Analysis and Monitoring of Mental Fatigue

André Pimenta Ribeiro
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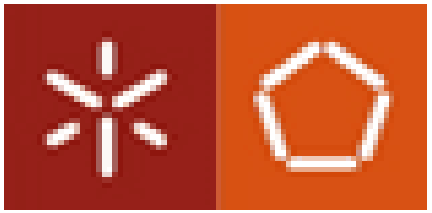

University of Minho
Department of Informatics

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Motivation

The Problem

Fatigue is considered one of the main causes for human failure and low performance.
It is also considered a key factor towards health and wellness

Application Contexts



Learning, Work, Productivity, Wellness and Health.

Objectives

Main purpose

A system capable of detecting and monitoring mental fatigue through the analysis of keyboard and mouse Interaction.

1. **Analysis of patterns of behavior and human activities**
2. **Development of a capture module**
3. **Collect data on user fatigue behavior**
4. **Analysis of the fatigue patterns**
5. **Validation of behavior patterns and models**
6. **Specification of an alert and recommendation system**

Fatigue

Fatigue

Lack of energy, physical exertion, physical discomfort, lack of motivation, and sleepiness

- **Mental fatigue:** difficulties with concentration, attention, visual perception, and somnolence
- **Physical fatigue:** loss of muscle strength, speed or agility, thus limiting the performance of physical tasks

Ambient Intelligence

A computer is seen as a proactive tool capable of autonomously adapting to the tasks of the day-to-day life of its user.

- **Sensing**
- **Acting**
- **Human-Computer Interaction**
- **Privacy and security challenges**

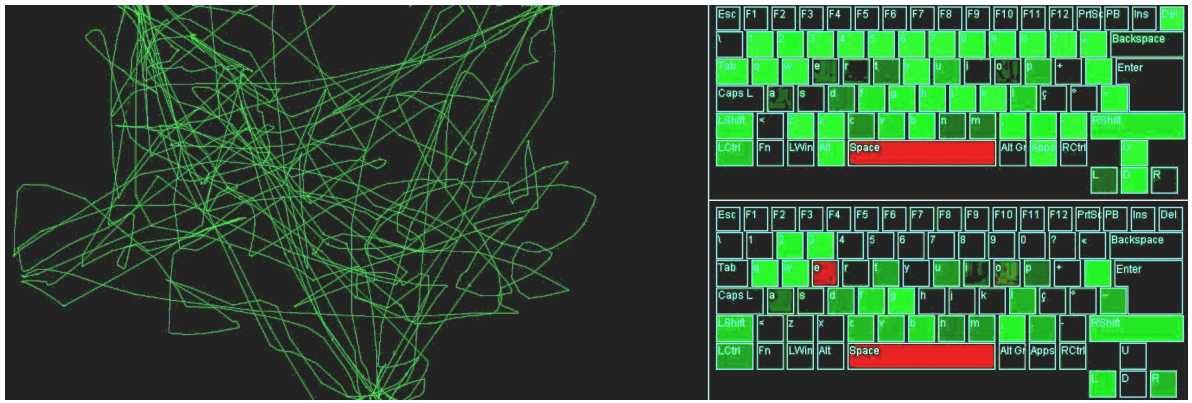
Fatigue Detection

fatigue symptoms

...A combination of symptoms that include low performance (loss of attention, slow reaction, poor performance in tasks where they have skills) and subjective feelings of sleepiness and tiredness...

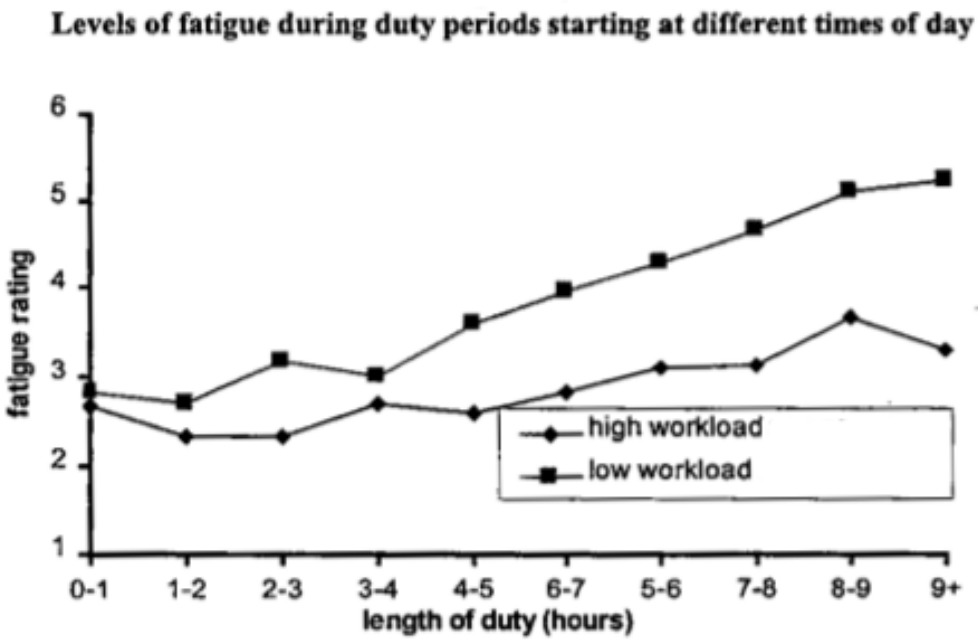
Behavioral Biometrics

Behavioral Biometrics, **keystroke dynamics** and **mouse dynamics**.



Methodology

- Collect data on user **normal** behavior
- Collect data on user **fatigued** behavior
- Using the concept of acute fatigue
- Statistical value with Mann–Whitney test
- Select the best metrics

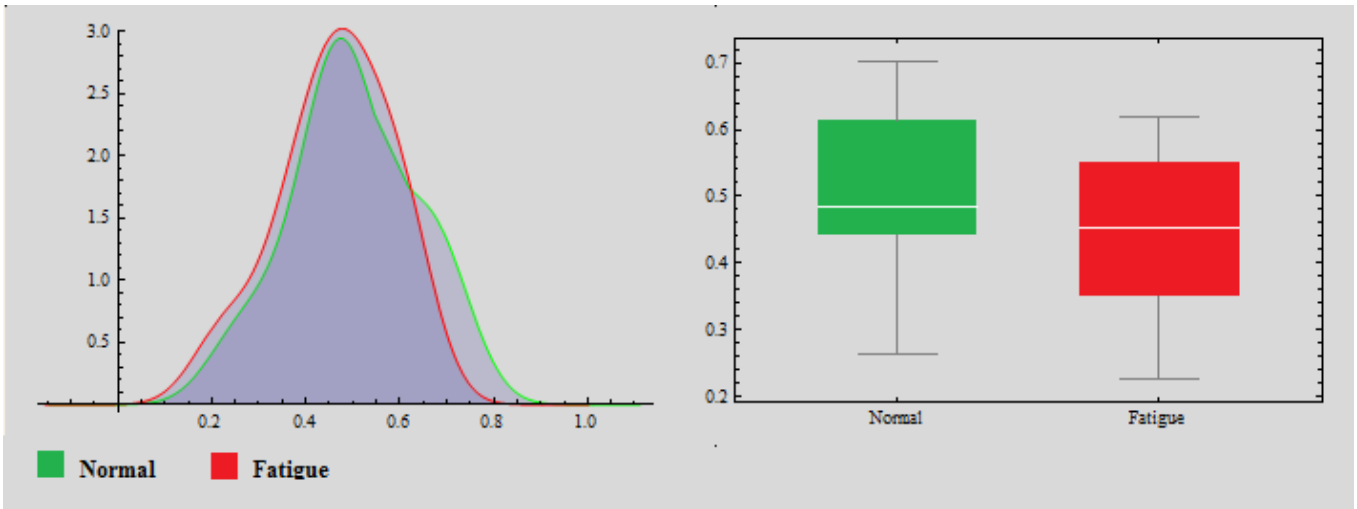


Case study

- 20 volunteers
- Data collected at the beginning and end of job
- Natural use of the computer
- Selected 5 of 14 metric under study:
  - **Mouse Acceleration**
  - **Mouse Velocity**
  - **Time Between Keys**
  - **Key Time Press**
  - **Error per Key**

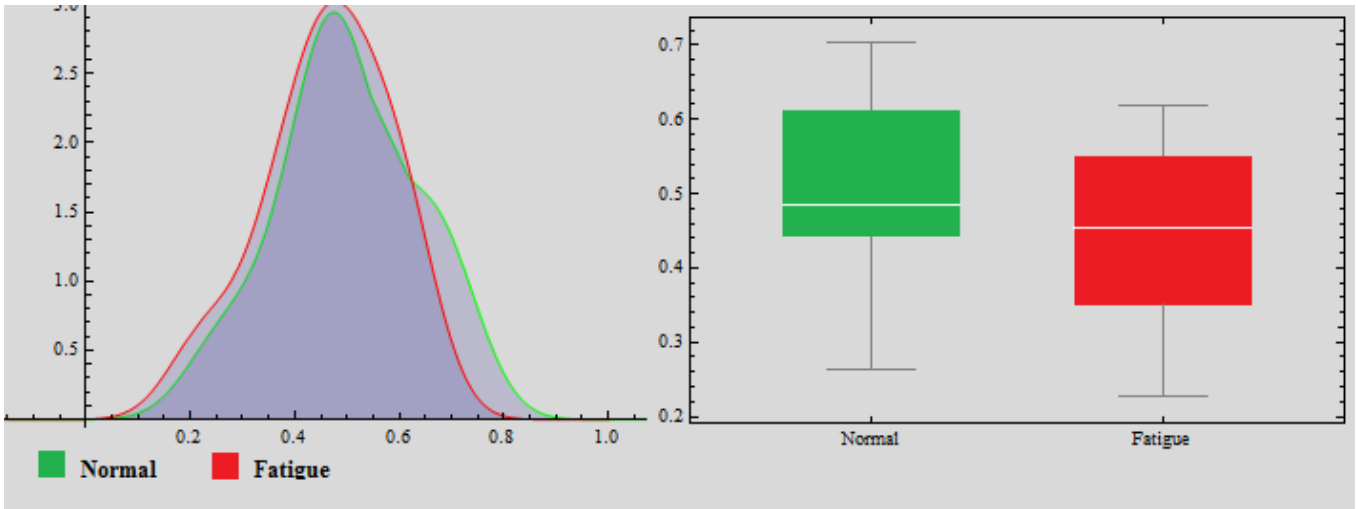
Mouse Acceleration

State	*Average*	*Standard D.*	*Median*	*Max*	*Min*
Normal	0.423	0.103	0.409	0.617	0.242
Fatigue	0.394	0.092	0.405	0.546	0.208



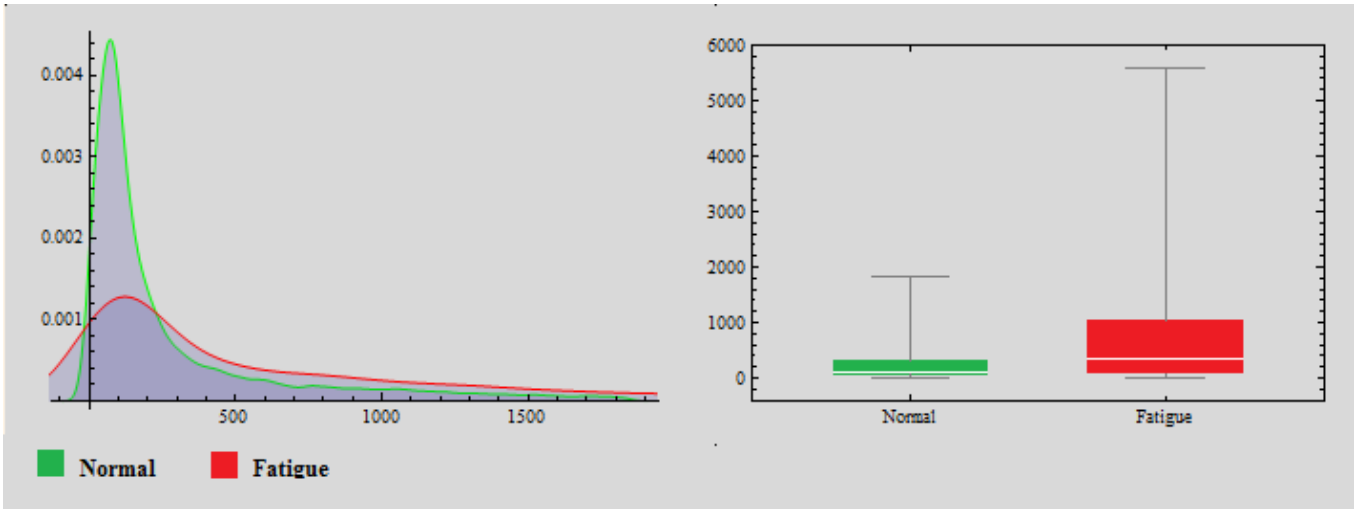
Mouse Velocity

State	*Average*	*Standard D.*	*Median*	*Max*	*Min*
Normal	0.500	0.132	0.484	0.702	0.262
Fatigue	0.462	0.119	0.469	0.618	0.226



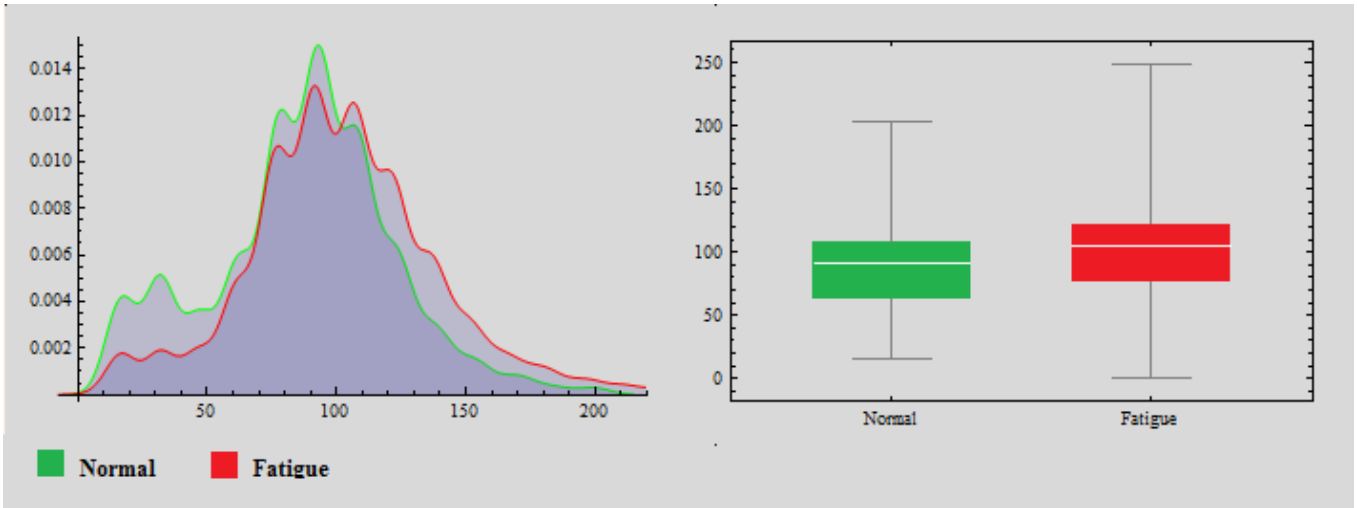
Time Between Keys

State	*Average*	*Standard D.*	*Median*	*Max*	*Min*
Normal	79.826	7.752	80.500	88.240	63.480
Fatigue	85.530	5.870	87.290	92.050	72.700



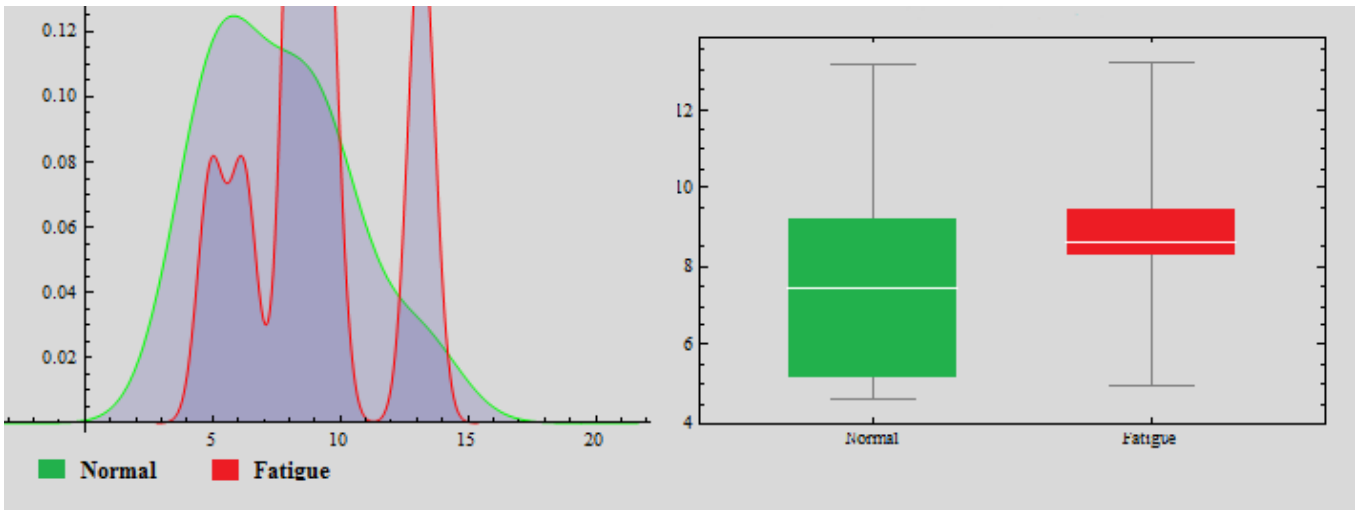
Key Time Press

State	*Average*	*Standard D.*	*Median*	*Max*	*Min*
Normal	469.193	399.321	299.726	1316.930	78.059
Fatigue	956.367	632.898	943.678	2156.400	87.892



Error per Key

State	*Average*	*Standard D.*	*Median*	*Max*	*Min*
Normal	7.643	2.768	7.444	13.137	4.625
Fatigue	9.010	2.600	8.597	13.217	4.942

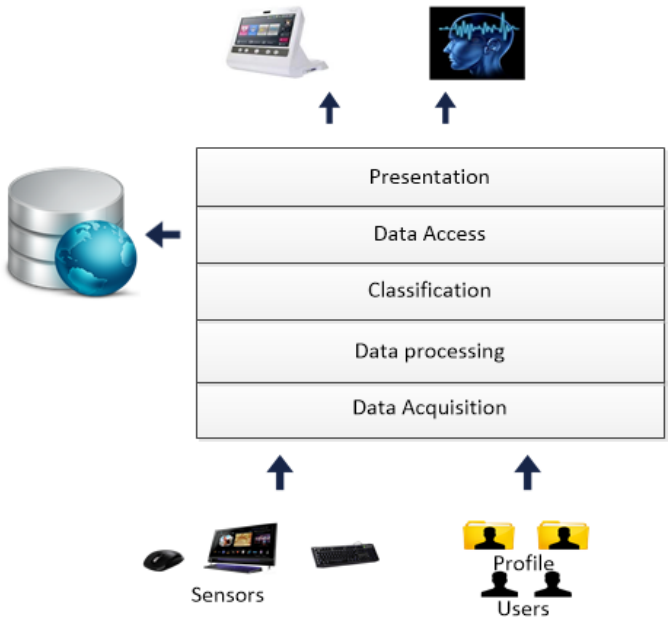


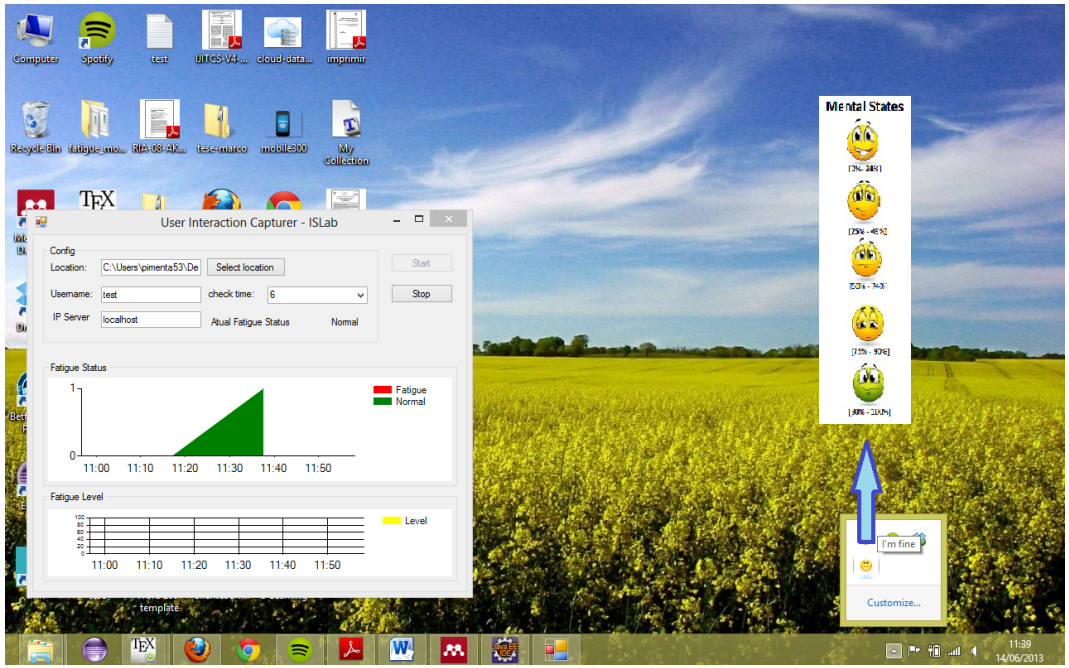
Classifying Fatigue

- K-nearest neighbors algorithm
- WEKA - weka.classifiers.lazy.ibk
- @attributes (mouse acceleration, mouse velocity, time between keys, key press time, error per key)
- A model based on instances of different users
- A model based on instances of a single user

Monitoring System

Prototype developed





Conclusions

- It is possible to detect and monitor fatigue through KeyStroke Dynamics and Mouse Dynamics
- Key press time, Time between keys, Mouse Acceleration and Mouse Velocity are good metrics
- Fatigue is manifested by the loss of performance and increased errors
- It is possible to detect acute fatigue with technological devices

Future Work

- Consider new metrics
- Introduction of external factors in the system, such as sleepiness, stress and mood states in order to improve the system
- Detection through new devices
- Validation through specialists in health and psychology

Relevant Work

- Carneiro D., Novais P., Catalão F., Marques J., **Pimenta A.**, Neves J., Dynamically Improving Collective Environments through Mood Induction Procedures, Ambient Intelligence-Software and Applications – 4th International Symposium on Ambient Intelligence (ISAmI 2013), Ad van Berlo, Kasper Hallenborg, Juan M. Corchado, Dante I. Tapia, Paulo Novais (eds), Springer - Series Advances in Intelligent and Soft Computing, Vol 219, ISBN 978-3-319-00565-2, pp 33-40, 2013.
- **Pimenta A.**, Carneiro D., Novais P. and Neves J., Monitoring Mental Fatigue through the analysis of Keyboard and Mouse Interaction, HAIS 2013 - 8th International Conference on Hybrid Artificial Intelligence Systems Patterns, Salamanca, Spain, to appear in LNAI Serie Springer 2013.

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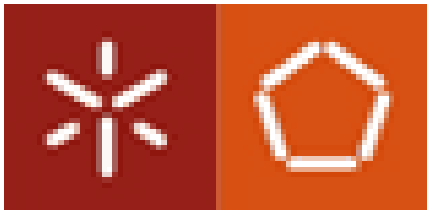

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