Universidade do Minho
Escola de Engenharia

José João Faria Pacheco

Analysis of interaction patterns - Attention

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José João Faria Pacheco

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Paulo Jorge de Freitas Oliveira Novais

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Nome: José João Faria Pacheco

Endereço eletrónico: pg23198@alunos.uminho.pt

Cartão de Cidadão: 12798861

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ABSTRACT

The attention, or focus, with which people perform their tasks has an important role on the success of them. Such tasks can be like study or work. Nowadays, our lifestyle can lead to a scatter of focus, especially when attending to several tasks or filtering loads of information, which in a laptop or desktop, can mean interacting with several applications simultaneously. This project will analyze and monitor the behavior of the users of desktop applications with the main aim to measure changes in user attention and focus throughout the day, and so, to know when a user is more focused and on better conditions to work. Leisure and work applications will also have an important play in this project, as the interaction with the laptop will be analyzed on both applications categories.

Keywords: Attention, Monitoring, Focusing

RESUMO

A atenção, ou concentração, com que realizámos tarefas tem um papel important na realização com sucesso das mesmas. Tais tarefas podem ser de estudo ou de trabalho. Hoje em dia, o nosso estilo de vida pode levar a uma dispersão da atenção, especialmente quando lidámos com várias tarefas ou informação, que num ambiente de trabalho pode significar interagir com várias aplicações simultaneamente. Este projecto irá analisar e monitorizar o comportamento dos utilizadores em aplicações com o objectivo principal de medir as mudanças na atenção do utilizador durante todo o dia, e assim saber quando um utilizador está mais focado e em melhores condições de realizar trabalho. Aplicações afectas ao lazer e ao trabalho também serão importantes neste projecto, dado que a interacção do utilizador com o portátil serão analisados em ambas as categorias.

Palavras-Chave: Atenção, Monitorização, Foco

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LIST OF ABBREVIATIONS

A2E2 Adaptive Ambient Empowerment for the Elderly

AAL Ambient Assisted Living

AAL JP Ambient Assisted Living Program Joint

ADHD Attention Deficit Hyperactivity Disorder

ADHD-PI Attention Deficit Hyperactivity Disorder - Predominantly Inattentive

AGNES User-sensitive Home-based Systems for Successful Ageing in a Network Society

AI Artificial Intelligence

AMI Ambient Intelligence

CAMCOF Context-aware MultimodalCommunication Framework

ECG Electrocardiogram

FCFA Frequent Change Focus Attention

ISLAB Intellilgent Systems Lab

KNN k-nearest neighbours

MAE Mean Absolute Error

1

INTRODUCTION

As a cognitive process, attention is strongly connected with learning and assimilating new concepts, either at school or at work. The lack of attention, or easily distraction, can be seen as a problem in some activities, like attending to lectures or multimedia learning (Mayer and Moreno, 1998) and car driving (Alm H, 1995). Concerning car driving, a study conducted in Norway revealed that on a high percentage of the accidents, the driver was using mobile telephone (Sagberg, 2004).

Also, on an extreme way, attention related problems are a psychiatric disorder, e.g. Attention Deficit Hyperactivity Disorder (ADHD), being one of its types Attention Deficit Hyperactivity Disorder Predominantly Inattentive (ADHD-PI). In order to minimize attention related problems, attention aware systems can be used, as it is already being done on fatigue detection systems in car driving and stress detection in computer users.

1.1 MOTIVATION

As attention as what keeps us focused, e.g. during a lecture, and allow us to assimilate it, it can be seen as one of the most important mental states.(Roda and Thomas, 2006)

Also, fatigue can be considered one of the major causes for human failure (Barker, 2009),(Dawson and Reid, 1997) , and it's when people are fatigued that they report more difficulties in concentrating and focusing their attention on the tasks they are required to perform (Maarten A.S. Boksem, 2005). As a key feature of dynamic behavior, allowing humans to process incoming information, attention is very important as it allow us to concentrate on the real important information.

This study shall be non invasive and non intrusive. On the contrary of other studies, e.g. "What's in the eyes for attentive input", conducted by Shumin Zai (Zhai, 2003) where systems were used that focused on eye gazing, in order to conduct this study, an application developed on ISLab and that was already used in other studies namely in "Monitoring fatigue in Ambient Assisted Living" (Pimenta, 2013) and "Analysis of the influence of stress on the interaction with the computer" (Catalão, 2013), will be used. This application allows the log and study of the interaction patterns with a computer, mainly concerning the movements of the mouse and keyboard typing.

1.2 BACKGROUND

There are already some approaches for detecting current attentional state and sensory based mechanisms for the detection of attentional states. In fact, amongst these approaches, the most common is gaze tracking that has been applied to the detection of current attentional focus of users performing several tasks, for instance participating on a virtual meeting, which can be considered invasive, and not very interesting for the study to be proposed (Posner, 1980).

Housed in a research topic in which has been studied and monitored the effects of conditions such as stress and mental fatigue in users, particularly in terms of mouse and keyboard usage on desktop applications, this project aims at analyzing the movements of keyboard and mouse in working considered applications (e.g. Office tools) and in leisure applications (e.g. websites considered leisure as social networks or news sites) and to try to detect attention/concentration on users based on application usage, having in consideration that the user is focused when using work applications and distrait when using leisure ones.

1.3 GOALS

It is intended to monitor user attention while working with their laptop or desktop. Such monitoring shall be non-invasive and invisible to the user. So, for this project, the following goals will be pursued:

- Definition of an experimental study to understand attention in the workplace.
- Data collection regarding desktop applications usage.
- Study the behavior of keyboard and mouse usage on work and its relationship with attention.
- Attention study based on the patterns of use of work/leisure applications.

1.4 RESEARCH METHODOLOGY

This project, in order to accomplish the goals presented, will and is following the Action-Research methodology (Kyriacou, 2007). This methodology begins with the identification of the problem so that it can allow the formalization of the hypothesis to be developed. During this process the information is collected, organized and analyzed on a continuous way, building a support to solve the problem. By the end, there should be possible to make conclusions from the analyzed and validated information resulting from the investigation.

In order to ensue the referred methodology, some steps must be taken:

- Specification of the problem and its characteristics;
- Constant and incremental update and review of the state of the art;
- Modeling and system implementation;
- Results analysis and conclusion formulation;
- System validation;
- Knowledge share, obtained results and experiences with the scientific community.

1.5 DOCUMENT STRUCTURE

This document's structure is as it follows: on Chapter 2 it is presented the concept of attention, it's importance and related problems. Besides the approaching of some attention monitoring systems, this chapter contains brief definition of work and leisure.

On chapter 3 it is approached the field of Ambient Intelligence. The forth chapter describes a non-invasive technology for attention monitoring and a set of metrics to it, where it is concluded the different usages patterns regarding the different types of applications.

On chapter 5 it is presented an experience based on the results of the previous chapter. In this experience it is also validated the developed prototype and the importance of attention on the classroom.

This document ends on Chapter 7, where it is done a synthesis of the conducted work, the thesis conclusions and some directions for future work.

2

ATTENTION

By attention we can mean a) "a concentration of the mind on a single object or thought, especially one preferentially selected from a complex, with a view to limiting or clarifying receptivity by narrowing the range of stimuli.", b) "a state of consciousness characterized by such concentration.", or c) "a capacity to maintain selective or sustained concentration" (dic), this in a psychological point of view. As for another point of view it can mean the courtesy or civility.

Therefore, attention can be seen as what keep us focused in performing a task, or tasks, with relevant success. Such tasks can be, for instance, listening to a lecture and assimilate it. In this case attention has a major role, as it is used to allocate human perceptual and cognitive abilities resources in the most effective way (Roda and Thomas, 2006).

2.1 ATTENTION CONCEPT

A possible definition for attention is "the cognitive process of selectively concentrating on one aspect of the environment while ignoring other things" (Anderson, 2009). Attention has been subject of several studies as well as several distinct subcultures: audition, visual perception, speed performance and physiological arousal (Kahneman, 1973).

Within attention there are levels, or types, described as:

- Focused attention: the capacity to respond separately to a specific visual, auditory or tactile stimulus.
- Sustained attention: the ability to keep a consistent behavioral response during uninterrupted and repetitive activity.
- Selective attention: the ability to maintain a cognitive set facing distractions or competing stimulus. Although there is no agreed concerning the definition of attention, most of re-

searchers refer to it as the set of process that enables and guides the selection of incoming perceptual information (Roda and Thomas, 2006). Selective attention has many variants, according to what tasks require the subject, such as a) inputs, or stimuli, from a particular source, b) outputs, or responses, in a particular category, c) targets of a particular type or d) a particular attribute of objects (Kahneman, 1973).

- Alternating attention: the capacity of mental flexibility that permits individuals to shift their focus of attention and move between tasks having different cognitive needs.
- Divided attention: the highest level of attention and is referred to the ability to respond simultaneously to several tasks.

As far as concerning the performance of several tasks, that can't be done if they are competitors, case in point, we cannot listen adequately to two conversations at once, even if both conversations are clearly audible, when attention is focused to each separately (Deutsch and Deustch, 1963). This can be explained by Broadbent's theory, case in point, when we are conducting a conversation while we are driving through city traffic and, as we are prepared to turn into the traffic, we normally interrupt the conversation. Whether attention is unitary or dividable was heatedly discussed by introspectionists in the nineteenth century, by experimentalists since 1950 and such question remains unanswered (Kahneman, 1973).

Attention and mental fatigue can be considered associated in the way that the lack of attention can be seen as a consequence of fatigue. When people become fatigued, they usually report difficulties in concentrating and focusing their attention on the tasks they are required to perform (Maarten A.S. Boksem, 2005).

When talking of attention, we must also refer the lack of it, or inattention, and the problems related to it, as well as mental disorders associated like Attention Deficit Disorder, also called Attention Deficit Hyperactivity Disorder Predominantly Inattentive, which usually has symptoms like not giving attention to details or makes careless mistakes in schoolwork, work or other activities. Having problems keeping attention on task or play activities, it is another symptom, according to DSM-5.

2.2 THE IMPORTANCE OF ATTENTION

Multitasking computer systems provide users a great value allowing to work with several applications and running numerous processes. However, having several applications running simultaneously may lead to environments full with notifications, alerts and messages, either from the operating system or from any of the main or background applications being executed. This leads to the importance to remain focused on a task, once that such ability is vital for any cognitive function, especially when there might be potential interference from distractors non pertinent to the task (Eric Horvitz, 1998). This importance can be noticed either at work or at lectures once that attention, as referred, is "the cognitive process of selectively concentrating on one aspect of the environment while ignoring other things", allowing us to learn.

2.3 ATTENTION RELATED CONDITIONS

Related with attention conditions, there's a psychiatric disorder named Attention Deficit Hyperactivity Disorder (ADHD). The already referred ADD, predominantly inattentive, is a subtype of ADHD, along with predominantly hyperactive-impulsive, and a combination of both subtypes. The common symptoms reported on an individual with predominantly inattentive can be easily distracted, miss details and forget things or having difficulty maintaining focus on one task. As for predominantly hyperactive-impulsive, the common symptoms are having difficulty doing quiet tasks or activities or often interrupting conversations or other's activities (Sandra JJ Kooij and Asherson, 2010).

2.4 ATTENTION DETECTION SYSTEMS

In this section shall be presented a set of systems, some already existing others only a research, to detect and monitor attention. As attention can be seen as a consequence of fatigue, some systems also aim to detect fatigue and attention. Most of the approached systems are implemented to detect and monitor humans behavior while car driving. Several car brands have their own attention, or fatigue, detection system.

Attention Assist – developed by Mercedes-Benz, Mercedes-Benz's Attention Assist is a system intended to help drivers to recognize when they are drowsy or inattentive. When drivers are alert, they constantly, and subconsciously, monitor the position of their car and make continual

Figure 1: Attention Deficit Hyperactivity Disorder, (ADH)

small steering adjustments to keep the vehicle on a safe path. However, when drivers are fatigued, there are periods of inattentiveness, during which there is little steering input, followed by sudden and exaggerated corrections when the driver regains attention. This system uses a sensitive steering angle sensor to monitor the way in which the driver is controlling the car. At speeds between 80 km/h and 180 km/h, the system identifies a steering pattern which is characteristic of drowsy driving and combines this with other information such as time of day and duration of journey. If a sequence of such events is identified, the system warns the driver to take a break by showing a coffee cup signal in the dash and by an audible tone (Daimler).

An automated optimal engagement and attention detection system using electrocardiogram – although isn't an attention detection system, this research proposes to develop a monitoring system which uses Electrocardiograph (ECG) as a fundamental physiological signal, to analyze and predict the presence or lack of cognitive attention in individuals during a task execution. This research aims to identify the correlation between fluctuating, i.e. change continually, level of attention and its implications on the cardiac rhythm recorded in the ECG. Furthermore, Electroencephalograph (EEG) signals are also analyzed and classified for use as benchmark for comparison with ECG analysis (Ashwin Belle and Najarian, 2012). This study will be somehow invasive, once it will use biometrics like ECG.

Figure 2: Attention Assist, (Care)

Attention Assistant – this system operates somehow in a similar way to others on the car market, measuring a variety of driver inputs, such as steering, on an ongoing basis looking for deviations. When a pattern is detected, it offers an audible tone, along with the words, “Break Recommended” in the display (BMW).

Fast Detection of Frequent Change in Focus of Human Attention – although not an already implemented attention detection system, this project presents an algorithm to detect attentive behavior of persons with frequent change in focus of attention (FCFA) from a static video camera. Such behavior can be easily perceived by people as temporal changes of human head pose. The authors propose to use features extracted by analyzing a similarity matrix of head pose by using a self-similarity measure of the head image sequence. Further, the authors present a fast algorithm which uses an image vector sequence represented in the principal components subspace instead of the original image sequence to measure the self-similarity. An important feature of the behavior of FCFA is its cyclic pattern where the head pose repeats its position from time to time. A frequency analysis scheme is proposed to find the dynamic characteristics of persons with frequent change of attention or focused attention. A nonparametric classifier is used to classify these two kinds of behaviors (FCFA and focused attention). The fast algorithm discussed in this paper yields real-time performance as well as good accuracy (Nan Hu and Ranganath).

How to Detect a Loss of Attention in a Tutoring System using Facial Expressions and Gaze Direction – Tutoring systems try to help students with certain topics, but unlike a normal teacher it is not very easy to notice when a student is distracted. It is possible to detect the gaze direction to detect a loss of attention, but this might not be enough. This project focus on a detection system that uses the detection of facial expressions and gaze direction to recognize if a student is distracted, plus several actions that can be performed to get the student back (t. Maat).

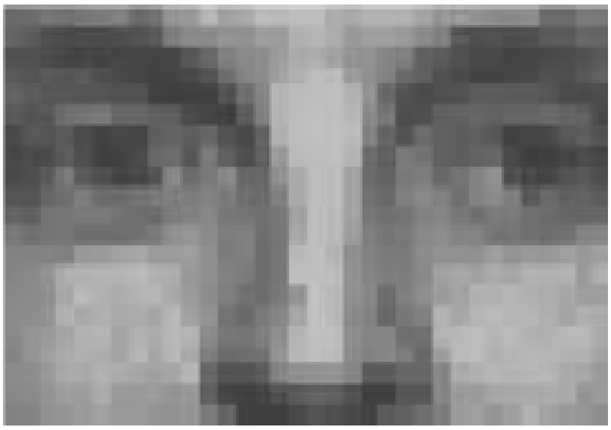

Figure 3: A typical face pattern,(t. Maat)

2.5 LEISURE AND WORK ACTIVITIES

Apart from Attention concept, this dissertation thesis will approach also leisure and work activities, mainly usage patterns, on both activities, when using computer applications.

2.5.1 *Leisure*

By leisure we can mean a) “freedom from the demands of work and duty”, b) “unhurried ease” or c) something “designed or intended for recreational use” (dictionary). Leisure activities can have an important role concerning antisocial behavior once that, regarding adolescents, participation in highly structured leisure activities was connected with low levels of antisocial behavior (Mahoney JL, 2000).

2.5.2 *Work*

Work, in a quick look over an English dictionary, means a) “exertion or effort directed to produce or accomplish something; labor; toil”, b) “productive or operative activity” (dictionary). Excessive time at work can be a problem that doesn’t affect equally everyone one. Factors like companies asking the remaining personnel to do more and the fact that, nowadays, through technology like computers people can work from home, public places or even on vacation, which leads to an excessive time at work thereby causing serious implications for health and safety (Porter, 2001). For this thesis, the concept of work will be more related with the attendance of working computer applications like Microsoft Office, IDE Microsoft Visual Studio or Eclipse.

2.6 SYNTHESIS

The concept of attention is, therefore, highly complex. Attention severe problems are among psychiatric disorders and even the non-psychiatric problems, like inattention, causing difficulty on tasks performance, should be monitor. Having in mind indicators such as the time reaction, it is possible to monitor attention on individuals. As for the concepts of leisure and work, which can be considered much simpler, they'll be monitored based on keyboard and mouse movements, concerning some different metrics, in order to detect usage patterns and possible differences. The work that has been done concerning the attention detection engines on the image capture or ECG, which is clearly an invasive way to do it. On this thesis dissertation there will be proposed a non-invasive method to monitor attention, free of image capture.

3

AMBIENT INTELLIGENCE

This dissertation engines on Ambient Intelligence, a new paradigm of IT. Also, the whole work behind this dissertation, especially the attention monitoring, will lay on Ambient Intelligent. In this chapter this concept will be approached, as well as its main usages, benefits and future perspectives.

3.1 AMBIENT INTELLIGENCE CONCEPT

Ambient Intelligence (AmI), as referred, is a new paradigm of IT, bringing out a potential impact on the near technology future (Ducatel et al., 2003), (Ducatel et al., 2001). On AmI concept, a person should be surrounded by intelligent objects that can understand the context where they're inserted, fitting themselves to it and giving response the persons need's. In Ambient Intelligent, users are centered on a digital environment that senses the presence and context on which they move, being sensible, adaptable and answerable to their needs, habits, attitudes and emotions, providing services. AmI can be seen as a multidisciplinary area encompassing features of several computational science areas (Brumitt et al., 2000), (Cook et al., 2009). Within AmI, a computer is seen as a proactive tool able to adapt in an autonomic way to daily tasks of its users, having as purpose helping them by making their tasks easier. According to AmI paradigm, there's no need of a traditional interaction with computers, once they can be used on a non-conventional way, e.g. by usage of verbal or gestural language (Cook et al., 2009). It is also a feature of AmI the interaction of men with machine through user-friendly interfaces.

In order to obtain an AmI environment, we must have some important components, which will be presented the most relevant for this dissertation.

Sensing – the usage of sensors it is extremely important on AmI. It's through sensors that the AmI components perceive the environment they are. Such sensors can collect several types of

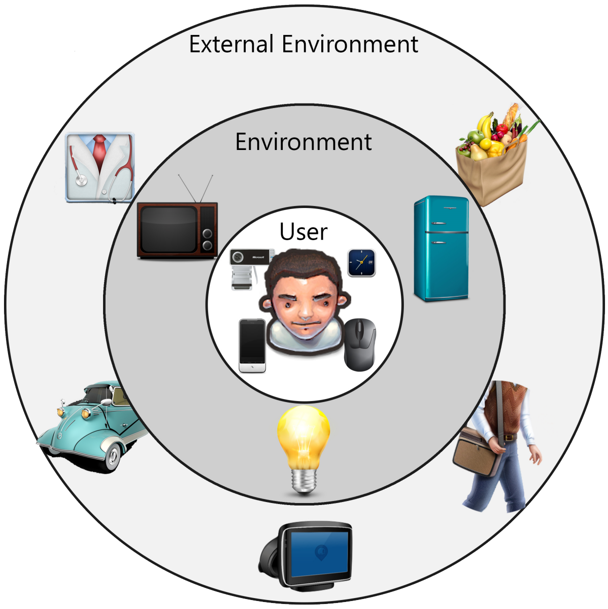

Figure 4: User on Ambient Intelligence context, (Costa, 2013)

data like geographical positions, humidity detection, and chemicals detection (Delapierre et al., 1983), light reading, temperature, sound, pressure, speed, stability, direction or even health care watch (Najafi et al., 2003), (Stanford, 2004). Knowing the environment as well as knowing the user it's very important regarding the accomplishment of the service to be provided. Knowing the user's preferences and limitations is very important to model it, as well as the surrounding context's definition. This knowledge is important to understand the collected data allowing the system to learn from it.

Support – one of the features of AmI environment is also supporting, or user's support. This means that such environment helps the user, when he has to make a choice, providing him with several scenarios and hypothesis giving the user's context. It also allows to present advantages and disadvantages of each scenarios and hypothesis produced, providing a role of assistance and recommendation.

Acting – acting, concerning AmI, is based in two ways: reaction to an event or an action to prevent or causing an event. When talking about the first way, reaction, and considering that AmI has an Intelligent Agent responsible for it, it can be reactive, deliberative or hybrid. Reactive is the simpler one, it only reacts to an event. Deliberative it means that it receives information, processes it and acts in accordance to it. A hybrid agent it's a mix of the two presented.

Privacy and security -- according to the data collected, AmI may be considered somehow invasive which can lead to some obstacles from the user. The feeling of a "Big Brother" watching the users all the time is an example of it. One of the ways to contour this problem is to encrypt the collected data, which will be done in this project.

3.2 AMBIENT ASSISTED LIVING

Ambient Assisted Living, can be either a funding activity, Ambient Assisted Living Joint Programme (ALL JP) started in 2008, with several countries, under the Ambient Assisted Living Association, or a subarea of Ambient Intelligence paradigm. As the main activity of the referred program aims to create better condition of life for the older adults and to strengthen the industrial opportunities in Europe through the use of information and communication technology, the referred subarea's objective is to help people at their daily life, making their days easier, especially on health care's matters. Assisted ambient normally are constituted by technologies featured by preservation, portability and environment integration (Costa et al., 2009). This means that it can be used in any environment, making it richer and easily available for any of its users. Such advantages must be taken in care primarily on people with deficiencies or limitations.

Figure 5: Ambient Assisted Living's context house, (Costa, 2013)

Applying assisted ambient with the purpose to assist people can mean maintaining their self-sufficiency as well independent (Haigh et al., 2003), enhancing, therefore, their well-being and self-confidence. It consents also an environment of comfort and safety at the person's home.

3.3 E-LEARNING CONTEXT

E-learning, or electronic learning, is the teaching practice without the presence of a professor or auxiliary, supported by the use of technology to monitor teaching, as well as to promote a communication and availability of distant content. E-learning it can be also defined as the process on which a student learn without the physical presence of a tutor, using informatics content based on stored information on his own device or on Internet (Clark and Mayer, 2011).

E-learning process may be seen as a teaching method that, not only, doesn't need of a classroom, but also as a method for apprenticeship accompaniment. Apprenticeship accompaniment allows a more personalized study, as well as the identification of the student's necessities or strong spots (Ducatel et al., 2003), (Novais et al.). Thus it is possible to accompany the student's progress, as to improve their study by using specific matters or learning methods. Identifying learning problems and their cause is another advantage that can be achieved by e-learning contexts.

3.4 AMI ON INTELLIGENT SYSTEMS LAB (ISLAB)

The ISLAB shares a vision that intelligent solution's purpose should be useful to the environment where they are incorporated. The group is committed with projects of many kinds, going from Computational Sustainability to Ambient Intelligent, characterized by the fact that well-being and sustainability are outstanding areas.

ISLab looks at AmI as a provider of services with a refinement: these provided services must be personalized, built up to the unique user's preferences and needs. Such personalization can only exist by *knowing* the user. To achieve this, ISLab focus itself on the development of studies in order to collect data of people's behaviours in certain scenarios. It is considered by ISLab the possibility of developing AmI systems sustainable and responsible to user's behaviours.

From a high-level point of view, the research work of ISLab inserts into the field of AmI enabled by three new key technologies: Ubiquitous Computing, Ubiquitous Communication and Intelligent User Interfaces.

Apart from the three technologies above referred, that underpinned the birth of Ambient Intelligence, there are several other fields involved, being Artificial Intelligence/Intelligent Systems. Artificial Intelligence is like an umbrella with many other methodologies, tools and approaches used by AmI.

The main lines of research followed in the last years, despite its differences, have some common ideas among them:

- The use of non-invasive and non-intrusive approaches;
- The use of techniques of Artificial Intelligence/Intelligent Systems;
- The training of the suitable models with data collected from behavioral studies.

ISLab's research group follows an approach in which merge different fields in their application to Ambient Intelligence. The core issues of the group's research lines are:

- Vision of Intelligent Environments as Multi-agent Systems

  This approach allows to take advantage of the main characteristics of agents, like their autonomy and capacity for planning and decision-making , being these key features in the above referred systems and also consolidate the tendency of development based on agent technologies and services.

- Forms of Knowledge Representation and Reasoning

  Being able to reason in settings of faulty information is imperative in this line of research, having in consideration the highly dynamic nature of technological environments: there is often loss of data, due to communication failure or the unavailability of any component responsible for the information. Nevertheless, the environment must be able to deal with such scenario and to make decisions even then.

- Context-based Information fusion

  Information fusion brings a large quantity of data from the environment gathered from network sensors with different characteristics that need to be efficiently processed. After it, and to obtain information of higher quality, there's the necessity to integrate context information obtained from vairous sources, as the information from the sensor may be defective or error prone.

- Learning

  Developing environments able to adapt themselves to their users has been on of the strengths of the research on this area. In fact, preferences, needs, desires, or even the emotional reply of users have been used as arguments to machine learning mechanisms whose main purpose is to ease the environment to observe and learn how to administrate itself, how to act and to adjust to changes in real-time.

- AmI Applications

  There are several projects that take place in ISLab. This group developed concrete implementations that gave contribution to solve real-world problems, with emphasis to Ambient Assisted Living, Online Dispute Resolution, Behavioural analysis and Computational Sustainability.

3.5 AMI AND ATTENTION DETECTION

Underneath the AmI paradigm it is possible to create computational power to be used on environments intended in a way almost unseeable to its users. Using AmI paradigm becomes quite clear as the main goal for this dissertation thesis is the monitor of attention, and possible detection of it, and the use of a traditional system would restrain monitoring and its results. Apart from the main aim of this thesis, the data collected will be used also to analysis work and leisure patterns. Therefore, there's a need to conceal from the user the system in order to produce uninfluenced outcome, resulting from a natural and unaware interaction between the user and the surrounding environment. Being, as referred, attention a state vital in order to perform a task with relevant success, is intended to create a system to help the user to have a better performance on his activities or to help .

3.6 SYNTHESIS

Although a recent concept of technology, Ambient Intelligence are used, as demonstrated by some projects, case in point, MAS – a communication platform and nanoelectronic circuits for health and wellness applications to support the development of flexible, robust, safe and inexpensive mobile AAL systems to improve the quality of human life and improve the well-being of people. Many of the projects based on AAL engines on user's oriented services, proof of that is the several projects conducted by AALJP like A2 E2 (Adaptive Ambient Empowerment for the Elderly) and AGNES (User-sensitive Home-based Systems for Successful Ageing in a Networked Society) among others. Therefore, using Ambient Intelligence for monitoring attention, in this project, is an obvious choice and an ideal scenario even more that allows a monitoring non invasive.

4

NON-INVASIVE METHODOLOGY FOR ATTENTION MONITORING

Attention monitoring based on leisure/work pattern analysis is the main focus of this thesis and the importance of attention a complement to it. In order to accomplish the main focus, a set of data must be collected and analyzed. This point is very important: this data collection must be the most non invasive and concealed as possible from the user, in order to the collected data be the most "clean" as possible as a result of a natural usage. The attention monitoring will be done under the pattern usage of Microsoft Windows leisure/work applications, having the keyboard and mouse as inputs. Mobile applications won't play a role in this thesis.

4.1 ATTENTION ASPECTS

Although the definition of attention doesn't gather an agreement, it is commonly accepted that the perceivers are more than passive receivers of information when with attention. It is also recognized that attention has three aspects fundamentally common: selection, awareness and control (Roda and Thomas, 2006). This thesis will not take in consideration the mentioned aspects and the users won't be subjected to any exteriors pressures that might influence them in order to spend more time attending work applications. The users will feel free to attend any applications they intend to, having in consideration the tasks to be carried, with no constraints.

4.2 BEHAVIOURAL BIOMETRICS

There are a number of advantages provided by behavioural biometrics over the traditional biometric technologies. Behavioural ones can be collected on a non-obtrusive way or even unaware to the user. Another advantage is that such collection of behavioural data frequently does not require special hardware and it has a high cost effectiveness.

When performing our everyday tasks, we, humans, use different strategies, styles and apply unique skills and knowledge. A defining characteristic of a behavioural biometric is the incorporation of time extent as a part of the behavioural signature. The measured behaviour is composed by a beginning, a duration and an end.

It is attempted by behavioural biometrics researchers to quantify behavioural traces exposed by users and, with resource to resulting feature profiles, to verify their identity successfully.

Based on the type of information gathered from the user, behavioural biometrics can be folded into five categories: category one is constituted by authorship based biometrics, which consists on the observation of a piece of text or a drawing made by a person. The second category is consists on the interaction of humans with computers (HCI)-based biometrics. Category three is intimately related with the last category as it is the set of the indirect HCI-based biometrics, i.e. the events observed by the user's HCI behaviour indirectly through observable conducts of computer software. The fourth category, which is most likely the best investigated one, leans on motor-skills of the users to perform particular tasks using our motor-skills. The final category is based neatly behavioural biometrics, like walking or typing.

There are several behavioural biometrics from which, for this study, it must be detach keystroke and mouse dynamics.

Regarding keystroke dynamics, each person has it's own characteristic typing patterns, for instance, some people more experienced may use the touch-typing method as others may utilise only the hunt-and-peck, thus using only two fingers. Such differences make verification of people based on their own typing patterns a proven possibility. Keystroke dynamics is probably the most research type of HCI-based biometric in different languages, long text samples and e-mail authorship identification.

Concerning mouse dynamics, by monitoring all mouse conducts by the user during his interaction with the graphical user interface (GUI), a unique profile can be traced n order to re-authenticate the user. The mouse actions of interest are general movements, drag and drop, point and click and pauses. (Roman V. Yampolskiy, 2008)

From these behavioural biometrics, ahead, some metrics used in this study will be approached.

4.3 METHODOLOGY

As referred, it is intended to realise if either is possible to monitor attention based on the interaction of the user with a laptop, regarding the keyboard and mouse as inputs. The first step to approach this problem was to collect data from users, and such step it lasted for one month. During that time twenty seven participants (twenty men and seven women), mostly volunteers from the University of Minho student population and on a range age from 18 to 30, participated providing data with their interaction with their own computer. All the volunteers were familiar with the technological devices used and the interaction with them represented no obstacle. There were no restrictions imposed selecting the volunteers and the only requisite was to have a personal computer with the operative system Microsoft Windows to be able to install an application able to log their activity.

In order to obtain the data required from the users, it was developed an application that could capture and log all the events produced by the input of a mouse and a keyboard. To such application it was added a component that would also capture the label of the main window in usage, when a user would select a window (web browser, a desktop application or even a directory) . With the purpose of being non-intrusive and to keep the confidentiality of the user's interactions, mainly chats and passwords, this application doesn't log the key itself, with the exception of "space" and "back-space". At the end of this period, the users were asked to submit the generated files by the application which contained the log of their interaction.

From a normal keyboard it is possible to record the moment a key is pressed and released. Such events, associated to a timestamp, allow generating information required to use the keyboard dependent metrics. It is important to refer that all the keys, with the exception of the "backspace" and "space", are encrypted which will keep the users privacy regarding the capture of passwords or conversations. The events occurred from mouse, through the different positions registered on the screen as well the clicks by both buttons (left and right), associated once again to a timestamp, allow to obtain the necessary information to use the metrics associated to the normal mouse pad usage.

Associating the referred label capturing by the application to these features, it is then possible to log the user's interaction with the distinct applications. The events triggered by the referred actions, upon the mouse and keyboard, to be monitored are:

- **MOV, timestamp, posX, posY** – is the event that describes the movement of the mouse, in a stated time, to coordinates (posX, posY) on the screen; MOUSE_DOWN, timestamp, [Left|Right], posX, posY – event that describes the first half of a mouse click, on a stated time. It also indicates which button of the mouse was pressed (either right or left) and its position in that same instant;
- **MOUSE_UP, timestamp, [Left|Right], posX, posY** – quite similar to the previous, this event describes when a mouse button is released;

- **MOUSE_WHEEL, timestamp, dif** – event that describes a mouse wheel scroll of amount dif, at a given time;
- **KEY_DOWN, timestamp, key** – event that captures and identifies a given key of the keyboard being pressed at a given time;
- **KEY_UP, timestamp, key** – event triggered by the release of a key, identifying the key being released and the given time;

These events describe the interaction of the user with a simple mouse and keyboard, and based on them it is possible to retrieve the following metrics:

- **KEY DOWN TIME** - is the timespan between two consecutive KEY_DOWN ad KEY_UP events, i.e., for how long was a certain key pressed.
  Units - milliseconds
- **TIME BETWEEN KEYS** - is the timespan between two consecutive KEY_UP and KEY_DOWN events, i.e., how long did the user took to press another key.
  Units - milliseconds

- **MOUSE VELOCITY** - is the distance travelled by the mouse (in pixels) over the time (milliseconds). The velocity is computed for every interval determined by two consecutive MOUSE_UP and MOUSE_DOWN events. Assuming two consecutive MOUSE_UP and MOUSE_DOWN events mup and mdo, respectively in the coordinates $(x1, y1)$ and $(x2, y2)$, that took place respectively in the instants $time_1$ e $time_2$. Assuming also two vectores $posx$ and $posy$, of the size$n$, keeping the coordinates of the consecutive MOUSE_MOV events between mup and mdo. The velocity between the two clicks is provided by $m\_dist/(time_2 - time_1)$, in which m_dist stands for the distance travelled by the mouse and is given by equation (1).
  Units - $pixel/milliseconds^2$

$$m\_dist = \sum_{i=0}^{n-1} \sqrt{(posX_{i+1} - posX_i)^2 + (posY_{i+1} - posY_i)^2} \tag{1}$$

- **MOUSE ACCELERATION** - is the velocity of the mouse (in pixels/milliseconds) over the time (in milliseconds). A value of acceleration is computed for every interval determined

by two consecutive MOUSE_UP and MOUSE_DOWN events, using the intervals and data computed for the Velocity.
Units - $pixel/milliseconds^2$

- **TIME BETWEEN CLICKS** - is the timespan between two consecutive MOUSE_UP and MOUSE_DOWN events, i.e., how long did it took the user to give another click.
Units - milliseconds

- **DOUBLE CLICK DURATION** - is the timespan between two consecutive MOUSE_UP events, whenever this timespan is lower that 200 milliseconds. Higher than that are not considered double clicks.
Units - milliseconds

- **AVERAGE EXCESS OF DISTANCE** - this attribute measures the average excess of distance that the mouse travelled between two consecutive MOUSE_UP and MOUSE_DOWN events. Assuming two consecutive MOUSE_UP and MOUSE_DOWN events mup and mdo, respectively in the coordinates $(x1, y1)$ and $(x2, y2)$. To compute this attribute, first it must be measured the displacement between the coordinates of the referred events as described by equation (2).

$$m\_dist = \sqrt{(x2 - x1)^2 + (y2 - y1)^2} \tag{2}$$

After that, it is measured the real distance travelled by the mouse through the sum of the distance between each two consecutive MOUSE_MV events. Assuming two vectors *posx* and *posy*, of size n, keeping the coordinates of the consecutive MOUSE_MV events between mup and mdo, the real distance travelled by the mouse, $real\_dist$ is provided by equation 1. The average excess of distance between the two consecutive clicks is thus provided by m_dist/s_dist. Units - milliseconds

- **AVERAGE DISTANCE OF THE MOUSE TO THE STRAIGHT LINE** - this attribute intends to measure the average displacement of the mouse between two consecutive clicks. Assuming two consecutive MOUSE_UP and MOUSE_DOWN events, mup and mod, respectively in the coordinates $(x1, y1)$ and $(x2, y2)$ and also assuming two vectors *posx* and *posy*, of size$n$, keeping the coordinates of the consecutive MOUSE_MOV events be-

tween mup and mdo. The sum of the distances between each position and the displacement determined by the points $(x1, y1)$ and $(x2, y2)$ is provided by the equation (3), in which *ptLineDist* returns the distance between the specified point and the closest one on the infinitely-extended line determined by $(x1, y1)$ and $(x2, y2)$. The average distance of the mouse to the displacement defined by two consecutive clicks is given by m_dist/n.
Units - pixels

$$m\_dist = \sum_{i=0}^{n-1} ptLineDist(posx_1, posy_1) \quad (3)$$

- **DISTANCE OF THE MOUSE TO THE STRAIGHT LINE** - this attribute is quite similar to the previous one considering that it will compute the *s_dist*between two consecutive MOUSE_UP and MOUSE_DONW events, mup and mdo, according to equation 3. Nevertheless, it retrieves this sum rather than the average value over the path.
Units - pixels

- **SIGNED SUM OF ANGLES** - this attribute aims to determine if the movement of the mouse tends to "turn" more to the right or to the left. Assuming three consecutive MOUSE_MOVE events, $mov1$, $mov2$ and $mov3$, respectively in the coordinates $(x1, y1)$, $(x2, y2)$ and $(x3, y3)$. The angle α formed by the first line (determined by $(x1, y1)$ and $(x2, y2)$) and the second line (determined by $(x2, y2)$ and $(x3, y3)$) is given by $degree(x1, y1, x2, y2, x3, y3) = tan(y3 - y2, x3 - x2) - tan(y2 - x1, x2 - x1)$. Assuming now two consecutive MOUSE_UP and
MOUSE_DOWN events, mup and mdo and assuming also two vectors *posx* and *posy*, of size n, keeping the coordinates of the consecutive MOUSE_MOV events between mup and mdo. The signed sum of angles between these two clicks is provided by equation (4).

$$s\_angle = \sum_{i=0}^{n-2} degree(posx_i, posy_i, posx_{i+1}, posy_{i+1}, posx_{i+2}, posy_{i+2}) \quad (4)$$

- **ABSOLUTE SUM OF ANGLES** - this attribute is quite similar to the prior one. Nevertheless, it aims to find just how much the mouse "turned", apart from the direction to which

it turned. Following that, the only difference is the use of the absolute of the value retrieved by the function $degree(x1, y1, x2, y2, x3, y3)$, as described by function (5).
Units - degrees

$$s\_angle = \sum_{i=0}^{n-2} |degree(posx_i, posy_i, posx_{i+1}, posy_{i+1}, posx_{i+2}, posy_{i+2})| \tag{5}$$

- **DISTANCE BETWEEN CLICKS** - this attribute expresses the total distance travelled by the mouse between two consecutive clicks, i.e., between each two consecutive MOUSE_UP and MOUSE_DOWN events. Assuming two consecutive MOUSE_UP and MOUSE_DOWN events, mup and mdo, respectively in the coordinates $(x1, y1)$ and $(x2, y2)$ and also two vectors $posx$ and $posy$, of size n, keeping the coordinates of the consecutive MOUSE_MOV events between mup and mdo. The total distance travelled by the mouse is provided by equation 1.

From these attributes it's possible to obtain usage patterns of the users on the different applications. Once having information abut the user's patterns, it is possible to monitor attention of the user in real-time. The fact that this monitoring is made through a computer makes it suitable for,e.g., attention monitoring in the classroom. The fact that such monitoring requires no great changes for user's routines and is made on a non-invasive way, makes it the great advantage in comparison with other traditional approaches based on questionnaires that people easily tend to exaggerate.

4.4 DATA PROCESS

The collected data by the application consists on the logged events caused by the usage of keyboard and mouse performed by the user. In order to retrieve any relevant information and transform it in knowledge, it is necessary to process the collected data. Such process transforms the data according to the presented features enabling its analysis. To process all the events generated an application was developed in Java that parsed all the collected data and extracted the required information to be assessed by the defined metrics.

As a regular step in any data process it is necessary to clean and validate the collected data, as it may contain some inconsistencies or even contradictions resulting by the free usage environment. After the referred transformation of the data it is then made a second process, the data cleaning, where it takes place filtering and analysing the already transformed data. Data filtering it is where outliers, i.e. inconsistent values, are removed. Keyboard and mouse usage can be very propitious to generate outliers, e.g. the use of "shift-key" to write capital letters or the use of "backspace". To such examples can be added also the time other like time between keys. Considering that the time between pressing two keys was way the normal usage, which reveals an inactive usage of the keyboard, such event must be considered an outlier and removed, before the statistical study.

```
remove\_outliers <- function(x, na.rm = TRUE, ...) {
  qnt <- quantile(x, probs=c(.25, .75), na.rm = na.rm, ...)
  H <- 1.5 * IQR(x, na.rm = na.rm)
  y <- x
  y[x < (qnt[1] - H)] <- NA
  y[x > (qnt[2] + H)] <- NA
  y
}
```

Listing 4.1: Remove outliers function on R

4.5 DATA ANALYSIS

From the data that was collected during one month, after processed and analysed, it was possible to observe different behaviours regarding the usage of keyboard and mouse according the different kinds of applications attended. The events captured by the application were split into 4 categories: (1) *Chat*, concerning inputs in applications like Skype, Hangouts and Facebook Messenger; (2) *Internet*, including inputs in web browsers like Internet Explorer, Google Chrome and Mozilla Firefox; (3) *Work*, inputs taken in consideration on applications like Eclipse IDE, TexMaker, Microsoft Office, Adobe Reader, Net Beans or Evernote, and (4) *Games*, with records of gaming applications.

Such differences were observed once analysed the interaction patterns of the users, where it was taken in consideration the distribution of the data for each category of application and analysed the statistical importance of their differences. In order to achieve this result, the following steps were taken:

First, using Pearson's chi-squared test, it was decided that most of the distributions of the collected data weren't normal. With this, the Kruskal-Wallis test was used in the further analysis. Kruskal-Wallis test consists in a non-parametric statistical method for testing whether samples have their provenience from the same distribution. It is used for comparing more than two samples that are independent thereby proving the existence of distinct behaviours. The null hypothesis here considered is H_0: all samples have selfsame distribution functions against the alternative hypothesis that at least two samples have different distribution functions. For every set of samples compared, this test returns p-value, with a small p-value proposing that is unlikely that H_0 is true. Thereby, for every Kruskal-Wallis test whose $p\text{-}value < \alpha$, the difference is taken as to be statistically significant, i.e., H_0 is rejected. In this analysis a value of $\alpha = 0.005$ is considered a regular value generally accepted by research. This statistical test is performed for every of the attributes considered, with the intention of determining if there are statistically significant differences between the several distributions of data, thus confirming the existence of different behaviours, in keyboard and mouse usage according to the kind of task being performed, through interaction patterns. For 90"%" of the users all the attributes revealed statistically significant dissimilarities.

4.5.1 *Time Between Keys*

Time between keys, that represents the speed with which user types, presents differences concerning the types os task. As stated in (6), user tended to type faster when attending to Chat applications.

Table 1: Time between keys.

Application type	*Mean*	*Median*	*Min*	Max
Chat	145,7	99	0	684
NET	264,46	128	0	1371
Work	689,18	368	0	3007

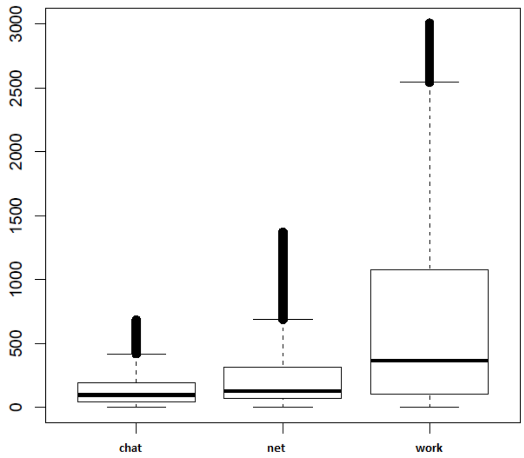

Figure 6: Time Between Keys

4.5.2 *Mouse Acceleration*

Another revealing metric difference was the mouse acceleration, as show on the table below. When attending to work applications, user's mouse acceleration tended to be lower compared to chat and net applications.

Table 2: Mouse acceleration.

Application type	*Mean*	*Median*	*Min*	Max
Chat	0,6	0,4	-1,2	2,5
NET	0,6	0,4	-1,3	2,5
Work	0,5	0,3	-1,0	2,1

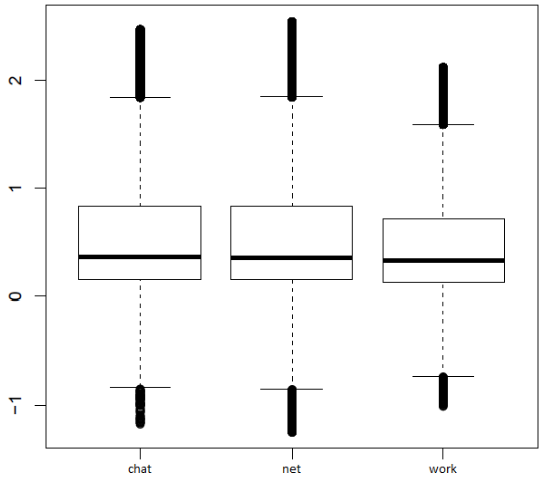

Figure 7: Mouse Acceleration

4.5.3 *Time Between Clicks*

Regarding yet the mouse input, it is worth to refer that the biometric Time Between Clicks also showed different behaviours according to the different tasks. As it can be stated, there was a tendency for the users to take less time between giving a click and another one.

Table 3: Time Between Clicks.

Application type	*Mean*	*Median*	*Min*	Max
Chat	2979	1693	0	15110
NET	3229	1834	0	16010
Work	2823	1656	-77	14440

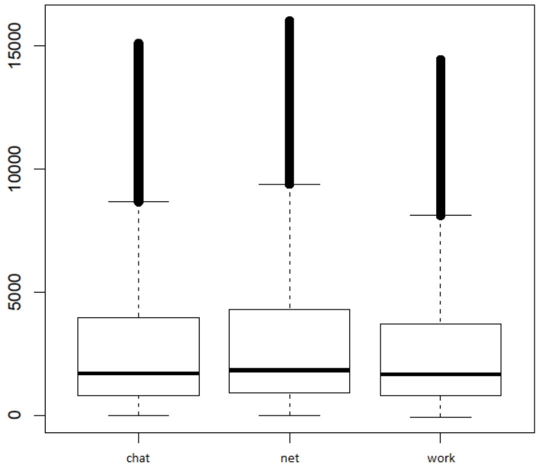

Figure 8: Time Between Clicks

4.6 SUMMARY

In order to monitor attention it is first need to "learn" the usage patterns of users while attending tasks that requires attention and focus.

After the analysis done on the collected data and described in the above chapter, it is then possible to conclude that users have different behaviours when performing different tasks that require different applications and different attentional states. When attending to chat application, users tend to type faster, whilst on a mouse, for instance, it was detected a lower acceleration on work applications when compared to chat and net applications.

Based on this results, it was developed a prototype of an application to validate the possibility to monitor in real-time users attention on a similar context as the one described on this non-invasive methodology.

5

CASE STUDY

The main aim for this thesis dissertation is to monitor user's attention while using a laptop. To do so, it was first necessary to know how the user behaves when interacting with different types of applications. Using a set of previously approached metrics, pretty much based on behavioural bio-metrics Keystroke Dynamics and Dynamics Mouse, it was acknowledge some of user's tendencies or behavioural patterns when performing different tasks on different applications. The analysis done on the previous chapter was very helpful and it was use on the case study here presented. In this chapter it will be presented the prototype developed, the experience conducted and its main results.

5.1 FRAMEWORK

The framework developed for this case study aims to estimate the level of attention in scenarios of study or work of individuals. In this experiment, the scenario used, as it will be exposed further, was a lecture in a classroom. As well as to assess the level of attention, this framework's aim is to serve aid and support for decision-making processes of team leaders, group coordinators, teachers or whoever has in charge collaborators whose primary work is performed on a laptop or desktop. Following this point of view, each element is regarded as part of a whole which contributes to the general level of attention of the group that the element is inserted. In the context of this framework, each user of the group is taken as a "Monitored User" with the single exception of the leader/coordinator, or in the case to be presented, teacher, who will be defined as "Coordinator". In Figure (10) it is presented the distribution of the referred roles and how the information flows from its state as raw data to the classification of the state of the user.

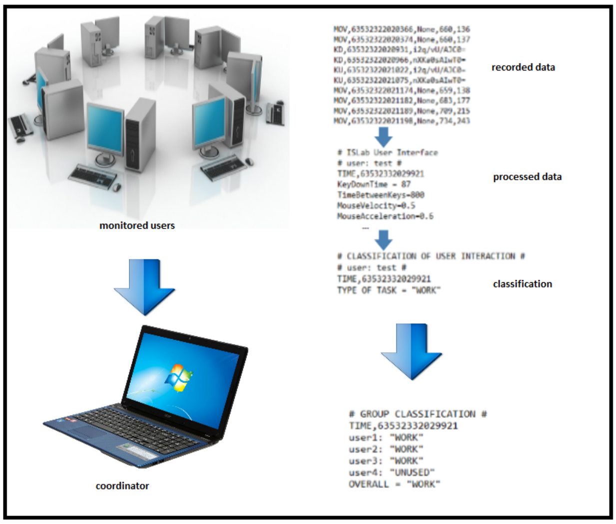

Figure 9: Distribution of the roles and flow of information from raw data to the classification of the state of the individuals

5.2 INFORMATION PROCESS

During the users's attention monitoring, pretty much like the methodology presented on the last chapter, all the events from the keyboard and mouse usage were recorded. It was then necessary to transform these inputs from raw data into information able to be appraised by the metrics previously defined. Based on the steps taken on the previous chapter, it was used the developed application Java to transform the raw inputs into data able to be analysed.

Once again, on the process of the collected data by the prototype, it was applied a filter before the process of the raw data. Such filter is responsible for deleting all the values considered outliers.

5.3 CLASSIFYING BEHAVIOURS ASSOCIATED WITH WORK TASKS

The main goal of attention assessment is achieved by the usage of machine learning algorithms, thus allowing to detect and classify different behaviours associated to different attention states.

As concluded in the previous chapter, it was proved the existence of different usage patterns regarding the interaction with mouse and keyboard in task of distinct types. Having the acknowledge of such behaviours, a classifier was constructed and trained in order to determine the kind of task being performed by the users from their inputs on keyboard and mouse and consequently their usage patterns. The parameters selected for classification were the ones that revealed more significant differences such as writing velocity and time between keys.

The classification of the kind of task being performed by the users is obtained through use of (k-NN) k-Nearest Neighbor algorithm helped by the data mining tool WEKA . In pattern recognition, the k-NN is a nonparametric method used for classification and regression. In both cases, the input comprises of the *k* closest training examples in the feature space. In this case, *k*-NN was used for classification, which means that the output is a class membership. An object is classified by a majority vote of its neighbors, with the object being assigned to the class most common among its *k* nearest neighbors. If $k = 1$, then the object is just assigned to the class of that specific nearest neighbor.

The data used to train the model used by the referred *k*-NN algorithm was collected in the methodology described in previous chapter. The classification of the state of the group is the result of the average of all monitored users.

5.4 INTERFACE

The prototype developed is provided with two different interfaces. Each interface is suited for the different type of users. For the "Coordinator" it is more interesting to have an overall view of the "Monitored Users", so his interface allows him to check the number of users, the current status and historical of the monitored group. From the current status the "Coordinator" can see through a "pie" the amount of time spent on working, other tasks and the time the user didn't provided any input, meaning that he didn't pressed any key or made any mouse movements.

The "Monitored User" has also an interface where he can see basically what the "Coordinator" sees but regarding only himself. The "Monitored User" has also the possibility to stop the prototype from register and classify his inputs.

Both "Coordinator" and "Monitored User" have displayed on each interface an historical graphic, allowing to check the last hour's activities classification.

5.5 USAGE SCENARIO

Having the model trained and the prototype developed, it was set up a case study to validate the possibility of monitor and measure the attention of users and how interesting and useful could be the information provided to the coordinator.

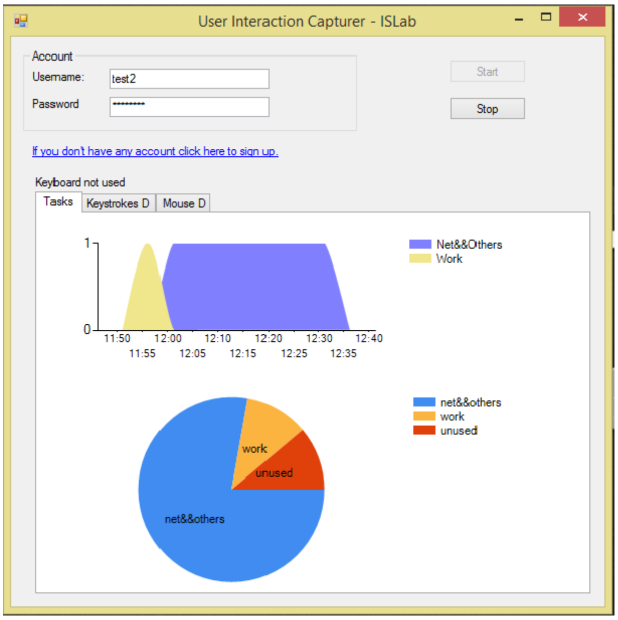

Figure 10: User's interface

The environment chosen for this study was a classroom during a lecture. For this case study a total of seventeen students (twelve men and five women, aged from eighteen to twenty five) from the University of Minho of the field of physical sciences, were chosen to be the group of monitored users. To test and validate the application with the referred users in a real scenario, a programming language, C to be specific, lecture was chosen. Each lecture of the referred course has the following guideline: at the beginning of the session some theoretical concepts are approached and for the rest of the lecture the students practice and solve exercises using the computer and a specific IDE (Integrated Development Environment). Either attending to the teacher while providing the new theoretical concepts, or practising and solving exercises, the use of computer is free of restrictions for the students, which means that they can be using any text editor, Microsoft Office tools, web browsing or even chatting on any chat application.

The sessions usually end with a practical evaluation exercises. This evaluation is made at an individual level and has the purpose to the teacher determine how well and if the concepts approached were transmitted and perceived by the students.

The students, which constituted the group of "Monitored Users", installed the prototype, to assess the level of attention, on their computers and during one of the described sessions above it collected and classified transforming their inputs into relevant data. The teacher, in this case "Coordinator", followed the normal guideline providing theoretical matter and at the end of the session the students were evaluated with specific exercises concerning the matter provided at the beginning of it. With this experiment it is intended not also to validate the prototype developed as attention level assessment but also to find a connection between distraction, interaction and scholar performance.

5.5.1 *Results*

During the experiment the developed prototype was running on the "Monitored User's" and "Coordinator's" computer which allowed, given the domain of the case study, to classify, based on their usage of the peripherals, as belonging to a work-related application or to any other one. Before the results analysis, the students were requested to estimate their level of attention during the lecture from a range of 0, meaning very distracted, to 5, attentive. This request had the single purpose to validate the results from a subjective point of view. Analysing the results, it can be observed that the students with lower levels of attention during the session had worse evaluations. On opposite, the students who had high levels of attention, thus being more attentive, obtained better results. The results revealed that the students number 4, 6, 8, 13, 14 and 16 are examples of students who did not pay much attention during the session and therefore obtained worse results. As confirmed by these students self attention level estimate, they were not very concentrated during the session.

5.5.2 *Validation*

In order for the attention monitoring be performed in a non-intrusive way, the developed system must not capture the label of the current application of the users. But, and to validate if the prototype was classifying correctly, for this experience it was capturing the label of the main frame, thus corresponding to the current application in usage as well as the time spent on it. To perform the required tasks on the class the only mandatory application was the Dev-C++ IDE, but some participants used alternative text editors like TextMaker, Microsoft Office Word or Evernote. As the prototype captured the label of the current application, it was possible to check at each moment the application being used and what type of application the classifier was sending as output. This allowed to validate the efficacy of the classifier. This validation was made based on the results obtained during the scan for all validations that occurred over the session described before, and as a result, 96% classifications as work tasks through the use of work applications were successful. For the remaining applications, the success rate of correct classification was of 92%, as it can be observed on the Confusion Matrix below.

Table 4: Overall results of all participants, where one can see the values of the monitoring, evaluation and values of the subjective level of attention to each participant.

user	minutes in work tasks	minutes others tasks	minutes unused	% work	% others	% subjective attention	% final evaluation
1	96	36	48	73%	27%	5	90%
2	60	36	84	63%	38%	4	100%
3	72	12	96	86%	14%	4	100%
4	54	48	78	53%	47%	2	50%
5	90	0	90	100%	0%	3	50%
6	54	90	36	38%	62%	3	30%
7	90	12	78	88%	12%	4	100%
8	60	42	78	59%	41%	4	70%
9	96	42	42	70%	30%	4	100%
10	108	0	72	100%	0%	5	80%
11	84	24	72	78%	22%	4	90%
12	96	24	60	80%	20%	5	100%
14	48	42	90	53%	47%	3	50%
15	54	36	90	60%	40%	3	0%
16	60	30	90	67%	33%	4	90%
17	48	54	78	47%	53%	3	20%
18	114	30	36	79%	21%	5	80%
Mean	76	32	71	71%	29%	4	70%

5.5.3 *Conclusion*

In this chapter it was approached and presented a prototype for attention monitoring and how a user's perform can be affected by his lack of attention. Through the usage of KNN algorithm it was constructed a classification model that was used to detect the type of application the user was attending on. Based on the spent time of the users, either individual or in group, it can be measured the level of attention in classrooms or workplaces scenarios. With the information provided by the application, team leaders and coordinators can improve or even have better decisions. In the experience that took place in the classroom, the coordinator can have an overview of the attention of the students thus having a better perception of how to prepare his lecture, e.g. for how long should he talk until he looses the attention of the students. An interesting outcome was the fact that the students could grasp the direct relationship among the attention they pay to the contents of a lecture and their final score.

Table 5: Confusion Matrix

task type	instances	% correctly classified instances	% incorrectly classified instances
work tasks	228	96%	4%
others	97	92%	8%
Unused	215	100%	0%

6

CONCLUSION AND FUTURE WORK

6.1 CONCLUSION

Attention monitoring is a complex process, but due to it's utility, makes it very rewarding. Usually eye gazing systems are used to measure attention, followed by questionnaires to assess the person's attention. Nowadays, with our desktops swarmed with applications and pop-ups and rings, it gets more difficult to focus on a specific task. Attention is likely crucial for people to perform tasks and improve their knowledge in any matter.

In this thesis it was approached a system to monitor attention while using a computer, or laptop, with it's main entrance peripherals: keyboard and mouse. As the system, and it's components, was non-intrusive, it allowed a more accurate monitoring, as the user's behaviours are natural.

The importance of attention was stated on the case study approached, as the students that showed higher attention levels, presented better results.

6.2 SYNTHESIS OF THE WORK DONE

The main contributions of this project are presented here:

- Data collection: very important step to be able to analyse the user's patterns, either to validate the prototype developed. The data collected from the user's interaction with keyboard and mouse, resulted from their normal usage without inducing any kind of pressure).
- Data analysis: the data collected on both cases was analysed based on biometrics of keyboard and mouse usage (Keystroke Dynamics e Dynamics Mouse). In the first case, the analysis revealed distinct usage patterns on the different types applications, which led to the case study.

- Prototype validation: based on these patterns, it was developed a prototype to assess the user's attention. With this prototype was validated the classification of user's type of application based on his inputs as well the importance of attention, in this case, on a classroom.
- The work done represents research in the area of analysis and monitoring interaction patterns, in this particular case, attention. With the help of new technologies and AmI, it was validated such approach to this theme. The developed prototype showed to be possible determining the user's application in usage through the keyboard and mouse.

6.3 FUTURE WORK

The proposed objectives for this work have been accomplished. Nevertheless, there is some future work to be done, that can improve the monitoring system, such as:

- The collection and analysis of more data under new metrics and parameters that allow a better attention monitoring;
- Have in consideration factors like fatigue to improve the monitoring system;
- Using different scenarios such as a software development company;

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