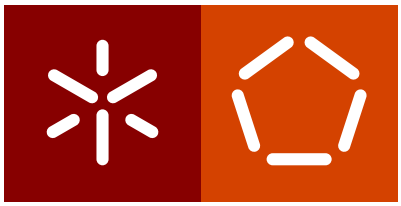

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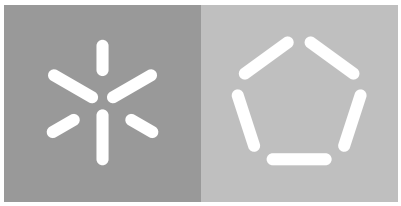

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David Barbosa Castro

Modelling an Intelligent Interaction System for Increasing the Level of Attentiveness and Engagement

Master dissertation
Master Degree in Computer Science

Dissertation supervised by
Paulo Jorge Oliveira de Freitas Novais
Dalila Alves Durães

June 2018

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To my sister for all the fun.

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ABSTRACT

One of the main factors for achieving school success is related to the level of attention and interest that students manifest in the classroom. When in the classroom students perform tasks on electronic devices, and if the classes have a high number of students, the teacher does not have the idea if a student is really attentive and focused on the tasks defined (Pimenta et al. (2015)). Usually the teacher only realizes this situation when he evaluates the students, which is in most of cases too late.

However, if the teacher receives information about the attention and interest of each user (student) of a class in real time, he/she can adopt a set of teaching strategies in order to maximize the results of his/her students. Hence it is possible to avoid and prevent some negative behaviors in the classroom and increase the level of attention and consequently, school success. In terms of school success, it is common sense that a high level of attention, allows to acquire better results.

This thesis intends to develop a framework which allows the teacher to visualize, in real time, the attention level of each student, allowing him to adopt strategies for the students with abnormal behaviors (Carneiro et al. (2015); Durães et al. (2016b)).

Keywords: Ambient Intelligent System, Attention, Decision Support System, Teacher, Students

RESUMO

Um dos principais fatores para a obtenção do sucesso escolar está relacionado com o nível de atenção e de interesse que o aluno manifesta em sala de aula. Quando os alunos, na sala de aula, realizam tarefas em dispositivos eletrónicos, e se as turmas tiverem um elevado número de alunos, o professor não tem a verdadeira noção dos alunos que realmente estão atentos e focados nas tarefas definidas (Pimenta et al. (2015)). Muitas vezes o professor só se apercebe desta situação aquando da realização da avaliação, o que pode ser, em muitos casos, demasiado tarde.

Se o professor receber informações sobre os níveis de atenção e de interesse de cada utilizador (aluno) de uma turma em tempo real, poderá adotar um conjunto de estratégias de ensino por forma a maximizar os resultados dos seus alunos. Desta forma é possível evitar e prevenir alguns comportamentos negativos em sala de aula e aumentar o nível de atenção e, consequentemente, o sucesso escolar. Em termos de sucesso escolar, é do senso comum que um elevado nível de atenção e interesse, permite obter melhores resultados.

Este projeto pretende desenvolver uma ferramenta que permite ao professor visualizar, em tempo-real, o nível de atenção de cada aluno, permitindo-lhe adotar estratégias para os alunos com comportamentos desviantes (Carneiro et al. (2015); Durães et al. (2016b)).

Palavras-chave: Sistema Inteligente Ambiente, Atenção, Sistem de Suporte de Decisão, Professor, Alunos

CONTENTS

LIST OF FIGURES

LIST OF ABBREVIATIONS

A

API	Application Programming Interface

C

CRUD	Create Read Update Delete
CSS	Cascading Style Sheets

D

DB	Database

F

fxml	Java FX eXtensible Markup Language

G

GUI	Graphical User Interface

H

HTTP	Hypertext Transfer Protocol

I

IDE	Integrated Development Environment
ISAmI	International Symposium on Ambient Intelligence

J

JSON	JavaScript Object Notation
JVM	Java Virtual Machine

R

Rest	Representational State Transfer

S

SHA	Secure Hash Algorithm
SQL	Structured Query Language

U

UI	User Interface

X

XML	eXtensible Markup Language

1

INTRODUCTION

This report and the project to which it refers were carried out for the Dissertation of the second year of the Masters Degree in Informatics Engineering of the Department of Informatics, School of Engineering, and University of Minho.

This chapter presents the global considerations about this thesis and it is structured in four sections: the first, which describes the motivation that sustains this research; the second section presents the main objectives intended to be achieved; the third explains all the project and his architecture; the fourth section will present some results and discussion; and finally, the fifth section presents the conclusions detailed for objectives.

1.1 MOTIVATION

Today, teaching is one of the most difficult jobs to do, especially when using new technologies, such as computers with Internet access. Internet access allows students to access subjects unrelated to the subject matter of the classroom, and it is a potential distraction.

The idea of this thesis is to create an application that will collect information about the interaction with the peripheral devices (mouse and keyboard)(Durães et al. (2016a)) where the students are working. Furthermore, these data are sent to a database which collects all the information. These data are analyzed and stored in each student profile. Therefore, this results will be sent to the teacher in real time, allowing him/her to adopt new strategies.

With the development of this project, it is intended to acquire the level of attention obtained through the time that the student spends on related tasks defined by the teacher and the time spent in other activities not related with the tasks defined.

It is also intended to analyze how students interact with peripheral devices, such as mouse and keyboard features in order to check patterns of use.

In the end, it will be possible for the teacher to adapt the teaching techniques to the learning styles of the students and avoid irregular behavior that can cause school failure.

1.2 CONTRIBUTIONS

In a world where the use of high technology is in fashion, we find ourselves attacked with a lot of information simultaneously. Therefore, the attention is easily dispersed, facilitating the occurrence of distractions. If we can create a tool able to provide the teacher with a way to measure the level of attention of the student, it is possible for the teacher to intervene when necessary.

It should be noted that sometimes students have low attention rates not because they are focused on their cell phones or other gadgets, or distracted by internet-related activities, but are affected and struggle with some personal problems that may increase their fatigue and stress, thus reducing the attention that the student can devote to class.

The development of new learning environments, supported by technology, may allow the improvement of the learning process but it is also necessary to mitigate problems that may occur in an environment with learning technologies. Learning theories provide insights into the very complex processes and factors that influence learning and give precious information to be used in designing instruction that will produce optimum results. The learning models are designed in order to supply to the students with practice, evaluation and improvement procedures, which will adjust the model (Eggen and Kauchak (1993)).

1.3 THEME SUBJECT AND OBJECTIVES

This dissertation project has the theme: Modelling and Intelligent Interaction System for increasing the level of Attentiveness and Engagement.

Taking as starting point the user attention, the objective of this work lies in the study of the main aspects of the creation and editing tools of intelligent system that monitored attention.

For this we identify central research questions that consist of:

- How to classify attention?
- How to create a user profile?
- What is necessary to store all these information?

The research questions previously specified allowed us to state the following objectives to be achieved:

- Modeling a graphic system that allow the teacher to control the level of attention and engagement in real time;
- Have an historical of the attention levels for each student;

- Suggest to the teacher different ways to proceed, in order to optimize the level of attention and engagement of the students.

1.4 RESEARCH METHODOLOGY

In this thesis it will be adopted an action-investigation methodology (Tripp (2005)) with the finality to model and develop a graphical system.

According to this methodology were recognized four major steps:

- Plan, this phase is where will be studied and planned the actions to take, in this thesis this phase is the all the research made and described in the state-of-art.
- Act, this step is where the previously made plan and research will be implemented, as shown in the chapter 3 of this paper.
- Describe, where the effects of the actuation will be monitored and described, this phase will be explored in chapter 4 of this thesis.
- Evaluate, when the conclusions of the process are presented and possible to be studied, chapter 5 in this thesis.
- Specifying learning, the diffusion of knowledge and results obtained in the scientific community.

As for the development of software solutions the methodology used will be adapted from SCRUM. As such, all previously explained steps will be applied in software development.

The first steps are diagnosing the problem and updating the state of art and objectives of the work. Next is the software development of the proposed objectives. With these tasks completed, an evaluation of the work will be done, whose results are reported in the paper. Through this results, new problems arise which leads to a new cycle.

Scrum development is a simple methodology intended to solve long product development, which allows the developer to focus in the set of goals proposed. This methodology also solves the mismatch problem between a products business requirement and the actual resulting implementation (which normally occurs when developing big products).

1.5 DOCUMENT STRUCTURE

This thesis can be divided into five main blocks: Introduction (Chapter 1), State of Art (Chapter 2), Project (Chapter 3), Case Study (Chapter 4), and Conclusions (Chapter 5):

- In the first chapter, Introduction with the thesis motivations and framework, definition of the objectives and the structure of the dissertation.

- In the second chapter, State-of-the-art, study, analysis and definition of detailed project objectives and framework themes.
- In the third chapter, the specification and explanation of an architecture model project, the project and his implementation decisions.
- In the fourth chapter, the testing and evaluation of the work objectives.
- In the fifth chapter, presentation of conclusions reached in this work.

In the end will be presented the bibliography, containing all the references used in this thesis.

2

STATE OF THE ART

2.1 ATTENTION

2.1.1 *A definition*

Attention is a concept that has many definitions, each of these definitions depending on the historical time and the field of study that is inserted.

Looking at the dictionary we can quickly found a wide definition:

"The act or faculty of attending, especially by directing the mind to an object", "notice, interest or awareness", "the act or power of carefully thinking about, listening to, or watching someone or something", "the act or state of applying the mind to something", "a condition of readiness for such attention involving especially a selective narrowing or focusing of consciousness and receptivity"(Dictionary.com (n.d.c); Merriam-Webster (n.d.)).

Although these definitions allow us to have a general idea of what attention is, we can further specify this definition and, for this, definitions of attention will be presented in some fields of knowledge, such as Philosophy, Psychology, Neuroscience and, finally, Computer Science.

In the field of psychology there are two communities willing to study the attention phenomenon, the cognitive neuroscience that takes on where the cognitive psychology stopped and computer science that aided with real data and new technologies are trying to get to a satisfying definition of attention (Mancas (2015c); Tsotsos et al. (2005)).

2.1.2 *Concept of Attention in Philosophy Subject*

Philosophy was the first subject to studied attention theoretical form, but nowadays there are more relevant subjects studying attention.

In this subject attention is studied by several authors. Descartes in his book Meditations briefly refers the important role of attention in achieving clarity and clearness in an idea, and introduces the idea of "pay attention" (Mole (2013)). Malebranche, a French priest, highlights the role of attention on management and the correct understanding of point of

view (Mancas (2015c)). Bishop Berkeley shares the principle that attention and abstraction are linked, an idea that is only taken up in the second half of the nineteenth century. Locke thoughts about attention are taken further than Descartes or Berkeley, for him attention is when ideas are noted and registered in memory, and to him attention is just a mode of think. This attention theory in the eighteenth century was very distant from the others existent theories (Mole (2013)). Gottfried Leibniz used the term apperception to describe the fact of learning with experiences. Accordingly this new point of view about the concept of attention nowadays is called a bottom-up approach in which an involuntary intuition about an unconscious event is needed for it to become conscious. Sir Hamilton in the nineteenth century added the idea of divided attention and brings the concept that is possible humans focused in a several tasks at the same time. Before Sir Hamilton theory, all theories assumed that humans could only focus attention in one task at once (Mancas (2015c)).

2.1.3 *Concept of Attention in Psychology Subject*

In the course of the years (eighteenth and nineteenth centuries) psychology became naturally interested in attention, his definition and his methods of work, which means also that attention started to receive a more scientific approach that that was given by the philosophy (Mancas (2015c)).

The idea of attention was divided attention concept into split concepts each one treated by a different branch of psychology: one that attention is used to collect ideas (experimental psychology); and other that focused more on the behavioral state of the attention (cognitive psychology) (Mancas (2015c); Mole (2013); Tsotsos et al. (2005)).

Experimental Psychology

In the line of thought of this branch of the psychology one of the first definitions of attention was given by Henry Home Kames as:

"Attention is that state of mind which prepares one to receive impressions. According to the degree of attention objects make a strong or weak impression. Attention is requisite even to the simple act of seeing." (Mole (2013))

Many researchers made several approaches, studies and experiments, here it is highlighted some of them.

Wilhelm Wundt considered by many the father of experimental psychology has started the study of the consciousness and attention, for this he conducted a series of experiences that were based in stimulate a participants vision (light, pendulums) or audition (metronomes, bells), measuring the time that the participant takes in response to the different stimulus, and he concluded that the subject can only focus one though at time. This

inspired other studies about mental processing speed (Mancas (2015c); Tsotsos et al. (2005); McLeod (2008a); Journal (2012); Carrasco (2011)).

H. Von Helmholtz in the nineteenth century has made some experiments about the imagination and illusion link to attention and proved also the existence of a covert attention that does not need to be accompanied by eye movements. Some of his experiments are requesting to a subject to sit at piano and play a certain note, attending to the sound, then imagining to ear that sound when another note is played, so that the participant listens the first sound at background when the other is played, demonstrating that imagination takes a toll on attention; another experiment was looking to inside a dark box using holes made for that matter, then concentrate is look in a certain direction, when a spark was used to briefly shed light into the box the participant only seems to remember the objects in the zone to where we was directing is eyes and concluding that attention is not linked with eye positioning or accommodation.

Helmholtz linked illusion to attention when he notice that even if brain make humans think that see everything at the same resolution, the movement and focus of the eyes is still needed so that we can see as distinctly as possible all the individual parts of the field in turn., that is defined as manifest attention, this is presented in Figure 1 (Mancas (2015c); Mole (2013); Tsotsos et al. (2005); Carrasco (2011); Rees (n.d.)).

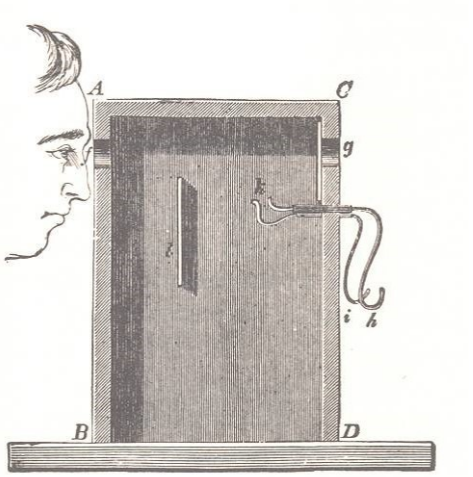

Figure 1: One of Von Helmholtz experiences.

William James was a psychologist that continues some of Von Helmholtz line of work in attention and resumes two processes of attention: one being the adjustment of humans perception organs (ears, nose, eyes,); and other using conclusions from studies of Von Helmholtz about the imagination, which according W. James the piano example of Von Helmholtz studies was a perfect example. Finally, for W. James, the concept of attention

is closely related to conscience and structure (Mole (2013); Tsotsos et al. (2005); Carrasco (2011)).

As focused by many authors, these two authors may be seen as complementary, because Helmholtz focused attention concept on the where the attention is needed and W. James focused the attention concept on what we need to be attentive (Mancas (2015c)).

Two other studiers that can be related are: the research of Francis Herbert Bradley, whose ideas contrasted to those of W. James and had a more Locke like vision, where the concept of attention work as a mode, and the research of Alexander Bain who was a more behavioral psychologist and closest to the cognitive psychology (Mole (2013)).

Cognitive Psychology

With the arrival of the twentieth century psychology suffered changes in his method and his approach. Now the main trend is behaviorism, and with that there is a tendency to ignore the attention field of study (Mancas (2015c); Mole (2013)).

Despite that some of the behaviorists tried, John Dashiell was one of them, and his project was one of the first that tried to describe the behavior of attention, this was an unpopular project and did not succeed (Mole (2013)).

A more successful project it was from John Ridley Stroop, which defined the Stroop Effect where it was shown that depending on the stimulation it could have a heavy toll on performance. This explanation is presented in Figure 2 (this tests are likely H. Von Helmholtz) (Mancas (2015c); PsyToolkit (n.d.)).

Stroop in his experiments asked to the participants to say a random color in which some words are written on, these words are themselves names of colors (as described in the image bellow).

The participants shown slower reactions when the color of the ink was not the same that the word, concluding that the stimulus the participants are subjected influence their ability of being attentive and performative.

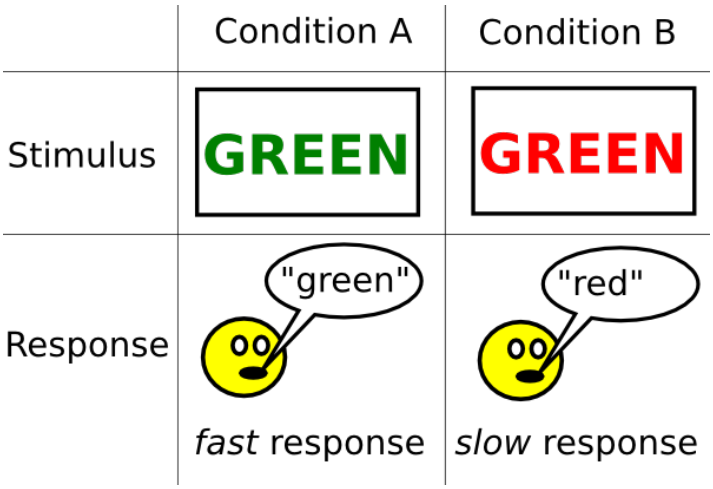

Figure 2: Stroop Effect explanation.

Historically only after the Second World War the attention study was once again renewed, perhaps because of all traumas that the soldiers were up to.

Colin Cherry gave a major contribution by study and defined the Cocktail Party Effect, which revolved around the human capability that in a crowded room follow only one conversation. It followed several steps: first two messages through headphones, one in each ear, and the subjects must write it down, which it proved difficult; later the test have been repeated without the headphones, and the participants could easily listen the messages. Cherry discovered also that once we reject a message it is very difficult to retain some information about it, with the exception of the tone and the voice that was talking (Mancas (2015c); Tsotsos et al. (2005); PsyBlog (2009)).

Donald Broadbent was the creator of the Broadbent Model, which summarizes with most of the previous knowledge a filter type model that shows the bottleneck of attention. As is presented in Figure 3 (McLeod (2008b)), he theorizes that bottleneck may limit the human brain capacity to be attentive he system has two parts: one that is a basically a sensory buffer and is attached to a filter that creates a bottleneck that will only let pass the information needed to the second system, who has a smaller capacity and to which information needs to be sent after been through a cautious selection. This theory was called early selection.

After a while Broadbent conclusions and findings started to seem conflicting and another theory was born, the late selection. The Deutsch and Deutsch model made by J. Anthony Deutsch, and Diana Deutsch proposes that the first the information being filtered and only then processed, the information is all processed and only then the filter acts unconsciously so that only wanted information raises awareness. This theory is lightly supported by the cocktail party effect.

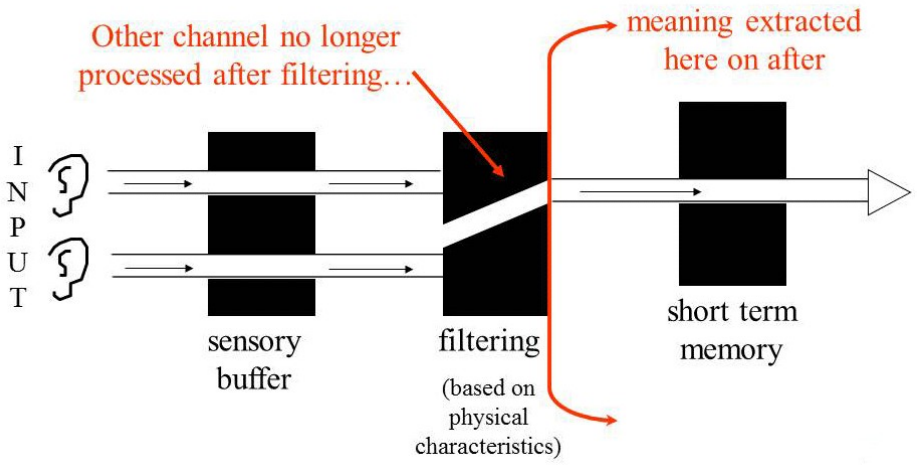

Figure 3: Broadbent attention model.

From this theory confrontation has emerged Anne Treismans and Garry Gelades feature integration theory, in which they suggest that attention is made by two steps, an unconscious parallel step that gets the details of an object and a second step where these details are going to be processed into a focus hierarchy. As presented in Figure 4, Treisman describes this steps with an example: imagine a tomato and an apple, the brain is going to get the colors and forms of these objects which is a pre-attentive way, but then is going to need to join the details all together, and that is when the processing area comes in, joining in the details and to which object pay attention first (Mancas (2015c); Mole (2013); Tsotsos et al. (2005); McLeod (2008b)).

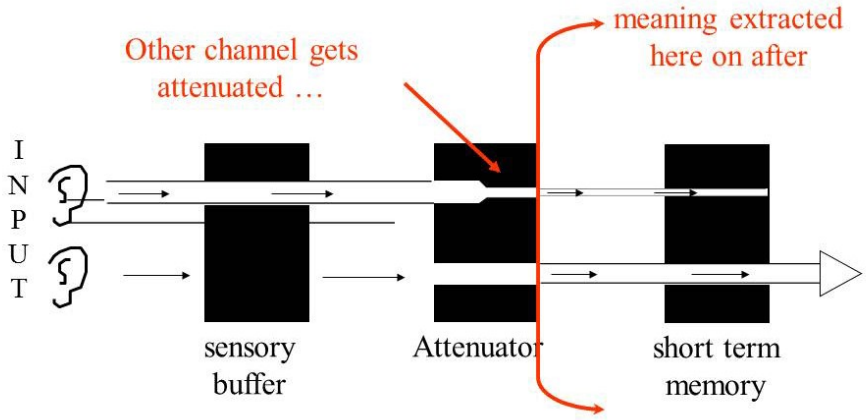

Figure 4: Treisman attention model.

In time, this theory comes to be disputed by Michael Posners theory that attention has three major functions: the capacity of alerting; guide and overt the activation of a stimulus; and look and detect a target in an environment; Daniel Kahnemans theory proposed that attention is oriented by a mental effort, and since processing capacity to support that attention is available multiple activities can be performed whereas total effort does not exceed processing capacity (Mancas (2015c); Tsotsos et al. (2005)).

2.1.4 *Cognitive neuroscience*

Helped by the cognitive psychology studies and with new high-tech tools that allow a more detailed study of what happens in brain during is stimulation. Some of those tools are electroencephalography (EEG), magnetoencephalography (MEG), magnetic resonance imaging (MRI), positron emission tomography (PET) and transcranial magnetic stimulation (TMS) (Mancas (2015d)).

Robert Desimone and John Duncan proposed an attention model based on studies with these new technologies. That model proposes that exists a biased competition, the information present in the human environment overrides the brain processing capabilities, so areas of neurons compete to be the predominant ones. This means that important information will always compete with less important information to influence human behavior (Mole (2013); Mancas (2015d); Tsotsos et al. (2005)).

Another model was later proposed by Laberge, this model, based on neuropsychological studies and neuroimaging data, pushes the attention control to mainly three brain regions. These regions compete to attention control, frontal areas; the thalamic nuclei; and the posterior parietal cortex.

Nowadays these are the two main theories in the field of neuroscience (Desimone and Duncan model and Laberge model) (Mancas (2015d)).

2.1.5 *Computer science*

Using the power of computation joined with Treisman and Gelade theory (feature integration theory) and mathematical foundations, Christof Koch and Shimon Ullman (Koch and Ullman (1987)), created a saliency map based in mathematical. This saliency is a weighed sum of all the details at each point, then the strongest feature will be the most saliently point and further processed. This theory was the first being implemented by Laurent Itti (Itti (2000)). This implementation simulates the eye fixations on the imaged and his saliency maps.

The model started to be developed for videos, 3D imaging, and audio. In more recent models learning (neural networks) started to be mixed with saliency maps, helping for the

search of unusual areas, which could explain and predict the attention focus searching for patterns that define what makes a human be attentive to a specific area, task or thought (light, color, movement,) (Mancas (2015d,a)).

Figure 5: Saliency model.

Other models that emerged from computer science were the visibility models, which rely on the focus of the eye when the brain has the notion of task, so that the eye moves and focus where he perceives that the information needed for completing that task, doing that the eye maximizes the attention in one area and reduces it in the surroundings (Mancas (2015a,b)).

Figure 6: Visibility model.

It is defended by Matei Mancas that both this models are important but the saliency maps tend to be more abundant, so that top-down and bottom-up approaches started to be combined with the help of neural networks (Mancas (2015a,b)).

2.1.6 *Concluding what is Attention*

Attention, as I refer at the beginning of this chapter, may have many definitions. Still the consensual meaning of the word attention has not yet been reached. Some used the concept of different attentions according to the field of study. However, there should be retained the following concepts:

- The difference of overt attention and covert attention. Overt attention is when the center and the focus of attention moves, for instance following a car with the eyes,

being the eyes the center of attention and the car the focus. Covert attention is when the focus change but there is no change in the center of attention. Using again the eye example, when someone keeps on looking to the horizon but is attentive to what happens at his side (Mancas (2015c); Tsotsos et al. (2005); Carrasco (2011); Boeree (n.d.)).

- The difference of serial attention and parallel attention. The human being can deal with only one task at time (serial attention) or several (parallel attention). Between this two definitions there are several degrees of attention: focused attention, focus on only one task at time; sustained attention, focus on a task for a continuous amount of time; selective attention, focus on one task and ignore the distractions; alternating attention, alternate between tasks; and divided attention, attend to several tasks at once (Mancas (2015d)).

- The difference of bottom-up attention and top-down attention. Bottom-up attention is based on the subconscious part of attention, for instance, a person is focused on working out on the beach, suddenly a wild roar is heard, instantaneously the person gets alerted (attentive) for the presence of some wild animal in the area. Top-down attention, is more related to memory, emotion, and goals (Mancas (2015d); Tsotsos et al. (2005); Mancas (2015a,b); Itti (2000)).

Finally, we can say that attention plays an important role in the human capacity to obtain and process information, and lack of it can bring several problems. The reasons that cause lack of attention can be diverse.

2.2 ELEMENTS THAT AFFECT ATTENTION

Attention is greatly affected by some factors such as mental fatigue, stress, anxiety, health, emotions and new environments. This elements are usually linked and affect each other, for instance, a person with too much stress usually has poor health (Durães et al. (2016a)). These elements is presented in Figure 7.

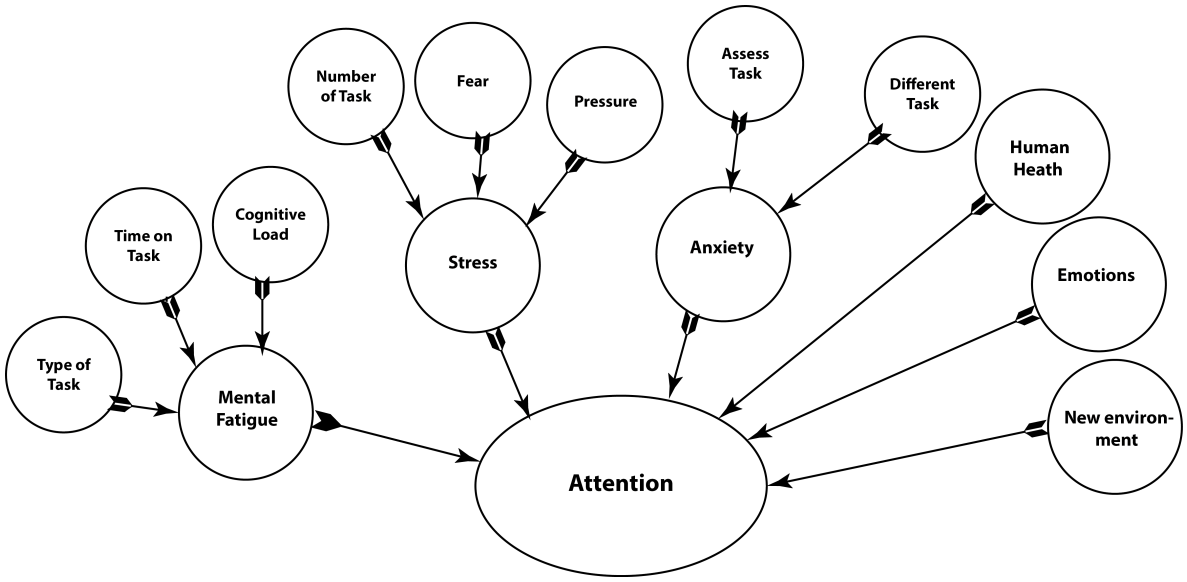

Figure 7: Elements that affect attention(Durães et al. (2016a)).

Mental fatigue can influence attention negatively, accordingly to the studies that were made by many authors, and almost all of them come around the same results, the fatigued a human being is harder it is to pay attention to something. The studies show that the error rate increases, distractions are more frequent and performance lowers. This is closely linked to the time in which a user is working on a task and it was verified that breaks helped to keep mental fatigue in lower levels. The type task of that someone is performing is also important and might increase the mental fatigue. For instance, operating a patient and cooking do not increase mental fatigue in the same way. Finally the cognitive load also directly influences the mental fatigue, the reason is because the overwork that the brain is subject to (Boksem et al. (2005); Mizuno et al. (2011)).

The stress is, as attention, another difficult thing to define, in part because it is very personal, as something that stress a person it will be unnoticed by other. The most suitable and simple definition available is in the dictionary:

"A specific response by the body to a stimulus, as fear or pain, which disturbs or interferes with the normal physiological equilibrium of an organism" (Dictionary.com (n.d.a)).

The right amount of stress can be favorable to attention, as it forces the humans to stay more alert and attentive, but generally stress is viewed as attention disturbing. A high stress rate is generally linked with more mental fatigue. The stress slows down the ability to switch attention between tasks and number of tasks at the same time. Stress increases if the user need to pay attention to multiple details and timings at the same time. Fear is also a stress inducer, fear may take several forms, among them, it may trigger a fight or flight response, which leaves the body and mind under additional stress. Stress can also be felled

by the fear of failure in a particular task. The pressure can increase stress as the tasks and activities do not have all the same importance, a professional firefighter should be under more pressure daily than a simple writer (of Stress (n.d.); Sänger et al. (2014); Foundation (2009); Shors (2006)).

Anxiety can decrease the attention level, and it can even contribute to stress. It can be viewed in two different situations, in a more visual and vigilance process when it can spike saliency points and improve stimulation (increasing attention) and in a more task oriented view, it can difficult the task as it lowers attention in that particular task. Anxiety can mess with the simple act of understanding a task, when a human is anxious it is less likely to pay attention, different tasks increase anxiety as the difficulty level of attending and successfully complete all that tasks increases (Pacheco-Unguetti et al. (2010)).

Human health, some of the previous factors also can temper with health, as we can talk about chronic stress, depression, attention disorders and other diseases and disorders that alter unnaturally some elements vital to attention. As it is usually said:

"Mens sana in corpore sano"

It is needed a healthy body for our mind to works at is full capacity, also it is of extremely importance that human sensors that allow to capture stimulus to be correctly working, if that does not happen the stimuli will not be corrected capture and can lead to attention errors.

Emotions are a powerful variant in humans lives, with attention is not different, positive emotions can be an instigator of attention and negative emotions generally lower attention.

When a human being is feeling emotionally well it has more predispositions to be attentive and to respond to stimulus although sometimes it could also lead to a state of euphoria that makes the person focus and be attentive. This state is easily understood, for instance, a person who wins a lottery hardly is going to pay attention to something in the next minutes. A human that is feeling low and emotionally negative is not going to be attentive to anything except is problem, the more extreme example is when a person loses someone, the grief tends to block the stimulus and therefore no attention is paid whatsoever (Fredrickson and Branigan (2005); Brosch et al. (2013)).

New environments tend to change people state of mind, generally increasing anxiety, curiosity, stress. This is obviously bad for the attention, sometimes a new environment can help as it makes the human create new habits and let emotional locks behind, allowing to pay attention, for instance, a student that changes of classroom, the new environment can confuse the student causing him to have a loss of attention, or if the student already has poor attention can force him to re-adapt and be more attentive.

Finally, the engagement, this is a property which defines how much interested and willing to be attentive someone is. This is important because if a person is mentally and physically fit to pay attention to something, but that something does not pose an interest

to that person it will be extremely difficult to be attentive, much like a student in a subject that he does not like, it will be much less attentive that to his favorite subject, even if is equally ready for both subjects.

2.3 LEARNING AND TECHNOLOGY

Learning is a skill used in all of the humans lifetime, and it can be defined as:

"The art or process of acquiring knowledge or skill" (Dictionary.com (n.d.b)).

It is a very linked with attention as without attention the learning ability is severely impaired, this is corroborated by scientific studies that note that with less attention less information is retained by the brain(Nissen and Bullemer (1987)).

2.3.1 *Technology in Learning*

Many technologies can be used to learning such as online collaboration tools, presentation software, tablet, course management tools, clickers and smartphones, lecture-capture tools, audio tools, etc.

The teacher can these technologies in a synchronous or asynchronous interaction, these two forms of interaction and can be used together. Synchronous interaction is when a student action has an immediate response by the teacher, examples are telephone calls, video calls and instant messaging, this type of interaction obliges for coordination between the participants. Asynchronous interaction can be defined as when a student action does not have an immediate response from the teacher, examples are blogs, videos, email and discussion boards, this type of interaction allows flexibility for the student to learn at is own pace and timetable, helping deep information processing (University (2017)).

In conclusion these technologies have many advantages to help students learn faster and better, by allowing the teacher to adapt to the students learning style. But there are many distractions that can undermine attention present in this technologies, with the rising of social networks and digital games it can prove hard for a teacher to know if the students are really working and learning with the classroom tasks, or if they are wasting time and attention in other non-related tasks (of Washington (n.d.); McNeely (2005)).

2.3.2 *Learning Styles*

Every student has is own characteristics and will process information differently from the others, therefore there are different learning styles. To evaluate and explain those learning styles there are several theories, one of the most known is Felder-Silverman Learning Theory (Felder and Silverman (1988)).

This theory describes that there is 32 possible learning styles, each learning style has 5 different dimensions, there are:

- Perception, what information the student will perceive.
- Input, through which channel the student will obtain the information.
- Organization, in which order the information should be given to the student.
- Processing, how the student likes to process information.
- Understanding, how the student progress to understand the information.

Each of this dimensions has two options to the students characteristics:

Preferred Learning Style	
sensory intuitive	perception
visual auditory	input
inductive deductive	organization
active reflective	processing
sequential global	understanding

Figure 8: Felder-Silverman Learning Styles

- Sensory, the student perception is preferentially external, favoring sounds, physical sensations, sights, ...
- Intuitive, the student perceives more internal, using possibilities, hunches, insights, ...
- Visual, the student retains more information through pictures, diagrams, graphs, ...
- Auditory, the student will favor sounds and words as the information channel.
- Inductive, first the facts and observations are presented and the student infers the principles.
- Deductive, the principles will be given, facts and consequences will be inferred by the student.
- Active, this type of student will prefer physical activity or discussions to process information.
- Reflective, the student will prefer to concentrate, meditate and think to process the informations presented.
- Sequential, the student will understand the information in small steps, step by step.
- Global, the student will understand the information in big steps, understanding all the information at once.

Usually the teaching techniques used in schools are better suited for the students that are intuitive, auditory, deductive, reflective and sequential. This theory has guidelines to be able to provide the teachers some teaching techniques and styles to help the students to improve their information processing and retaining the information more easily.

3

PROPOSED ARCHITECTURE

The goal of this project is to be able to measure the attention level and identify a more profitable user behaviour.

The main themes for the planned work were presented in the previous chapter. Attention and user behaviour will be fundamental throughout the proposed work and resolve the propose problem.

In this chapter it will be explained the requirements, methodologies used in this work, as well as the architecture, technologies and implementation decisions of this project.

3.1 THE PLANNING

As shown in Figure 9, for the realization of this project it was necessary to follow several steps. In the first stage, an architecture of the system was studied and defined. In the second, the technologies to be implemented in this project were chosen. The third stage consists of the technical development of the system, this development can be divided in several sub-stages, these sub-stages were the individual development and integration of the modules that compose this system that are the REST module, ROOM module, DB module, CORE module and CHART module. Finally in the fourth stage, the system was tested.

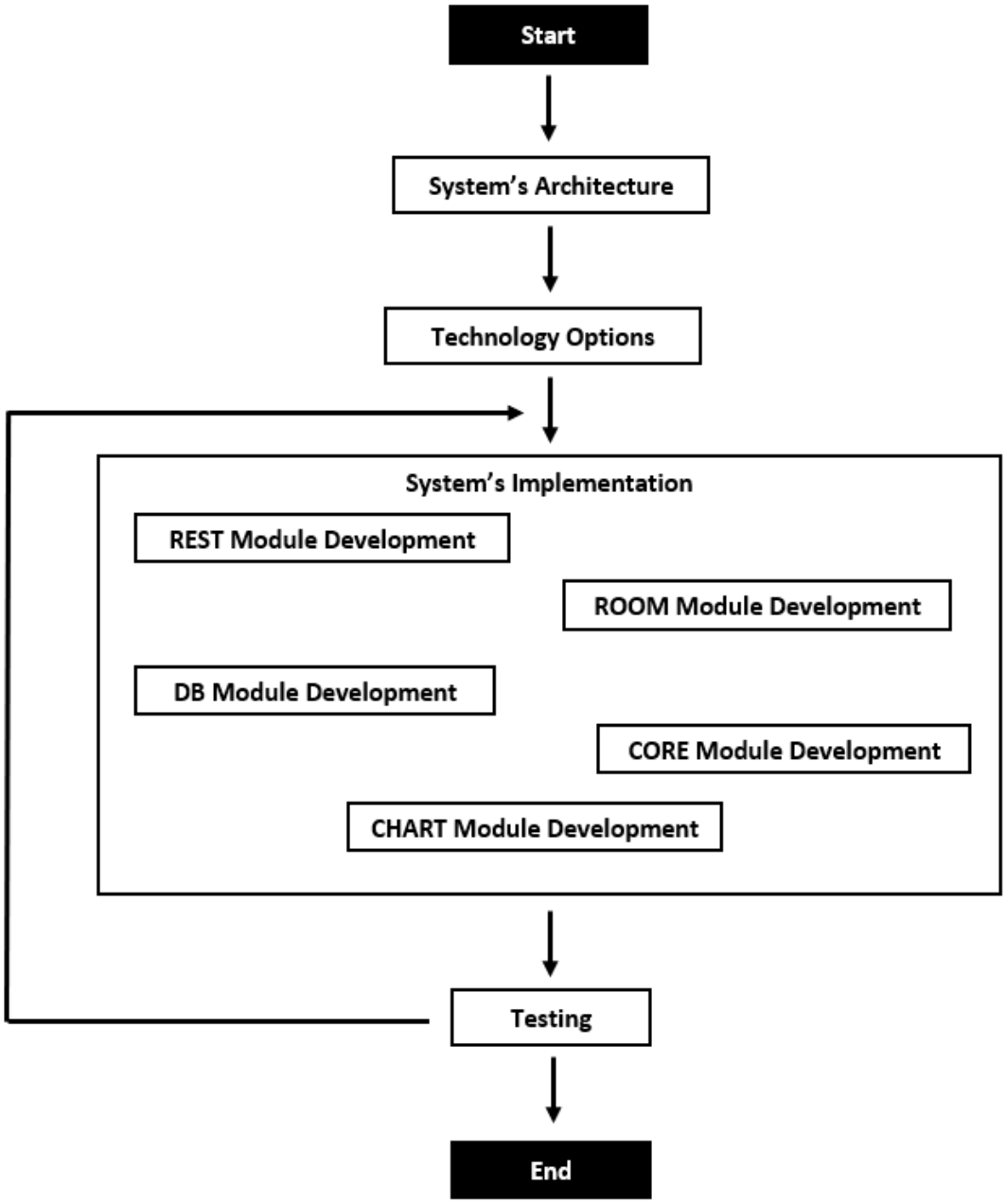

Figure 9: Project Planning

In order to keep track of the work that had to be done, work in progress and work already done it was used an agile framework adapted to the project.

That framework is known as Kanban (LeanKit (2016)), this agile framework is constituted by four core principles and a visual board. This will allow to keep track of all the work and at the same time give flexibility to plan the path ahead.

The four core Kanban principles are visualize work, limit the work in process, focus on the flow, continuous improvement.

The Kanban Board (Figure 10) used was a simple board with three divisions that are usually done in Kanban.

TO DO	IN PROGRESS	DONE
Implement Grades	Implent Students	Implement Database Interface
Implement Classrooms		Implement Real Time
Define CORE		

Figure 10: Kanban Board

The task starts in "To Do" column, when it starts to be detailed and developed it goes into the "In Progress" column. The "In Progress" column should not have more than two tasks at the same time, and it should only have more than one in blocking cases. The last column, "Done", is where the task will be once it is finished.

3.2 System's Architecture

In the Figure 11 it is possible to see the architecture of the system. It will have two possible workflows, one when in real time mode and the other with historical mode.

This architecture is divided in six different modules: REST, CORE DB, UI, ROOM, CHART, this modules are receive the data via a classifier, that will be outside of the system and has connection to the students.

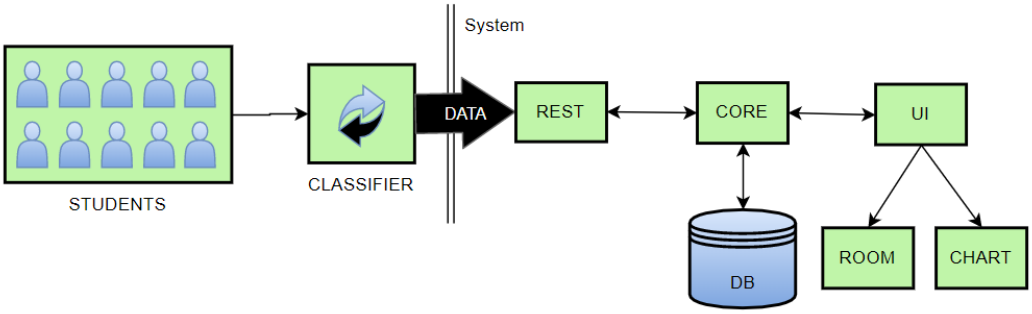

Figure 11: System architecture

All the data is received through an external classifier, this classifier will handle the treatment of the data into useful information, doing for instance the necessary calculations to reach the attention index.

In real time mode the data flow will be processed in the following way, the rest service (REST) receive the students data in real time. The REST module is composed of a http service controller that is responsible for receiving and send data to the classifier using the rest protocol. The REST module has also a synchronization controller that controls data syncing, solving any problems of integrity caused by the real time data feed, this controller will send and receive the information to the http service.

The data will be accessed the core (CORE) of the application where all the needed processing will be made. When the application starts the CORE module will run the IO controller automatically in order to collect the configuration variables needed from the configuration file. This module also has several controllers responsible to comprehend all the data received by the REST module.

Used by every module are the domain classes, these are used to represent and store the information in runtime, they are of the most importance to REST, CORE and DB modules because they represent the physical world in the application, like students, rooms and classes.

The core is connected to the database (DB) that will be updated and allow to compare previous data. The DB module has a controller that allows for all the needed operations between the CORE and the DB, allowing to store or retrieve any needed informations.

Then there are some graphical modules that allow showing the information in an intuitive way to the user, all of these graphical modules depend on the CORE to provide them the needed controllers and information, since they are mostly interfaces to output the results of the application and to receive the input of the user.

From these graphical modules stand out the user interface (UI) that allows the teacher to control the application, being responsible for presenting the screens that allow the teacher to create, and modify students, classes, tasks, in the application and for present received information to the teacher.

The module that allow the creation and visualization of charts (CHART module), the charts can be personalized by the user to display any information that is found to be relevant.

The layer that allows the creation and display of virtual classrooms (ROOM) so that the teacher may view intuitively the students behaviour with a classroom view, this view allows the teacher to define their classrooms and display the students how they want, that way being able to easy overview of the entire classroom.

The historical part of the system will work as the rest service (REST) will retrieve the historical data of the students and send it to the core (CORE) that will do the required processing.

After this the user interface (UI) will show the processed data and allow to create charts (CHART) using that data.

3.3 TECHNOLOGY

The technologies that were used were: MySQL, Java, JavaFx, Rest and Git.

3.3.1 *MySQL*

The project requires a database connection, as the users will be required to authenticate in order to access the functionalities offered by the system.

The users will also have the capability to create the students, rooms and other data in the database.

In order to choose a viable database technology for this project, it has been made a first choice whether it should be a relational database or a non-relational database.

Virtualy all relational databases use SQL (Structured Query Language) for querying the database, so there are several SQL versions from which to pick (Oracle SQL, PostgreeSQL, MySQL, Microsoft SQL Server, ...).

The non-relational databases that were studied as candidates were MongoDB and CouchBase.

The choice of using a relational database was because of the better consistency enforced by this type of database, the better logical scheme approach allowed by it, the system will not have be a distributed database and it will not be needed a large scalability (Serra (2015)).

Later came the choice of which SQL database to use, the choice has mainly fallen to this parameters, an easy to install and use database, a proved database, a robust database and if possible an open source database, this way the choice was MySQL, as it is a simple database, with many years of market and completely open source.

MySQL is an Oracle database server, that has as strong points its fastness, being multi-threaded, multi-user and robustness. It is avaliable as an open source product under the GNU General Public License (Oracle (2018)).

3.3.2 *Java*

For the core of the project, the controllers and where all the data will be handled, it was chosen Java. Java is a well-known and mature programming language, it works by compiling the code to a JVM (Java virtual machine).

Because it uses a JVM, Java it is multi-platform as a JVM can compile Java code to work with almost every operative system needed (Oracle (2017a)).

Other languages were studied to be used, some of them were, C, C#, C++ and GoLang, but none had a better fit in this project as Java, it has a wide display of libraries, it is as previously said a mature language and that makes it stable and it is a language object oriented.

To develop in Java the used IDE was Netbeans, Netbeans is the official Java 8 IDE, and it is multi-platform (Oracle (2017b)).

3.3.3 *JavaFx*

JavaFx is a front-end platform that has become one of the best alternatives to Java Swing package. It uses FXML (an XML based markup) to design the structure of the user interface, this structure will be controlled by a Java controller (Oracle (2016)).

This platform has some designer tools, for this project it was used Gluon Scene Builder that is a drag and drop tool to design the user interface.

JavaFx also implements a special CSS version, that allows to apply styles to the user interface.

For the front-end it could have been chosen other graphical frameworks like Java Swing, AngularJS, Angular, React and Ember.JS. Java Swing is considered an outdated library and should be replaced in next Java version for JavaFx as the official GUI Library. The other frameworks are web-based, and the idea in this project is to have a desktop application, so JavaFx was elected.

3.3.4 *Rest*

It is required to have connection to outside of the system for that it is necessary a messaging protocol. Nowadays Rest (Representational State Transfer) is the most used communication protocol and it was chosen to be used in this project (Pivotal (2016)).

Rest uses the HTTP verbs (get, post, put, patch and delete) in order to make CRUD (create, read, update and delete) operations requests.

- Get is a retrieval request, so it is corresponding to the read operation.
- Post is a request usually meaning a create operation, although sometimes could be an update.
- Put is an update request that generally leads to an update operation.
- Patch is another update request, the difference beteween put and patch is that put will normally update the entire object, while patch will only partialy change the object.
- Delete, this request is a delete operation.

This link between HTTP verbs and CRUD operations it is considered just a good practice, because Rest does not actually enforces this. In this project the link was respected.

Rest is known for its simplicity, good standards and versatility (as it can connect to different technologies without changes).

3.3.5 *Git*

Git is a version control system, it was used to keep backup of the work done, track the changes that were made and the history of the project. It has a repository that will keep all the code, and a local copy of the same, the changes need to be manually committed and pushed to the remote repository (Chacon and Straub (2014)).

The repository can be cloned and pulled in every computer with an internet connection and git installation.

This remote repository is placed in BitBucket, which provide spaces for allocating projects.

Other alternatives to this version control could be Mercurial, Apache Subversion and Microsoft Team Foundation Server, however Git was chosen because it is easy and simple to work with and open source.

3.4 IMPLEMENTATION DECISIONS

During the project several implementation decisions had to be taken, here it will be referred the most important of them. These decisions shaped the entire application and were made to simplify and improve the application and the relation of the users with it.

3.4.1 *Attention Classification*

For achieving the attention metrics it was used a classifier, this classifier is reached via rest requests. The application can work with different classifiers provided that they respect the JSON object params defined to send and receive the information.

There is already one classifier (Cardoso (2017)) that can work with the required JSON and provide the information needed. That classifier measures the attention level using the formula presented in the following figure:

$$\text{Attention} = \frac{\text{Task Effective Time x 100}}{\text{Total Time}}$$

Figure 12: Classifier attention formula

To measure the attention and other indexes the classifier will receive from the application the rest information about the expected tasks and the time that it should retrieve, it will access it's own raw database and process the information about what the students are doing and resend back to application.

In the UI part the attention statistics will be classified by using a color system, this system will allow the teacher to understand faster the students behaviour, the colors are:

- Red, for very low attention (less than 20%).
- Orange, for low attention (more than 20% and less than 50%).
- Light green, for normal attention (more than 50% and less than 80%).
- Green, for good attention (more than 80%).

3.4.2 *Configuration File*

It is intended that the application would be adaptable to the user environment.

For this purpose several variables are stored on the configuration file named "main.config" (Figure 13). They are:

- The database authentication data, composed of three variables, MYSQL_DATABASE_URL, MYSQL_DATABASE_USER and MYSQL_DATABASE_PASSWORD.
- The remembered user data, composed of TEACHER_USERNAME, TEACHER_PASSWORD and PASSWORD_PREVIEW_CHARS.
- The web services endpoint, DATA_API_URL.

```
1  --- PLEASE DO NOT EDIT THIS FILE ---
2  --- THIS IS A CONFIGURATION FILE ---
3  1>MYSQL_DATABASE_URL
4  2>MYSQL_DATABASE_USER
5  3>MYSQL_DATABASE_PASSWORD
6  4>TEACHER_USERNAME
7  5>TEACHER_PASSWORD
8  6>PASSWORD_PREVIEW_CHARS
9  7>DATA_API_URL
```

Figure 13: Configuration file "main.config"

This way if there is any change to make at these points it will be easier and faster to adjust the application.

The previously stated variables were found to be the most changeable global variables, as such they will be required to be changed every time that the application is deployed in a new system or a support module (database or rest data channel) is changed.

The three first variables are connected to the database, being:

- The first is going to provide to the application the connection address to access the database.
- The second provides the database authentication user
- The last is the password to authenticate and be able to access all the data stored in the database.

The fourth and fifth variable are the variables that when the teacher has the remember me function selected in the login screen will save his authentication data. The the sixth variable it is just a help to display the preview for the password mask display in the login screen.

The last variable is the rest endpoint url where the outside data are.

3.4.3 *Graphical decisions*

This project is required to have a simple and intuitive graphical design, that is why a decision has been made of not doing a normal design but rather try to make a less distracting design, a design that allows the user to focus on what he want to see highlighting the area where the most important information is.

The design is desktop based rather than web based, this was also planned, because desktop designs tend to be more intuitive and allow to facilitate a workflow for the user to use Chia (2017).

The design colors are grey based, with some different colors (green, orange and red) to stand out and draw the user's attention to the development of the attention levels in the classroom.

The application allows to the user to use some charts of several indexes such as: attention level, historical attention, mouse, keyboard, time and useful time. This is done by using JavaFx chart library which makes simple and user-friendly charts.

3.4.4 *Security*

In every application is important to have a certain degree of security, this degree must be as high as required by the sensitive data accessed in the application.

In this application the stored data is not highly sensible, but nonetheless was important to have some kind of authentication that guarantees the veracity of who is accessing to the data, because of this it was implemented a SHA-2 security cipher, the used version it was SHA-256, which uses 256 bits (32 bytes) Convert (2015), being safe enough to encrypt the teachers password before save them in the database. This way the database will never have stored the real password of the teacher, but rather an encrypted version.

3.4.5 *Database Model*

Accordingly to the previously stated, the database will be developed in MySql, this database need to be able to store the data for the system to work, as it is an Sql based database the data will be saved in a relational scheme (Figure 14).

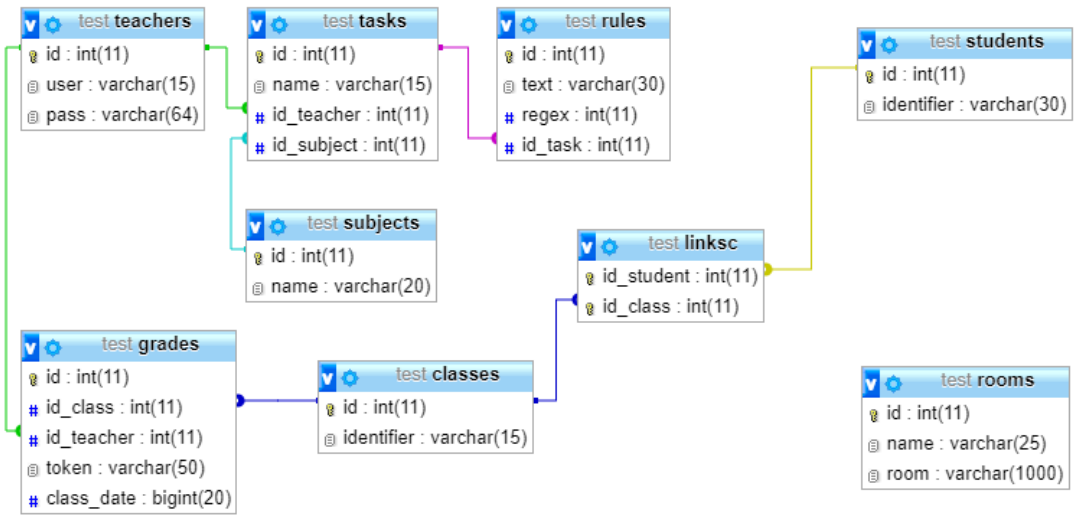

Figure 14: Database Scheme

This scheme has 9 tables, they will bellow be described in detail:

- First the ”teachers” table (Figure 15), this will be where the teachers username and password will be saved, in this project the teachers are also the users so it will serve as an authentication table to enter the application.

Teachers		
Field	Data Type	Constraints
id	int(11)	PK
user	varchar(15)	
pass	varchar(64)	

Figure 15: Teachers table

- The ”students” table (Figure 16), this table is the representation of a student in the application and it is composed by the identifier attribute.

Students		
Field	Data Type	Constraints
id	int(11)	PK
identifier	varchar(30)	

Figure 16: Students table

- The ”classes” table (Figure 17) has the classes that the teachers have defined in the application, they will also have an identifier that will work as the name of the class.

Classes		
Field	Data Type	Constraints
id	int(11)	PK
identifier	varchar(15)	

Figure 17: Classes table

- The classes are groups of students and a student can be present in more than a class, so a link table is required this is represented the ”linksc” table (Figure 18).

LinkSC		
Field	Data Type	Constraints
id_student	int(11)	PK/FK(Students.id)
id_class	int(11)	PK/FK(Classes.id)

Figure 18: Link students and classes table

- The teachers teach subjects, that reality needs to be mapped in the application, so it was created the ”subjects” table (Figure 19), this table will save the name of the subjects inputted by the teachers.

Subjects		
Field	Data Type	Constraints
id	int(11)	PK
name	varchar(20)	

Figure 19: Subjects table

- As the teachers input the subjects for the features of the application is required the input of tasks, this will be stored in ”tasks” table (Figure 20), this tasks are recognized by name and are linked to a teacher and to a subject.

Tasks		
Field	Data Type	Constraints
id	int(11)	PK
name	varchar(15)	
id_teacher	int(11)	FK(Teachers.id)
id_subject	int(11)	FK(Subjects.id)

Figure 20: Tasks table

- Every task will need rules, this rules define what is supposed the student to do when the teacher defines that task for the class’s lesson, it is stored in the table ”rules” (Figure 21) and has the text and the regex attributes.

  The regex attribute can have 4 different values and meanings, 0 means that the regex ”contains”, 1 the regex ”starts with”, 2 the regex ”ends with” and the 3 which means ”not contains”, this regex will be used so that the classifier which filters it should apply by joining regex and the task name.

Rules		
Field	Data Type	Constraints
id	int(11)	PK
name	varchar(30)	
regex	int(11)	
id_task	int(11)	FK(Tasks.id)

Figure 21: Rules table

- The ”grades” table (Figure 22) represents the class in which the teacher does not made an assessment of the students and did not report that it was not necessary. Then this data will be stored awaiting this information. This table is linked to a class, a teacher, and has a token that represents the lesson you are referring to, and a class date that allows the teacher to recognize the lesson.

Grades		
Field	Data Type	Constraints
id	int(11)	PK
id_class	int(11)	FK(Classes.id)
id_teacher	int(11)	FK(Teachers.id)
token	varchar(50)	
class_date	bigint(20)	

Figure 22: Grades table

- Finally, there is the possibility that teachers can represent the classrooms scheme in the application, and to store this information there is a table, "rooms" (Figure 23). Here in addition to the classroom name also a JSON contains all student data and the table positions are saved under the position within the classroom.

Rooms		
Field	Data Type	Constraints
id	int(11)	PK
name	varchar(25)	
room	varchar(1000)	

Figure 23: Rooms table

3.4.6 *Application Features*

On this subchapter, it will be presented the features from this project. It will be explained the feature workflow, the feature goal and some of the taken decisions for the implementation.

Rest Calls

The application has several rest calls and json is the usual format to send and receive data in this calls.

The application main rest call sends the data that the teacher will need to overview the students attentiveness levels in real time, this call will send several parameters:

- A token which can be overviewed as a key that represents the lesson.
- An initial date from where the data should start to be taken into account.
- A final date until where the data will count.

- A json containing peoples, rules and the type of the lesson selected by the teacher.

The peoples json array (Figure 24) has all the identifiers of the selected classes where the research will be made, the rules array will contain the regex and name of the rules.

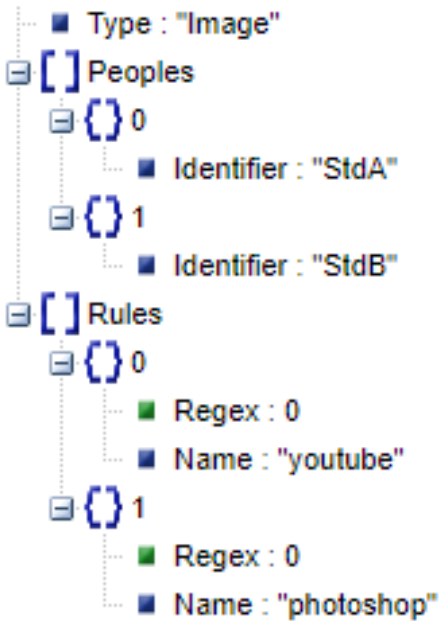

Figure 24: Real time rest request sent information

The server will respond to the call with the following response:

- The combined attention of the class.
- The useful time that the class has spent on tasks.
- The total elapsed time.
- It brings the users array.

The users array for each user has the following data:

- The user identifier.
- Those users personal attention.
- Their useful time in task.
- Their total time.
- The rowData, two major datasets.

The two main data sets mentioned above have peripheral information, one contains keyboard data and the other mouse data (Figure 25).

From the keyboard we can retrieve:

- Time Between Keys (tbk) - timespan between two consecutive key up and key down events;
- Key Down Time (kdt) - time spent between the key down and key up events;

From the mouse dataset is retrievable:

- Mouse Acceleration (ma) - acceleration of the mouse at a given time;
- Mouse Velocity (mv) - velocity at which the cursor travels;
- Time Between Clicks (tbc) - time spent between two consecutive clicks.
- Time During Clicks (tdc) - time spent between the mouse down and mouse up events;
- Distance Point to Line Between Clicks (dplbc) - computes the distance between two consecutive key up and key down events;
- Duration Distance Clicks (ddc) - time between consecutive key up and key down events;
- Distance Between Click (dbc) - total distance travelled by the mouse between two consecutive clicks;
- Click Duration (cd) - time spent between key up events, whenever this time interval is inferior to 200 milliseconds;

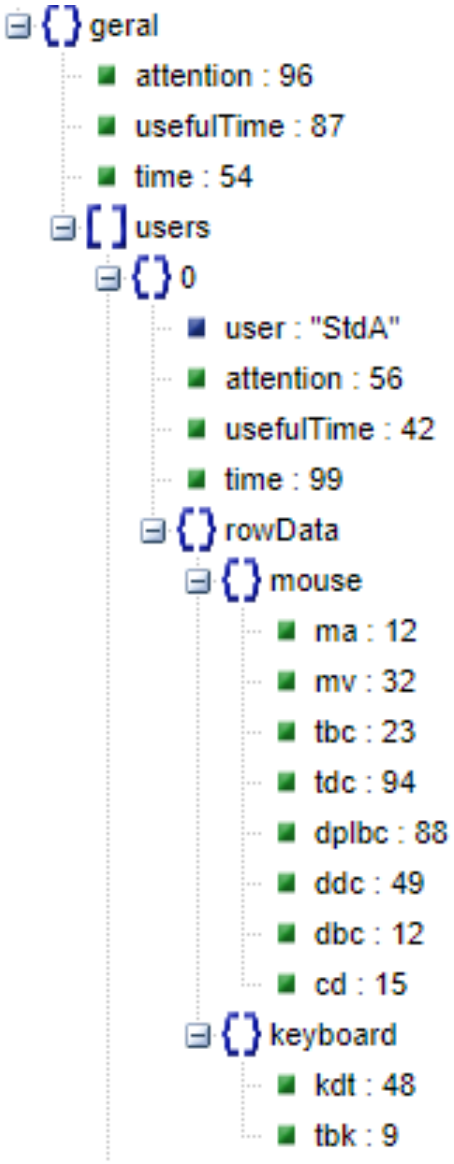

Figure 25: Real time rest request received information

When the lesson is over, the teacher has the option to evaluate the students, and this action needs to be communicated via request of rest. In this request, the lesson token and json will be sent with the evaluation (Figure 26), which is an array containing the students corresponding identifiers and evaluation.

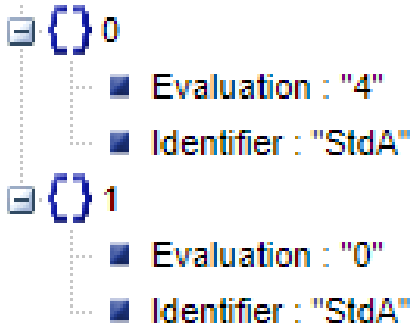

Figure 26: Grades rest request sent information

As a response this request will return only an acknowledge if the grades were successful received or not.

There are two more requests, they are historical requests. The first is the global request, here it will be sent the identifier and the expectable response is a single value with the student total attention level.

The other request is a more complex historical request (Figure 27), which allows that for a sent student identifier receive not only it's total attention statistics but also an array containing the days and the respective attention in each one.

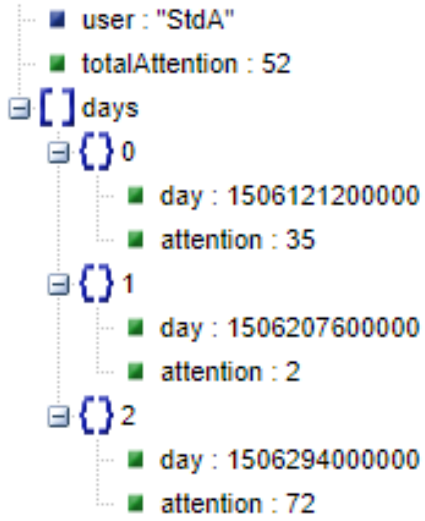

Figure 27: Historical rest request received information

Charts

There are several charts in the application, these charts will be useful for the teacher to track students performance.

In real time mode there is the simple attention chart (Figure 28) which shows attention by time, this is the most simple chart but also one of the more useful because it will allows the teacher quickly understand if the student's attention curve and take action if needed.

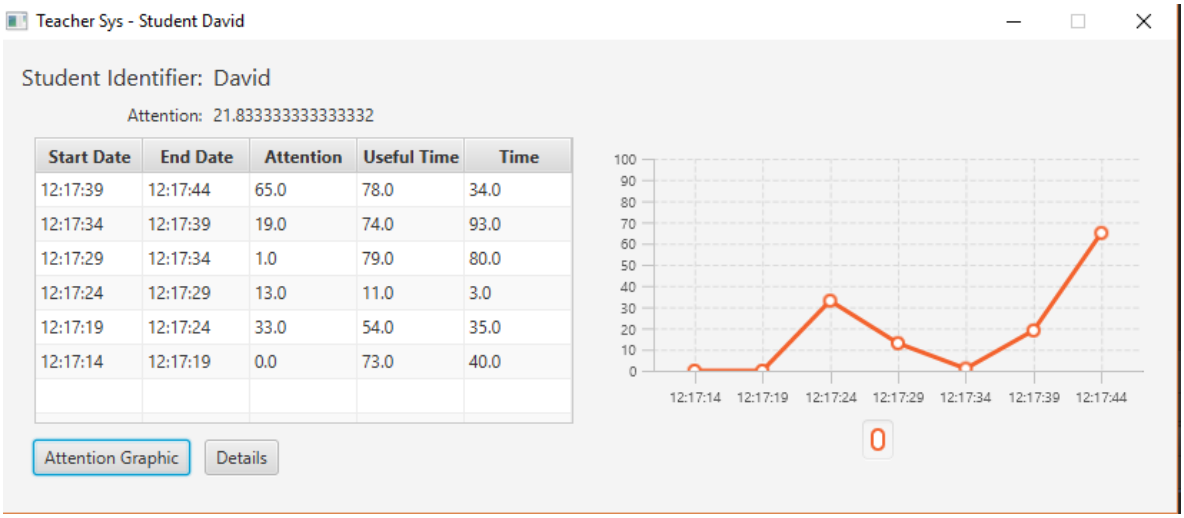

Figure 28: Attention Chart

There is also an advanced feature (Figure 29) that allows to the teacher to define two data indexes and compare them graphically and therefore have an extended comprehension about what is happening with the student.

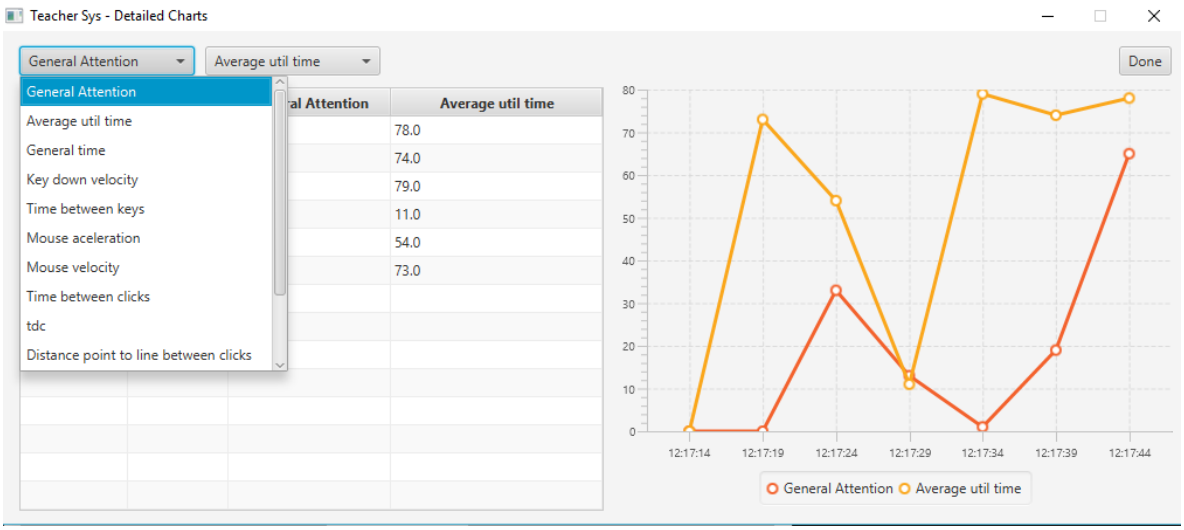

Figure 29: Detailed Chart

The students are grouped by classes, these classes also have a global chart (Figure 30), because in one lesson may be present several classes. This chart will allow the teacher to see class by class behaviour of attention.

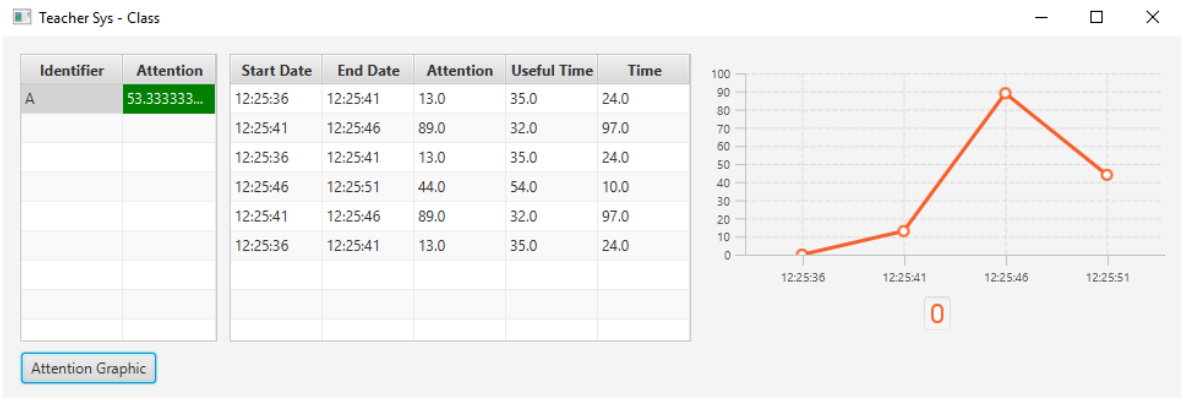

Figure 30: Classes Chart

There is yet another chart available (Figure 31), that shows the student history and it reflects attention level day by day, having the possibility to choose starting and ending days of the chart representation.

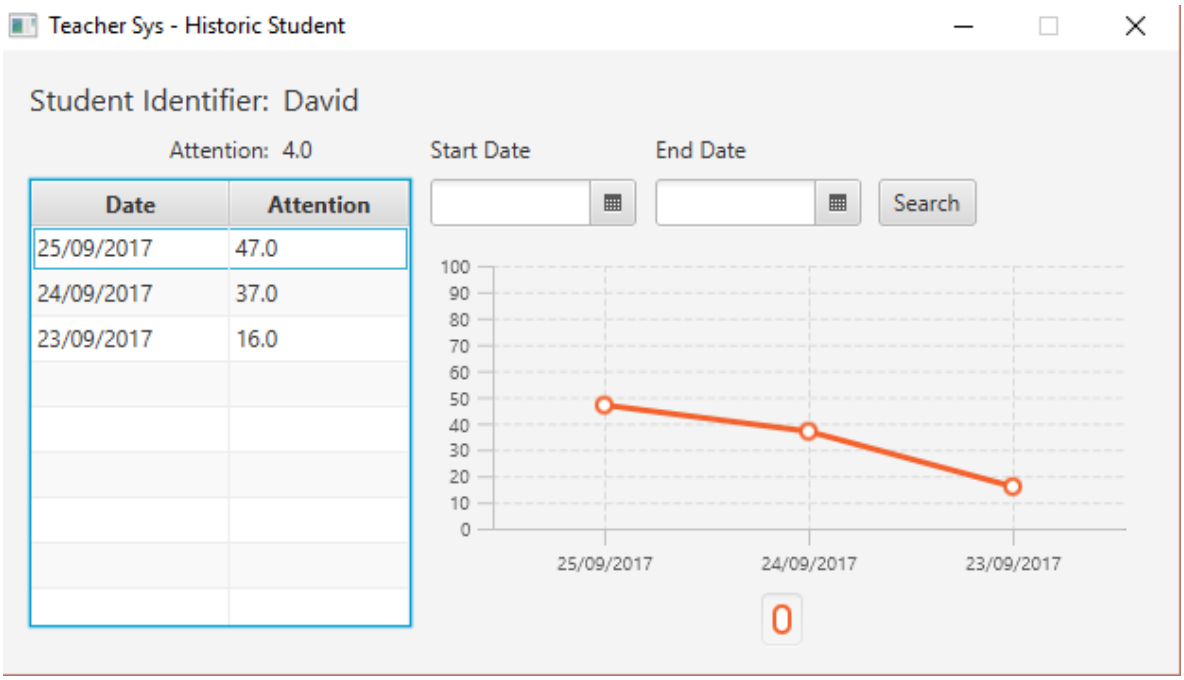

Figure 31: Historical Chart

3.4.7 *Login screen*

This will be the application entry screen (Figure 32), the login screen will enforce the authentication of the users, protecting the students data so that only registered teachers can use the application.

The screen has a remember-me feature, this feature when selected will save the teacher password and username, and keep the textboxes filled when the application is started.

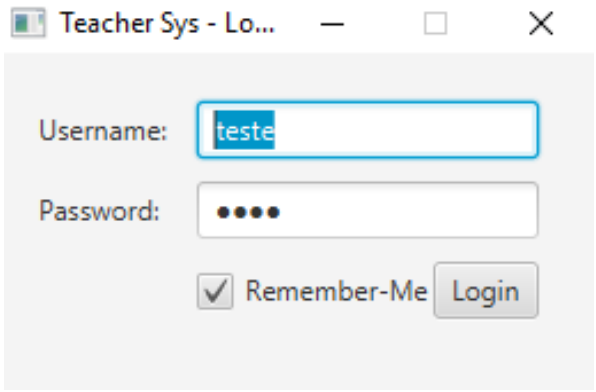

Figure 32: Login screen

3.4.8 *Mode screen*

Because the application has two possible modes there is a screen (Figure 33) to help choose which mode we want to start, either the real time mode, where the students will be monitored in real time, or the historical mode where the teacher will have access to the historical values of the students.

In this screen there is also a board with the lessons that can be graded and still were not dismissed or graded by the teacher.

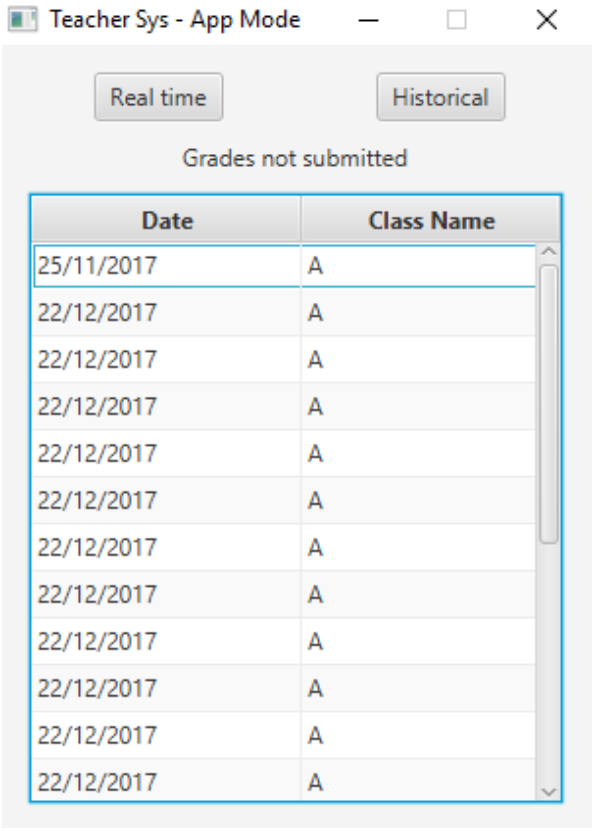

Figure 33: Mode screen

3.4.9 *Grades screen*

This is the screen (Figure 34) where the teacher can input the grades, from 0 to 20 and later send (send button) or refuse (forget button) the grades input, this will help the classifier with the assessment of the learning style of the student.

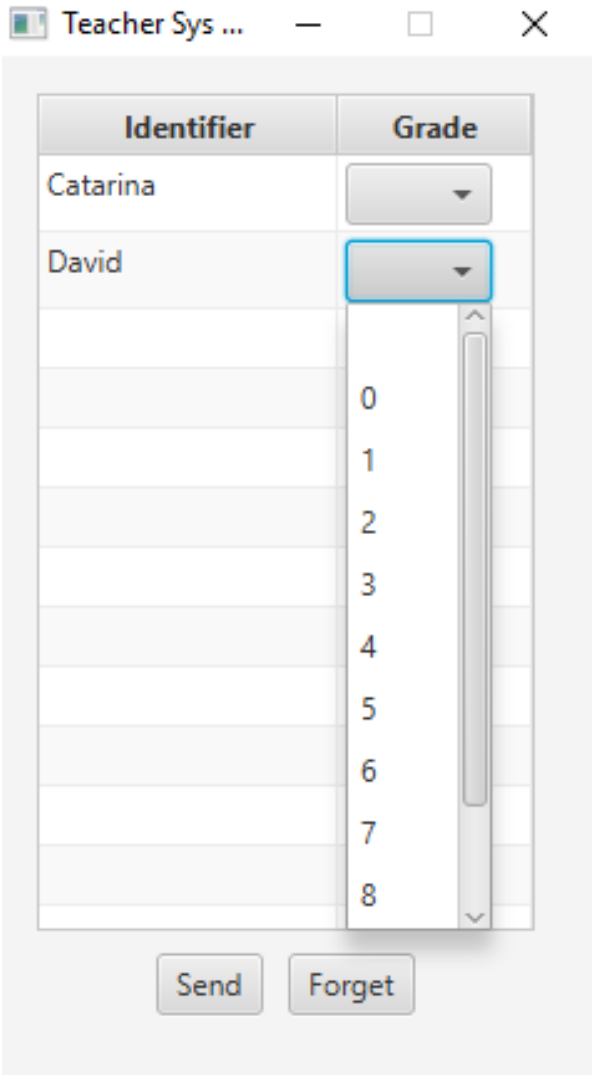

Figure 34: Grades screen

3.4.10 *Real time mode*

In this mode the teacher has access to the students attention and peripheral interaction statistics in real time, while they are in a classroom with their computers on and with designed classroom tasks. This way the teacher may use this information to take action on a student to quickly increase and improve his classroom behaviour and attentiveness level.

Tasks and rules screen

There is a tasks screen in the application (Figure 35), where the tasks and rules can be selected and deleted if needed. The rules are defined by inputting a name and select a regex, in case of tasks they will have a name and are linked to a subject.

When a task is going to be used in a lesson it should be enabled by clicking on the corresponding checkbox in the enabled column.

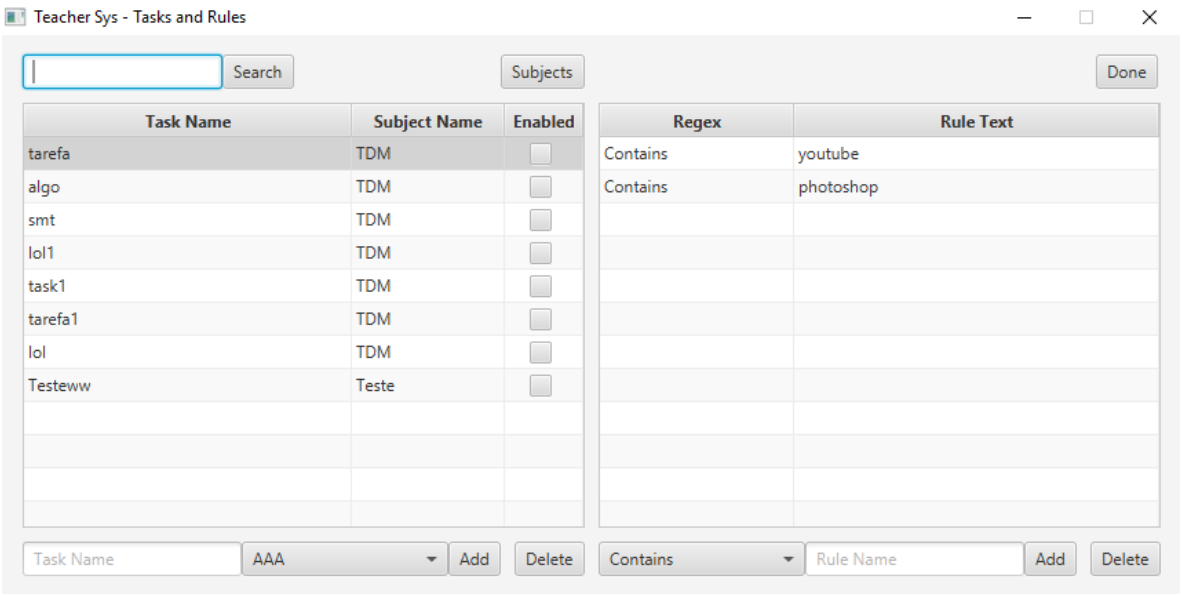

Figure 35: Tasks and rules screen

Subjects screen

This will be the screen (Figure 36) to insert the subjects in the application, the subject is be defined by its name, and it can be selected or removed if necessary. The subjects are linked with tasks.

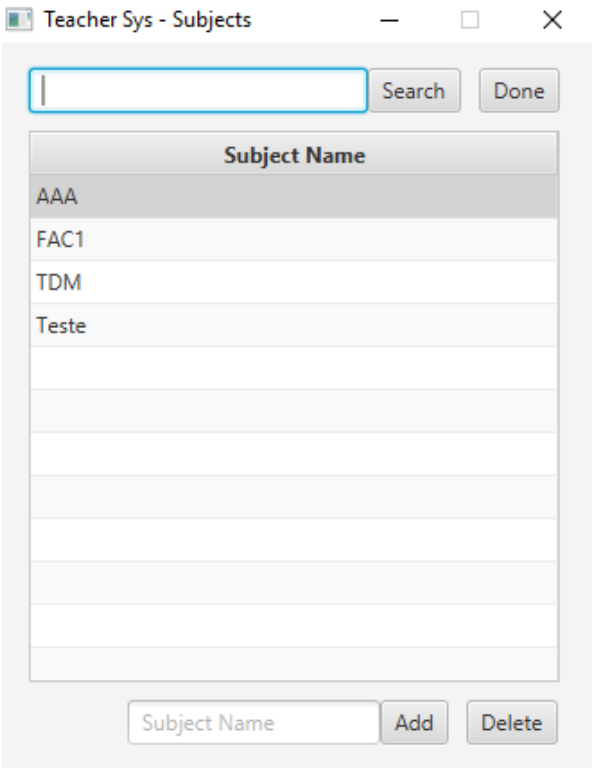

Figure 36: Subjects screen

Main screen

In the main screen of the application (Figure 37) are listed the students and presented the general attention level of the class. The attention level will be classified by colors.

If a left mouse click occurs the classroom indicator panel, it will be triggered the opening of a classroom details screen opening.

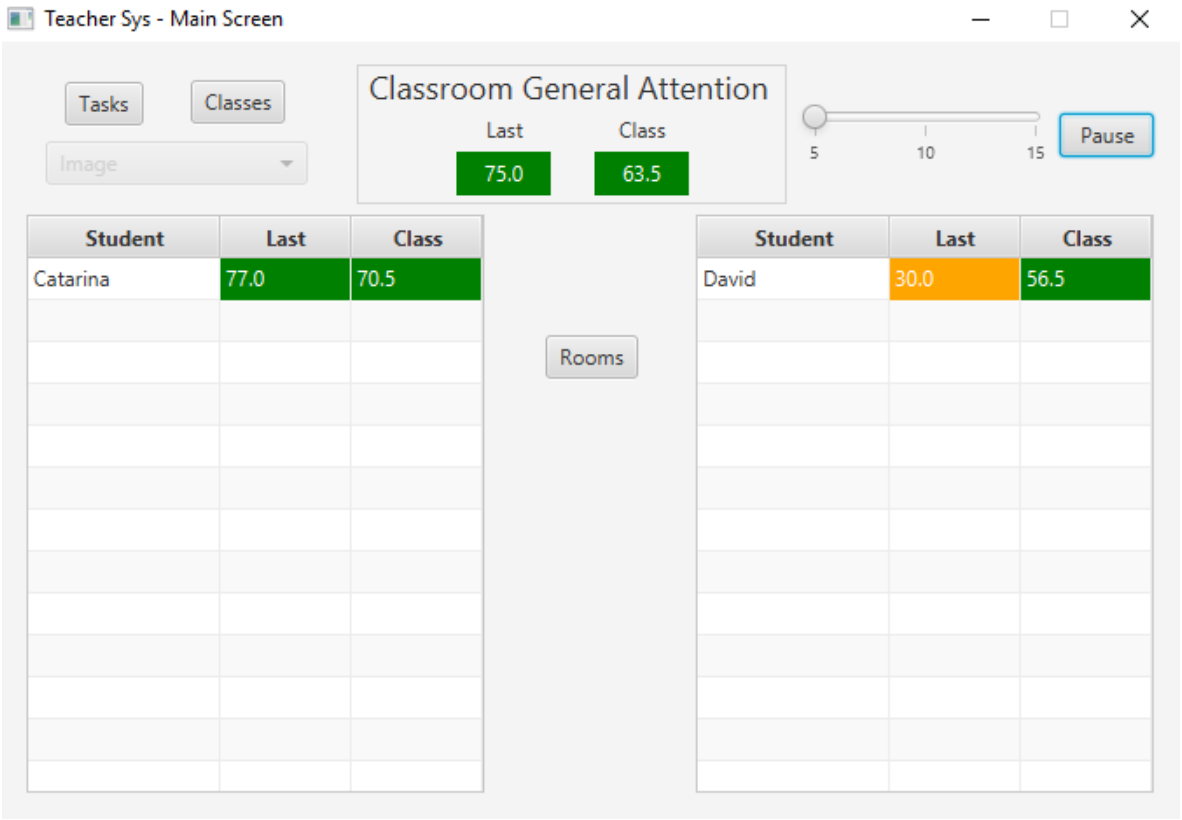

Figure 37: Main screen

The students list intends to be used for the teacher to control the attentiveness level of students and when a left mouse click occurs in one student, it will trigger the opening of a student details screen (Figure 38).

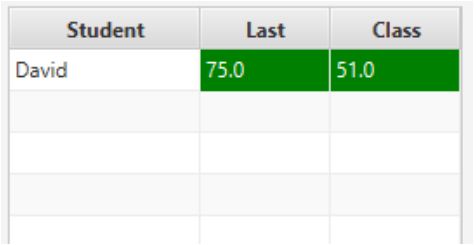

Figure 38: Students in the main screen

In the main screen is where the refresh rate will be defined (5, 10 or 15 minutes), it is present a button to start or pause the application refresh (Figure 39).

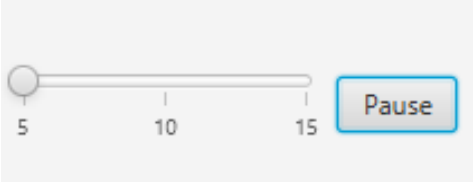

Figure 39: Refresh rate in main screen

The teacher as also the possibility to change the previously defined classes, students and tasks (Figure 40). And a button is available to go to the classrooms screen, in the main screen will be also defined the expected lesson type:

- Audio, when the lesson is mainly taught using sound content.
- Image, when the lesson is mainly taught using pictures content.
- Text, when the lesson is mainly taught using textual content.
- Video, when the lesson is mainly taught using movie content.

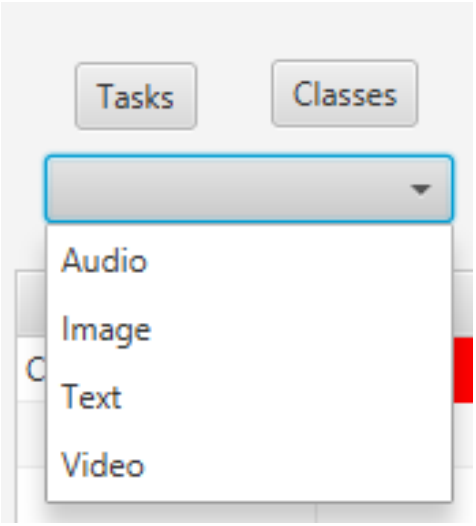

Figure 40: Lesson type, class and tasks

Classes screen

The classroom details screen (Figure 41) is opened when a left click is issued in the classroom panel, this screen will allow the teacher to see the attention chart by class, this proves useful because one lesson can be composed of multiple classes together in a classroom at the same time.

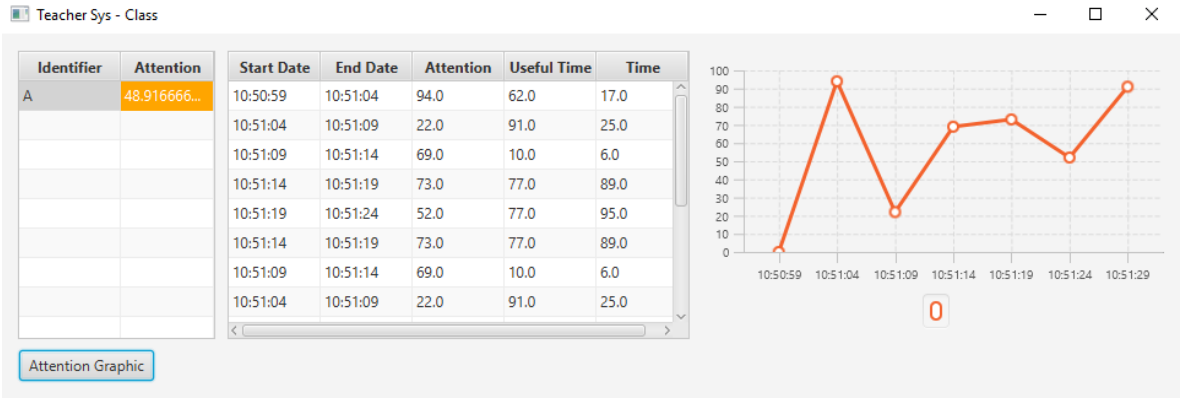

Figure 41: Classes details screen

Students screen

This screens are the student details screen and the advanced student details screen. The details screen (Figure 42) is opened when a left click is issued on the students placeholders in the classrooms screen or in a student in the main screen of the application.

This is the student details screen (Figure 43), in this screen it is possible to click the button details and access a more advanced screen where it will be possible to check more statistics comparisons and do more extensive analysis to the student state, the attention graphic button allows for the opening and closing of the attention level chart on the right.

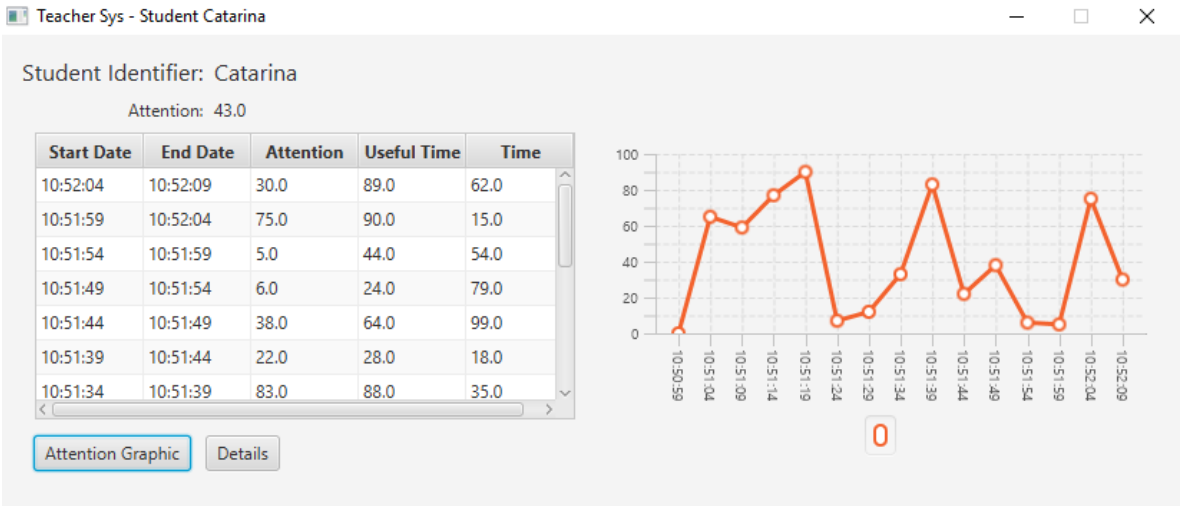

Figure 42: Students details screen

This is the advanced student details screen, and as stated before it has a set of comparable statistics that allows the user to have an advanced overview on the student.

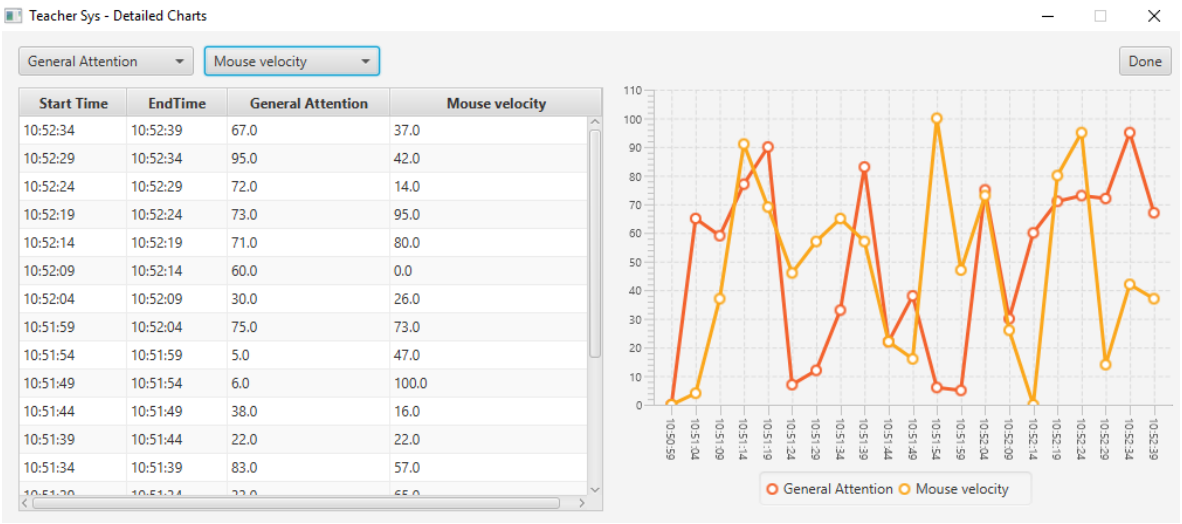

Figure 43: Students advanced details screen

Create classrooms screen

The teacher will have the choice to create classrooms schemes inside the application (Figure 44), this schemes are made by using a drag and drop feature.

If the user holds and drags the left mouse button, he will create a square that will represent a classroom table. To add a student placeholder, simply click the left mouse button to ensure there is no student overlap. A series of crash tests are done. If you click the left mouse button on an existing table or a student, it will select it and allow it to be erased.

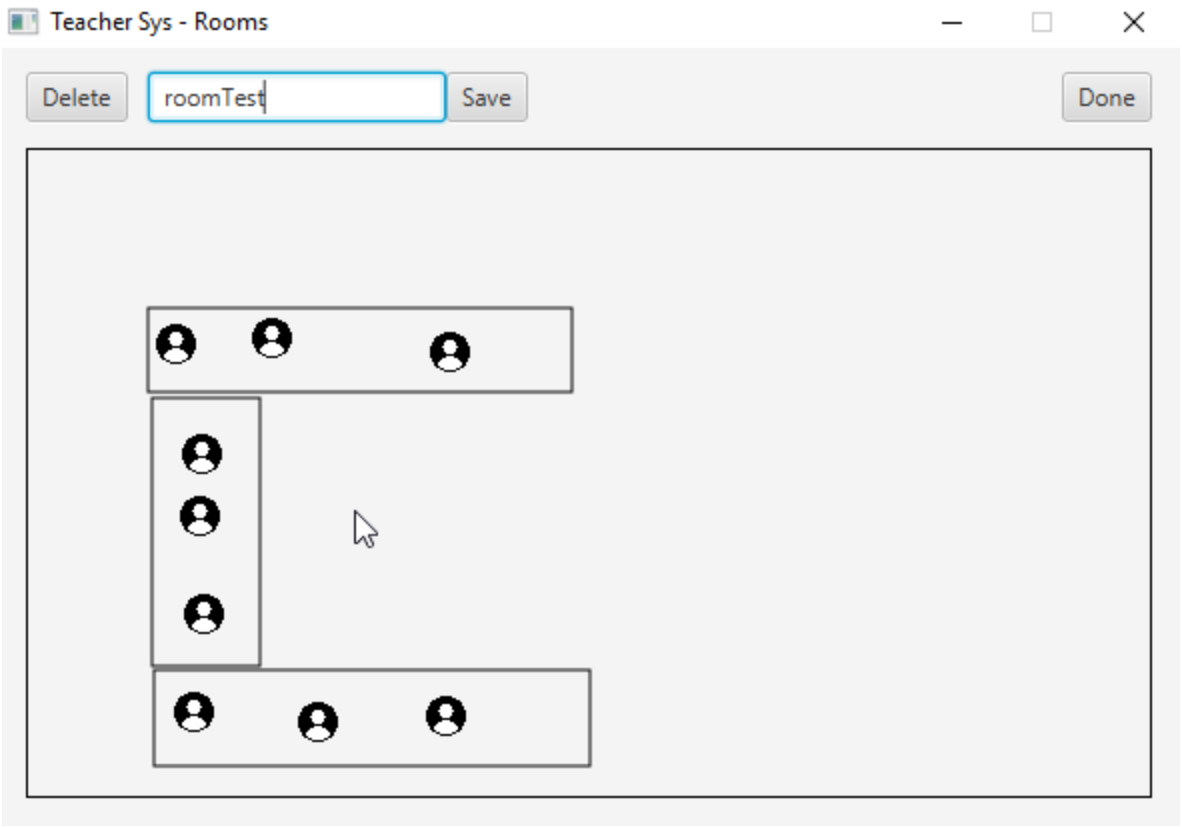

Figure 44: Room designer

Classrooms screen

After saving a classroom the teacher has the possibility to drag and drop the students to inside of the placeholders, and after that he will receive the attention updates on the students that will change colors to represent the attention quality of the student in the moment, if the teacher moves the mouse on top of a student a tooltip will appear, that tooltip gives additional information about the student attention level, when the placeholder with a setted student is left clicked the student details screen will open (Figure 45).

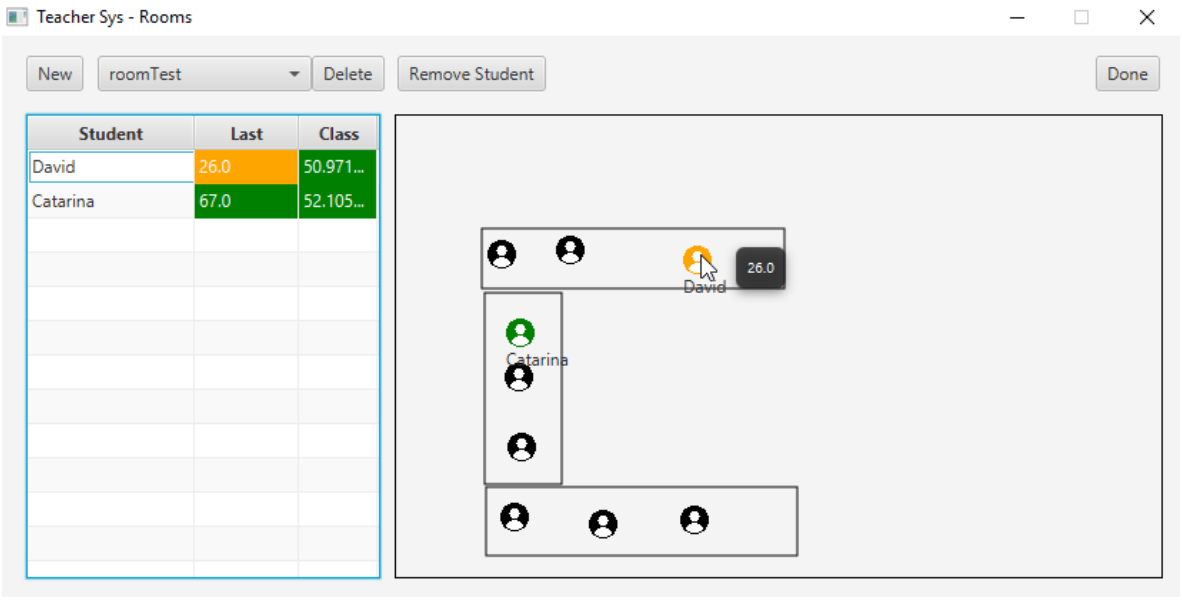

Figure 45: The use of a room

3.4.11 *Historical mode*

The historical mode will give an overview of the students history, it will allow to see the past attention indexes and help teachers to track and analyze the students progress.

List of students screen

So there is a first screen (Figure 46) that contains a list of all the students with their global attention classified by colors.

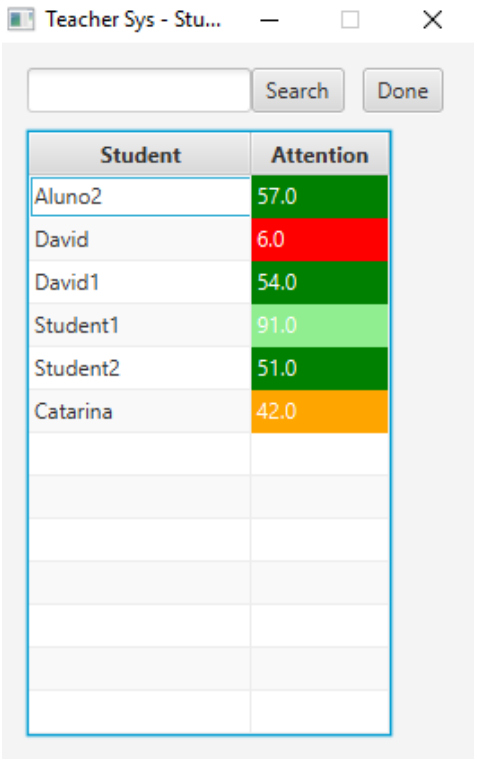

Figure 46: List of students historical screen

Students screen

The teacher has the option to select one student to see his attention using a day by day scale, with a filter that allows to constraint the start and end date of the displayed chart (Figure 47).

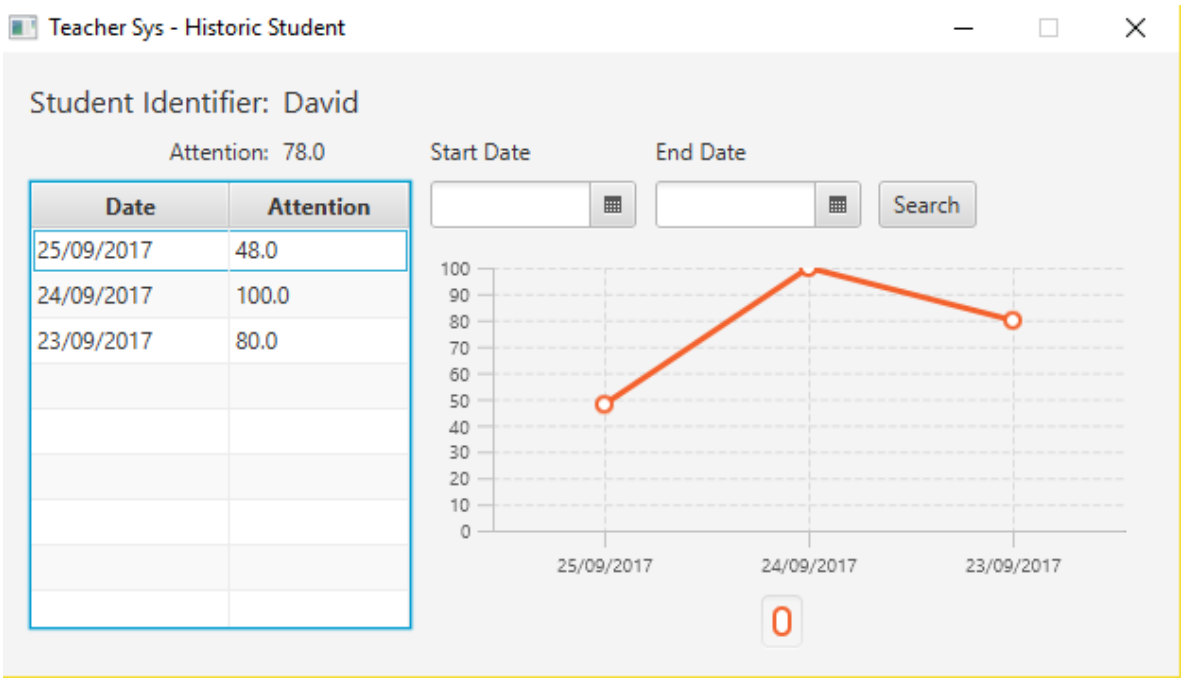

Figure 47: Student historical screen

3.4.12 *Update Strategy*

One of the challenges of this thesis was the application to work in real time and the data to be updated in real time automatically.

To solve this problem has been traced a strategy (Figure 48) using an interface structure which will force the implementation of the method ”update”.

This interface will be implemented in the screens controller when needed and later these controllers are going to be registered in an array belonging to the update main controller.

The controllers then are going to await to be triggered by the update controller, that will trigger them when a rest response containing updated data is received.

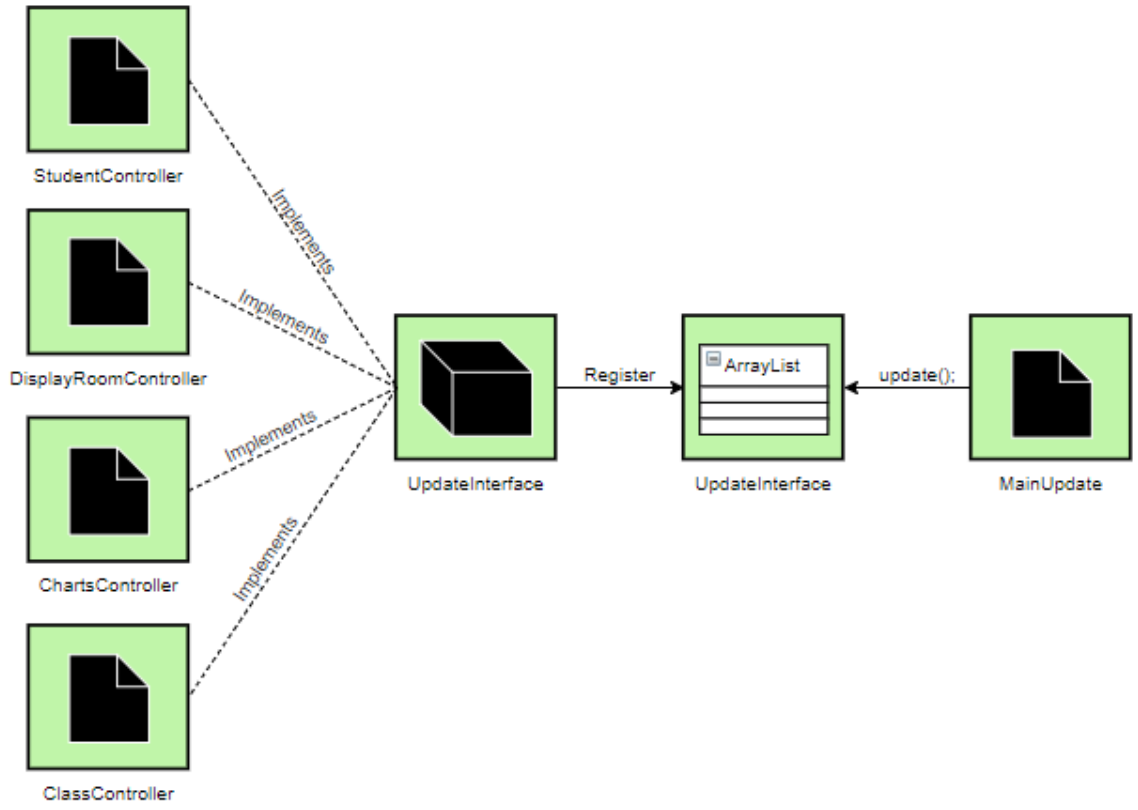

Figure 48: Update workflow

The update controller is composed of a secondary thread, that runs alongside the main application. This thread will be awoke in a predefined time interval and will make a rest request to the predefined api. Later, it will asynchronously receive the response and propagate it to the required controllers.

The update controller will be the used one whenever an asynchronous or automated rest call is needed. It has the needed methods to start, stop and change the synchronize frequency.

3.4.13 *Proposed Architecture Conclusion*

It is concluded that the system has two working modes a real time mode, and a historical mode, they can be described by two different workflows, although they both use an external classifier to retrieve the required data.

The real time mode workflow starts when the REST module receives the students data in real time which will be passed onto the CORE module for processing. This module is connected to the database (DB module) that will update accordingly.

Then the graphical modules will show the information in an intuitive way to the user. These graphical modules are the UI module that allows the teacher to control the application, CHART module that allows the creation of charts and the ROOM module that allows the creation of virtual classrooms.

The historical mode of the system will work when the REST module retrieves the historical data of the students and sends it to the CORE module for the required processing.

After this the UI module shows the data and allows the use of the CHART module to create charts using that data.

4

CASE OF STUDY

This chapter describes a case of study used to test and validate the application's results.

The experience context, outcome and conclusions will be described here.

4.1 CONTEXT

To test this project against a real-world situation a student class was used. The selected class belongs to High School of Caldas das Taipas, Guimarães, Portugal. This class belongs to the 10th grade so the students ages range from 15 to 17 years old.

The selected class was monitored in two different lessons, in two separate days. Both lessons had the duration of one hour and thirty minutes, all the students had individual and similar computers and all of them were given the information about the lesson tasks and what was expected of them as the lesson objective.

One lesson is a regular lesson that has "Acrobat Reader" and "Microsoft Access" selected as the lesson tasks. These tasks are inputted in the system by specifying that the applications that the users are expected to use "contains Microsoft" or "starts with Acrobat" and it can be inputted some software that is not expectable to count as work, in the likes of "not contains Facebook". All this information is converted by the system into a regex to be considered in all the measurements of the student's attention.

In the second lesson the students will have a school evaluation, using the same technologies that were used in the first lesson.

This way it is intended to understand the variations in the student's attention when they have a normal lesson versus one with an evaluation, proving how useful this software can be helping the teacher to better understanding the class behaviour. For now, the teacher was not involved in using the application's data in an active way to prevent or revert any student's lack of attention or deviating behaviour.

During this monitorization it was collected and analyzed the attention level of the students which led to some results.

4.2 RESULTS

To obtain results of this experience using the context described above, every 5 minutes data has been collected for every student.

Both lessons were 90 minutes long.

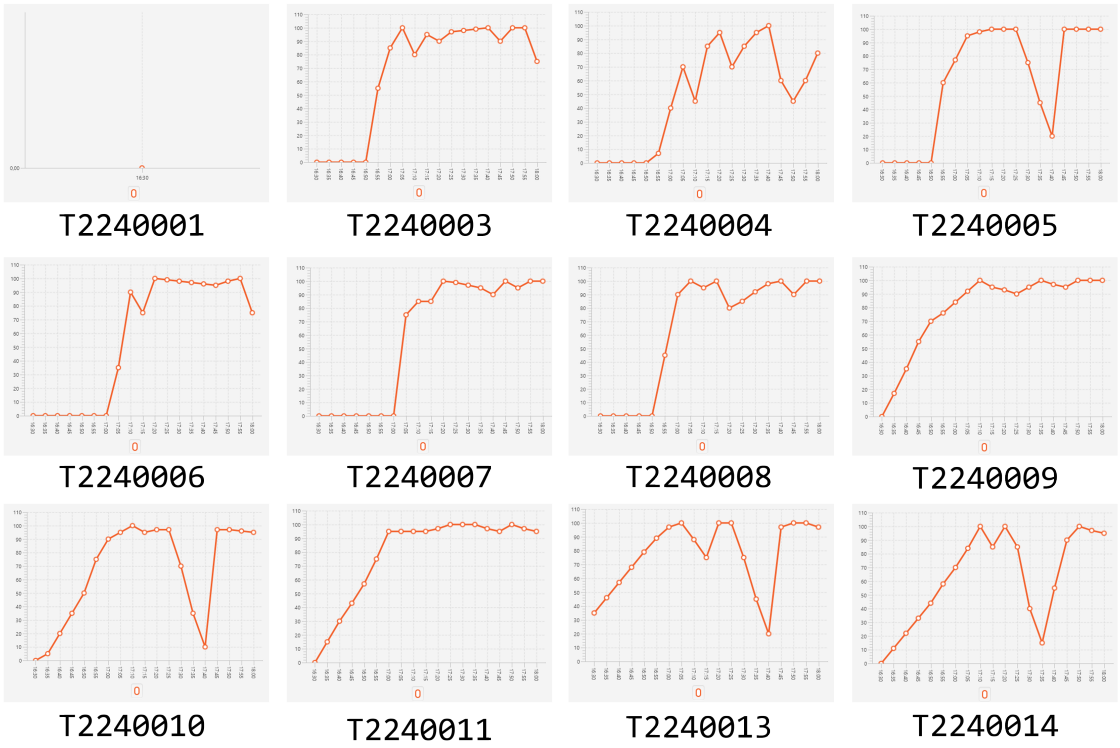

Figure 49: Regular lesson students results

In the first lesson as shown in the image above it seems the student T2240001 is the most deviating student because it only has one reading in the entire lesson, while all the others have several.

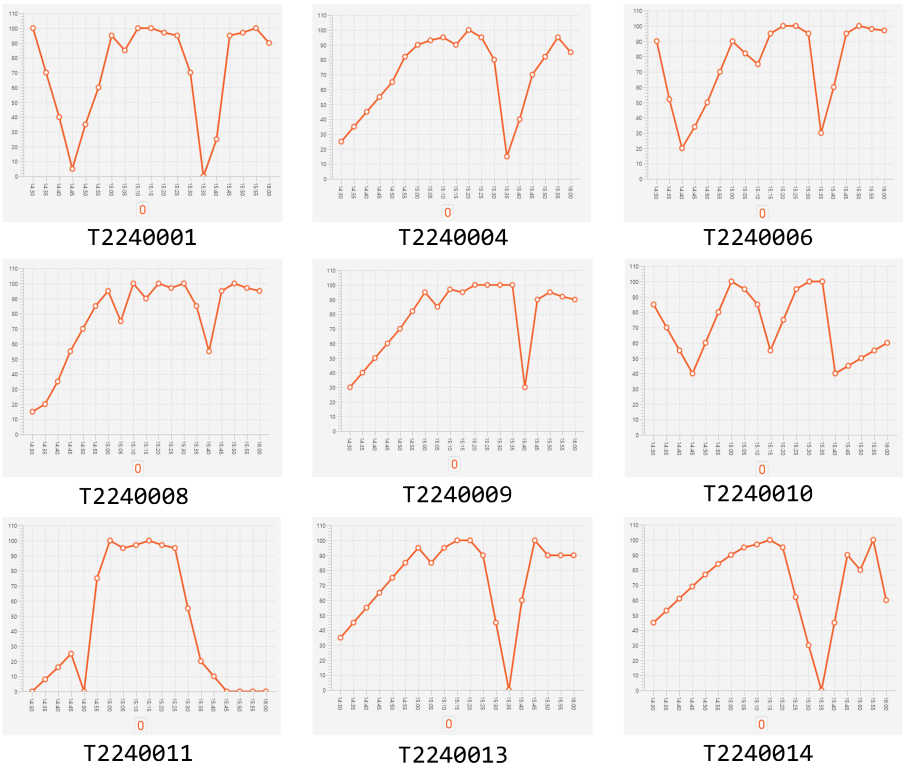

Figure 50: Evaluation lesson students results

This is the evaluation lesson where there are some notable differences to the other lesson. The students T2240003 and T2240007 are missing which means that the students were not present or were not on a computer in this lesson.

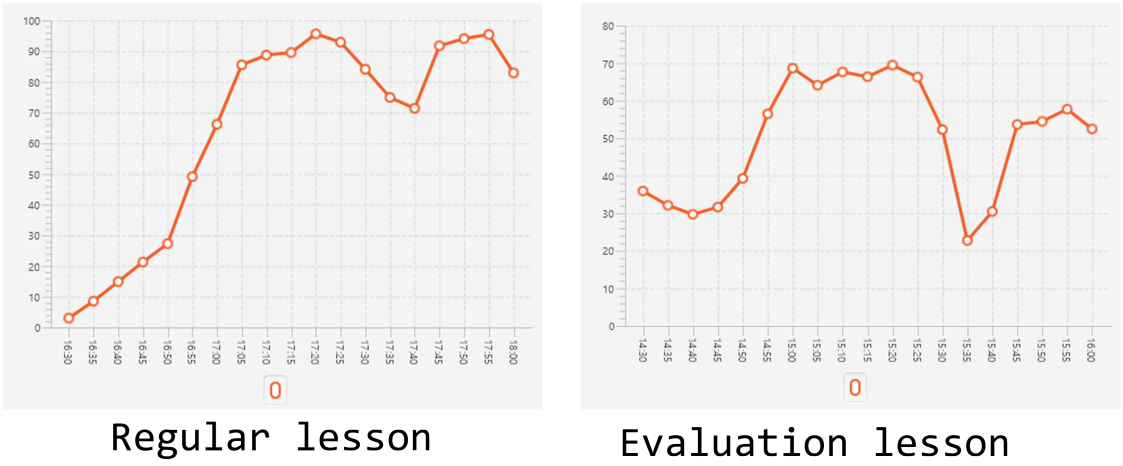

Figure 51: Both classes results

In the system is also possible also to get the global charts for the class. The maximum attention value is lesser in the evaluation lesson, but the minimum attention value and its duration is noticeably larger in the evaluation lesson.

4.3 Case of Study conclusions

From this use case it is possible to conclude that the attention rises in minimum value and duration when the students are subjected to the increased pression of an evaluation. It can be explained that the students do not achieve in a evaluation lesson a maximum attention value as higher as in a regular lesson because the way the used classifier works, that directly compares working time to attention, and in an exam the students will probably try to be more assertive than in a regular lesson and as such they will have a smaller "work time" while they decide the next steps to finish the exam.

The student T2240001 in the first class only had one data point collected and it leads to believe that the student has 0% attention during all the classes. What could have happened

is the user has opened a non-lesson related application and did not interacted anymore with the computer until the end of the task.

Other found issue is when a student opens a lesson related application and stops the interaction with the computer, which will lead to a 100% attention rate.

To solve these issues it can be used a different or updated classifier, one that takes into account the user interaction with the mouse and keyboard. This way with this feature the teacher will be able to have more accurate data, thus improving the performance of the system.

5

CONCLUSION

Over the years the definition of attention has been reviewed, but it's connection to learning was always accepted and the discovery of how attention can be improved and what factors can affect it and how it was always a concern for everyone that study attention and learning and teachers that try to pass knowledge to their students. This is what makes this application a great tool to help keep track on the students, discover how to motivate them, the best way to work in classroom and mitigate problems that the students may feel.

These problems may be personal, something that causes stress, sadness and other feelings to the student to the student or it can be a distraction caused by one of the many gadgets or services available on the internet nowadays.

The best way for a teacher to improve his rate of success is to adapt to their students learning style, and with this tool he will be able to do experiments and watch their results much faster that he would be without this application, where he would have to rely only in his instinct and later in the grades of his classes. Now he can instead take a look on the statistics list that are available in the application.

5.1 ACCOMPLISHMENT OF OBJECTIVES AND CONTRIBUTIONS

In a previous chapter of this thesis there were identified objectives that will need to be reviewed in order to evaluate if they were achieved and why.

As for "Modeling a graphic system that allows the teacher to control the level of attention and engagement in real time" it was an achieved objective. This system connects to a classifier that will deliver the data to the system, the data is then treated and presented to the teacher. This application will make the requests in real time and gives the results to the teacher also in real time and therefore achieving the described objective.

The second objective, "Have an historical of the attention levels for each student", is achieved by having a rest endpoint that allows the requesting of the historical attention values of the students.

The final objective was "Suggest to the teacher different ways to proceed, in order to optimize the level of attention and engagement of the students", the teacher by having

available in real time the attention results will be able to notice how his actions are having effect in the students and from there decide which strategy to use with the class.

5.2 Dissemination of results

Throughout the making of this thesis the dissemination of the results was a great objective, as such an article was published in ISAmI 2017 (International Symposium on Ambient Intelligence) (Durães et al. (2017))

Durães, D., **Castro, D.**, Bajo, J., Novais, P. (2017). Modelling an Intelligent Interaction System for Increasing the Level of Attention. In Book: Ambient Intelligence Software and Applications 8th International Symposium on Ambient Intelligence. ISAmI 2017, pp 210-217.

5.3 Limitation and future work

This thesis objectives were achieved, but there is always chance to improve so a few limitations and future work were identified:

- Design improvements, it is possible to improve the usability of the application to the user, for this it will be required to work with the teachers while they are using the system and collect their ideas of which interface changes would help them.
- Use the IoT (Internet of Things) in order to get better statistics, it will allow to calculate attention indexes more accurately, for instance by using a table and chair with weight sensors it would be possible to see how the student is seated, his hands disposition, it would even be possible to use this in order to use this application even in not computer assisted classes.
- Use image analysis to understand the student behaviour while he is on computer or in the classroom, this feature like the previous one could enable the use of this tool in other lessons where the student is not using the computer.
- Have different classifiers working simultaneously, this way the teacher could alternate between several ways to get the attention value and choose the one that suits him the best.

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