SmartCoping: A mobile solution for recognizing and preventing stress

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www.smartcoping.net
Agenda

1. Starting point and motivation
2. Mobile stress warning based on vital data
3. Adding context data
4. Biofeedback
5. Summary and outlook

Stress is a societal problem

- Chronic stress is wide spread
- Associated diseases: burnout, depression, addiction
  - high health costs
  - high economic costs (absenteeism, early retirement etc.)

Support for treatment and prevention of stress
  - Patient self-management
Objectives of SmartCoping

Developing a smartphone app:

a) Warning when stress increases
b) Analysis: Which situations frequently show high stress level?
c) Relieving stress by means of Biofeedback
d) Validation of its effectiveness via medical field tests with the Forel Clinic

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Physiological stress indicators

- Increasing cortisol level
- Decreasing HRV
- Increasing heart rate
- Increasing skin conductance

HRV: Heart Rate Variability

- HRV is the *variation* of time intervals between two heartbeats.
- HRV is affected by the interplay between the sympathetic and parasympathetic nervous system.

In stress conditions HRV decreases!
HRV Measurements

- Body Sensor
- Transmission of heartbeats to smartphone
- Determine the variability of heart rate in 4-minute intervals

Various calculations for HRV:

- SDNN: standard deviation of RR intervals in the current time frame;
- RMSSD: root mean square difference of successive RR intervals in the time frame
- PNN50: percentage of pairs of adjacent RR intervals differing by more than 50 ms in a time frame (Bilchick and Berger, 2006)
- LF and HF: low and high frequency spectral powers
- LF/HF: balance between sympathetic and parasympathetic nervous system.
Problem: There is no general HRV threshold

HRV differs from person to person
Therefore, we cannot set any general threshold.

Solution:
The app adapts to individual user

→SmartCoping goes far beyond existing approaches

Application Scenario: With vital data only

How does the app know which patterns show stress?
User adaption: Learning Phase

HRV → Heart rate → Stress Recognition Patterns

User feedback on stress level

Application Scenario: Stress warning recognition

HRV → Heart rate → Stress Recognition Patterns → Stress Warning
Learning task: Learning a classifier for stress level

Classification attribute:
- Stress level = «high», «medium», «low»

Input attributes with respect to HRV:
- Lowest HRV within the time window
- Difference between the highest HRV value among all and the lowest HRV value within the time window
- Difference between the highest and the lowest HRV value within the time window

Input attributes with respect to heart rate:
- Highest HR within the time window
- Difference between the highest HR value among all and the lowest HR value within the time window
- Difference between the highest and lowest HR within the time window
Learning task: Time window

\[ \text{Feedback} \]

Learning from stress detection patterns: First results

- Decision Tree Algorithms (See5, YaDT)
- 100 Tuples – 2/3 as training data, 1/3 as test data
- Error rate on test data < 10%
Example of a learned decision tree…
(YaDT)

...error rate broken down by classes

<table>
<thead>
<tr>
<th>Class</th>
<th>Low</th>
<th>Medium</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actual</td>
<td>22</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>Classified</td>
<td>Low</td>
<td>Medium</td>
<td>High</td>
</tr>
</tbody>
</table>
Learning from stress detection patterns: Further steps

- How does the error rate **change** with more input data?
- How much do the **learning results** and **error rate** depend on the **input data**?
- Using other learning algorithms (support vector machine)

Problem: Good input data for fast learning

**Objective:**
Gathering feedbacks frequently

**Solution:**
The app automatically prompts the user to give feedback

**Objective:**
Gathering feedbacks in «interesting» situations

**Solution:**
Active Learning Principles – Generation of feedback prompts for major changes, extreme values, etc.
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Adding context data

Problems:
• «Positive» Stress – No Warning!
• Artefacts (especially from movements)

Solution:
Adding context data!

Additional features:
• Exact detection of stress patterns
• Analyze in which conditions stress is frequently high
Application scenario with context data

- HRV
- Heart rate
- Physical activity
- Daytime
- Location
- Relocation
- User feedback on stress level

Personalized stress warning with context data

- HRV
- Heart rate
- Physical activity
- Daytime
- Location
- Relocation

Stress Recognition Patterns

Stress Warning
History analysis

- Trend of stress levels (Hours, Day, Week, Month, Years)
- Analysis: Which situations frequently show high stress level?

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Stress reduction with biofeedback

Studies have shown the impact of biofeedback on HRV

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Summary

Innovation in the following aspects:

• **User adaptation:**
  Learning from individual stress recognition patterns

• **Interpretation of vital data within context**

• **Medical and therapeutic efficacy:**
  Field study with Forel Clinic

Outlook

Challenges still to be solved:

• **Artefacts:**
  Possible solutions:
  - Combine with context data
  - Better sensors (not too expensive)

• **Active learning:**
  Algorithm for monitoring the HRV data and generating feedback prompts for those “interesting” situations

• **Learning from reliable stress detection patterns:**
  Finding out the most suitable learning approach
  (Algorithms, Input)