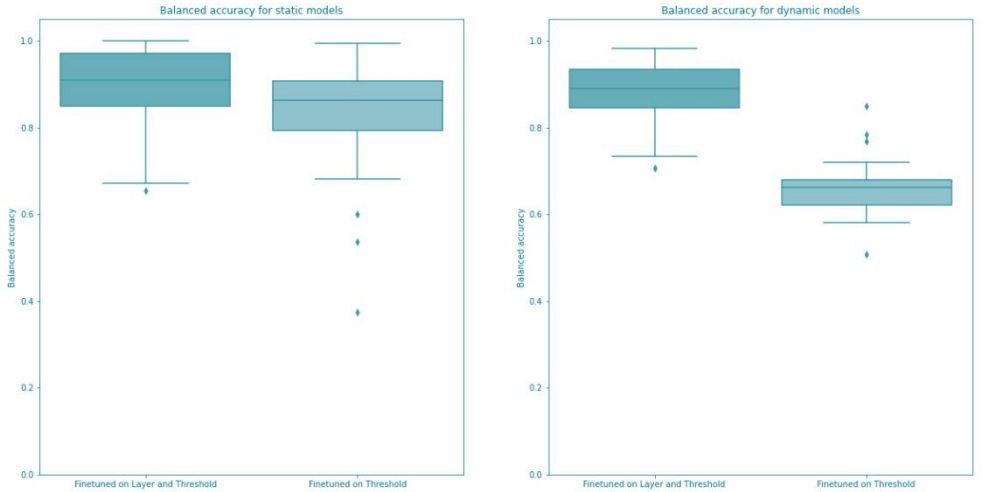
- The reference data set was used to train the neural network (AI) model framework for arousal detection;



Stress detection with wearables

- The static model, trained with data from test persons performing static tests without movement artefacts, gives an average balanced accuracy of 80%.
- The dynamic model, in which movement artefact are deliberately incorporated, shows a similar performance. The average balanced accuracy is 80%.
- The dynamic model results indicate the capability of the stress model to distinguish between physical movement and mental stress;

		Model prediction	
		Stress	Calm
Label	Stress	True positives	False negatives
	Calm	False positives	True negatives



Method

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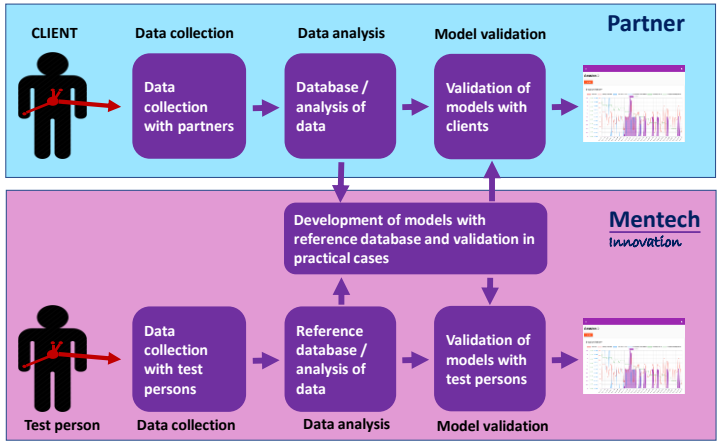
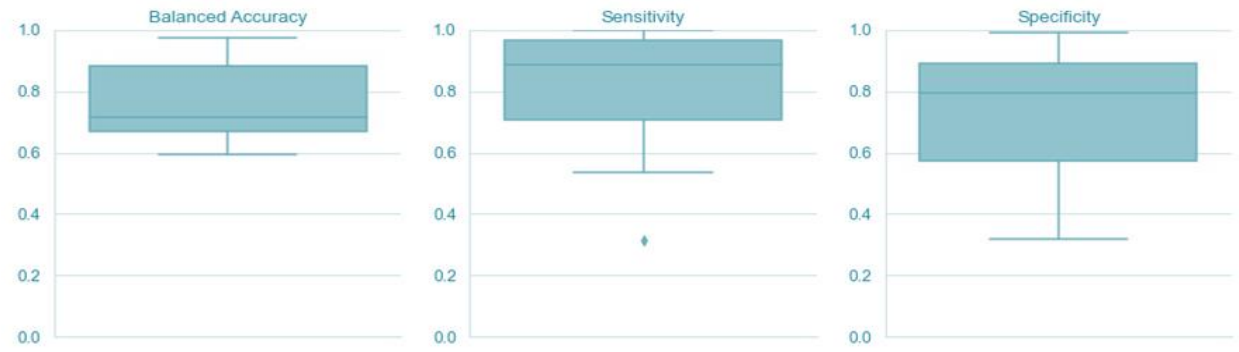
- The stress detection system was applied to clients in care homes, at the same time, video observations were made for behavioral analysis.
- The stress annotations from these video observations done by at least 2 independent care professionals were used as label to validate the stress model predictions.
- The validation study was assessed by the medical ethical committee of the VU Amsterdam (METC-VUmc) and declared non-WMO mandatory.
- Validation question: is the stress detection system able to recognize mental stress in people with intellectual disabilities, dementia or psychological problems using sensor technology and smart (e.g. machine-learning-based) stress index models?



Validation in care homes

- The trained model was validated with data from case studies performed in care homes;
- The data labels were provided from stress observations made by 2 independent care professionals (psychologist and personal caregiver) from video observations and signaling plans;
- In total 225 minutes of labeled data from in total 10 clients were included in the validation study;
- The average balanced accuracy of the stress model, was 76%. The normal accuracy was 77%. The average sensitive of the model is 80%, indicating that in 80% of the stress cases labelled by the observers, the stress model also labelled stress. The average specificity of 73% indicates that in 73% of the calm labels given by the observers, the stress model also labelled calm.



Results

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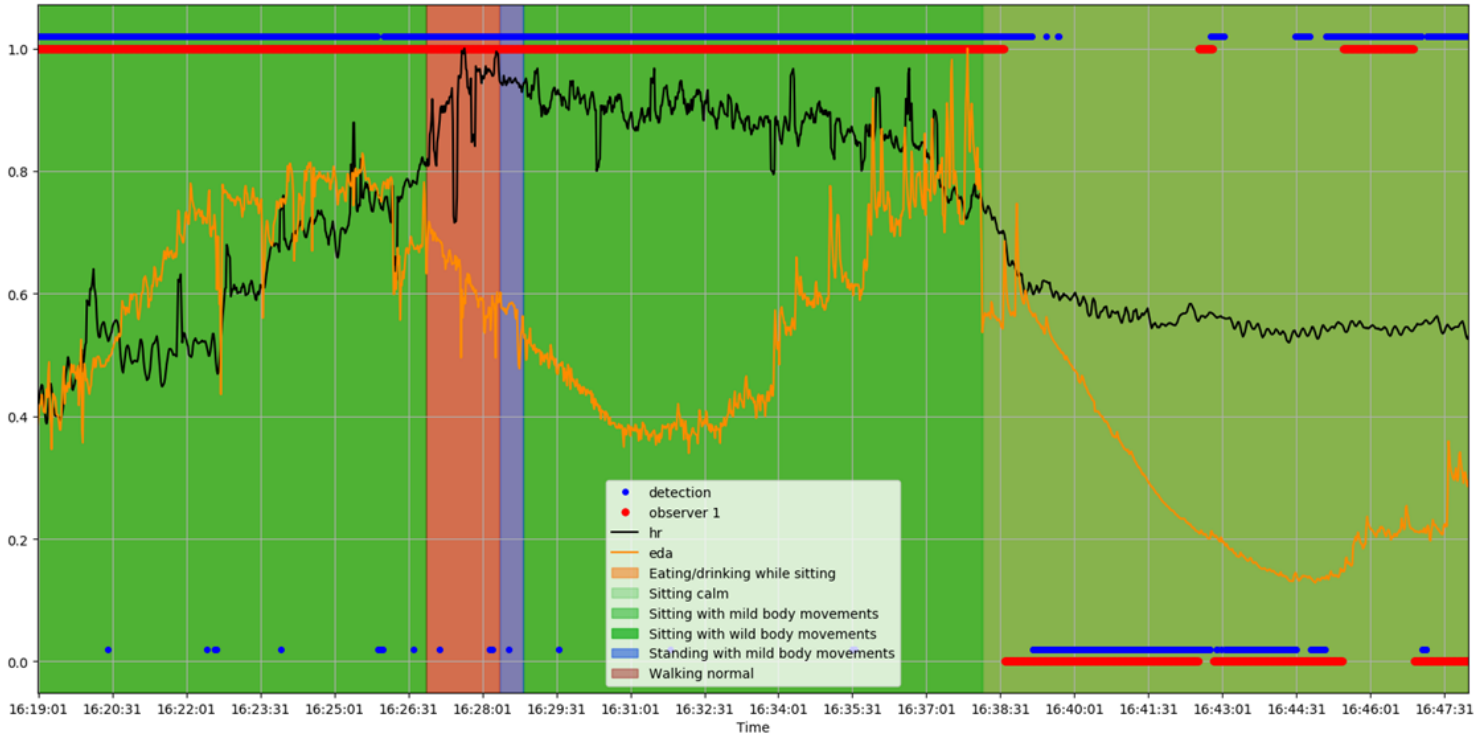
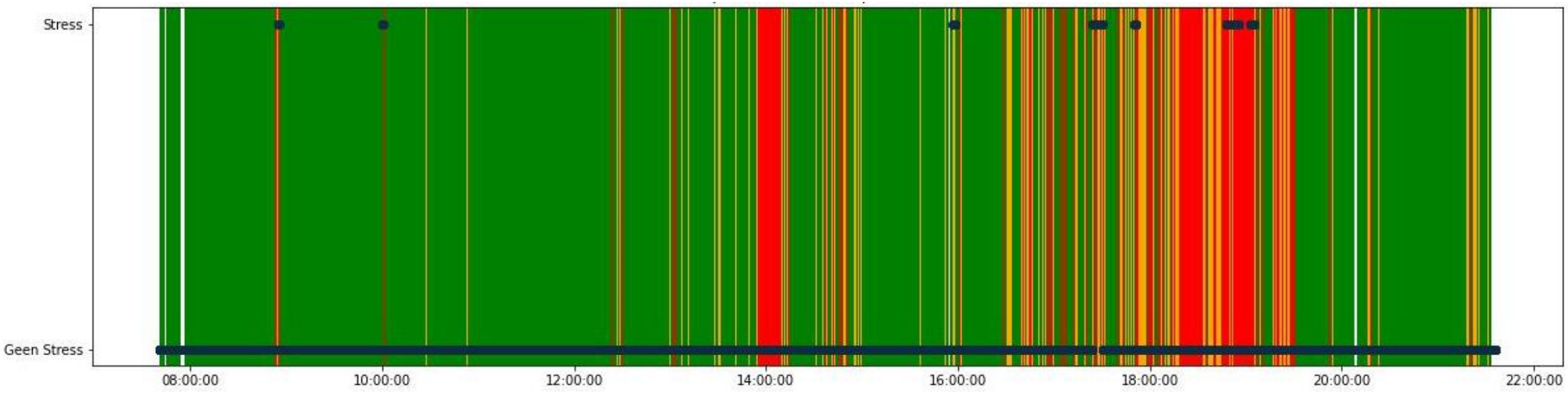
Application in care houses

- Example of case study: model predictions (blue) and annotation of two care professionals plotted in a de-escalation event.
- Accuracy basic model is ~75%
- Accuracy models after finetuning @ clientlevel is ~85%



Application in care houses

- Example of case study: early warning of an escalation



Conclusions

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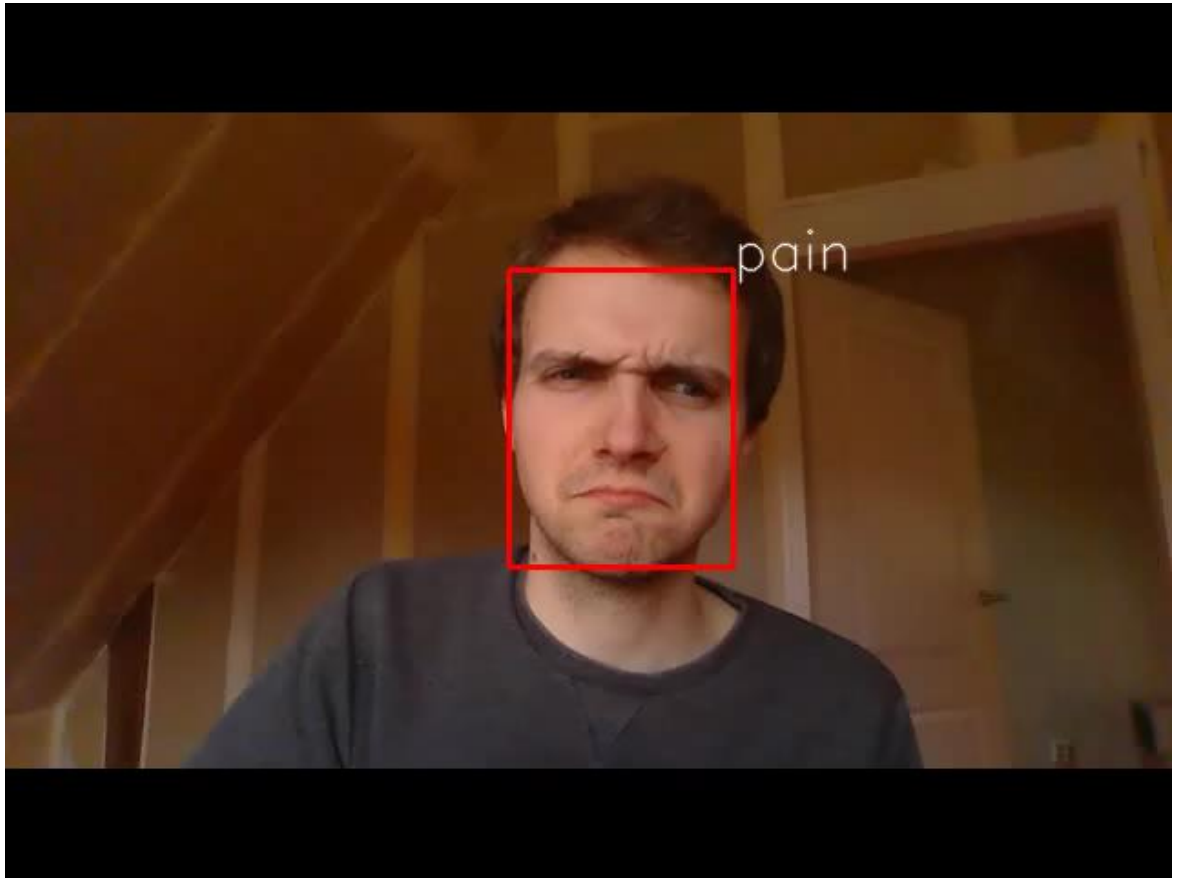
- Escalations are clearly reflected in physiology and are well recognized by the stress detection system;
- The system demonstrates its potential in detecting these escalations earlier than healthcare professionals often can;
- Tension seems to build up internally before it is expressed in behavior;
- The developed stress detection system is an accurate instrument to measure the effect of interventions, for instance taper off the need for medication (psychopharmaceuticals);

Future - roadmap

- Expand to pain detection and specific emotions
- Integrate additional wearables / features;
- Possibly include face and voice recognition in emotion detection platform;



Acknowledgements


Thank you for your attention!

Erwin Meinders, +31 (0)6 106 25250
erwin.meinders@mentechinnovation.eu
http://www.mentechinnovation.eu

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