

Application of Soft-Computing techniques for analysis of external influential factors in the emotional interpretation of visual stimuli.

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Abstract– As it is well known, in the real world, during the development of any activity every human is always under the influence of a set of external factors that can affect their performance. Therefore, all people know that aspects such as hour, accumulated fatigue, or mood, can be very influential in a person's productivity. However, there are other less studied factors that can equally be influential, to a greater or lesser extent. For this reason, in the present work are used different techniques belonging to Soft Computing, with the objective of detecting those most influential factors by the execution of a set of experiments under different simulated circumstances in a controlled environment.

Keywords: Emotional interpretation, pattern recognition, decision trees, clustering.

1. Introduction

Currently it is well known that, during the performance of any activity, the set of external factors that surround a person, are capable of influencing the result of the same.

For this reason, assessing the influence of certain external factors on a person's mood or productivity is a widely studied area. However, most studies are focus on trying to verify if a set of factors popularly known and accepted as influencers are decisive or not in the performance of a specific task, leaving in the background to know the degree of real influence that each factor could has depending on the rest of the circumstances. In this context arises the present work with the aim of determining which factors are most relevant, trying to determine its influence.

To do it, a set of controlled experiments with a group of people with similar characteristics (age, sex, academic training, etc.) are performed, simulating different external factors and situations during the development of a simple task: to observe a set of pictures, of different categories, and valuate the feeling that each of them produces according to a certain scale of emotions.

However, to obtain the degree of influence of each external factor, when they are conjugated to simulate different situations, it is a complex process.

For this reason, different Soft Computing techniques, such as similarity matrices, dendrograms, or CART decision trees [4] , are used to make it possible to determine which factors are most influential in the emotional interpretation of different sets of stimuli visual effects. This knowledge can be a important help in establishing environments that favor greater physical or mental well-being.

2. Related Work

At present, one of the main concerns of research related to human psychology is to analyze the influence of the application of external factors on people.

For this reason, in the last years, studies like [3] have focused on analyzing and knowing how the exposure to different sets of visual stimuli (by visualizing the same sets of images used in this work) is interpreted by a group of individuals, through the development of numerous controlled experiments that share a neutral and common environment to all of them.

However, given that each individual behaves differently than another, and that their reaction to the same stimulus may be very different, researches such as [13] have focused on analyzing the individual reactions of each person.

Similarly, other researches such as [2] [9] [10] have based their studies on how age or sex may be a determining factor in the interpretation of the same stimulus set. In this way, in [2] and [9] different experiments are carried out with groups of men and women to try to know the differences before the same exposure to visual stimuli, proving that, indeed, the responses to the same stimulus can be different depending on the sex. Likewise, [10] analyzes through the realization of a set of experiments the reactions of a group of children to find out how their perception varies respect the adult population.

Without a doubt, knowing how the exposure to different types of external factors influences on each type of person, is something of great interest. One of the reasons is that controlling these factors can be very important to help to establish environments that favor physical and mental well-being or even the labor productivity of each worker.

With this objective some studies are highlighted, which try to investigate how certain concrete factors can influence the well being of each person, especially with the objective of obtaining environments that favor labor productivity. With this intention, researches like [5] and [7] are focused on analyzing how the color of the walls of a room affects the mood of each person or his labor productivity. Similarly, in [6] the influence of ambient light is investigated, and in [12] the importance of temperature is analyzed in order to obtain an environment that leads to greater well-being and productivity. Finally, although there are few researches that jointly analyze the influence of different external factors, it stands out among them [1], in which it is analyzed how the temperature and the light influence in the labor productivity.

As can be seen, there are currently numerous studies focused on analyzing how the exposure to different stimuli is interpreted by each person depending on aspects such as age or sex. In addition, there is also important research interested in how the control of some factors (such as ambient light, color of walls or the room temperature) could be influential to achieve higher labor productivity.

However, analyzing how and what external factors are most influential in the physical or mental well-being of each person is still a little explored area, which is why the present work arises.

3. Proposal

With the objective of determining which external factors are most influential in people during the execution of a task, a model has been designed that, based on data from different controlled experiments, and through the use of Soft Computing techniques, allows to identify those that get a greater impact. Knowing this is especially important and interesting to try to achieve environments that allow greater comfort, either with the aim of performing tasks with greater productivity, or simply to achieve greater physical and mental well-being.

To achieve this, a system capable of analysing data from performed experiments for detecting the most influent factors is proposed. Figure 1 shows a diagram of the different phases that make up the proposed process.

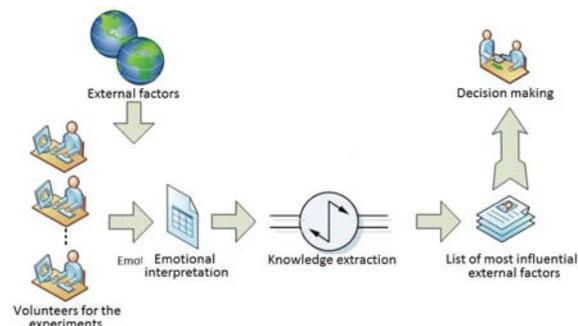


Figure 1. General Frame

The actors involved and the phases carried out are the following:

- Volunteers for the experiments:** In order to carry out the experiments, a group of five volunteers with similar characteristics were selected. All of them are men, aged between 30 and 35 years, and with a similar academic training and profession. Their mission during the experiments, in which different conditions of light, temperature, background music, etc. were simulated, was to evaluate (according to some specific scales) the emotion that causes them to observe different set of pictures.
- External factors:** It represents the elements that could affect during the execution of the tasks (in this case the perception of different sensations when observing images). The factors considered for the different experiments are: hour, lighting, ambient temperature, the presence or not of different types of background music, the level of interruptions, the color of the walls where the experiment is developed, the presence (or not) of food or drink, and the weather.

Considering different combinations of these factors, it is possible to perform a set of experiments with the objective of simulating different situations that allow determining the factors that are most influential in the results obtained.

• **Emotional interpretation:** Whenever one of the volunteers observes an image, he must value the impression he feels in relation to 3 pairs of feelings:

- Unhappy vs. Happy.
- Excited vs. Calm.
- Controlled vs. In-control.

In order to make easier the valuation of each image, a scale is proposed (as a figure) for each pair of feelings [8]

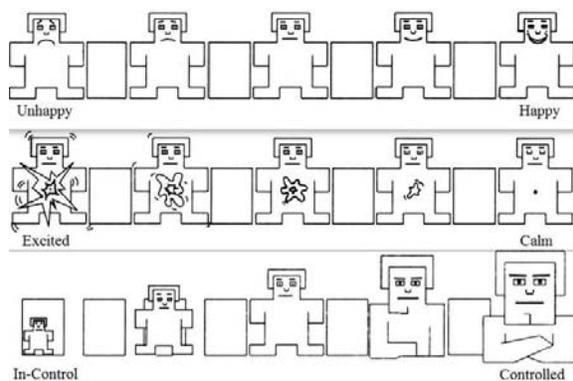


Figure 2. Scale to evaluate different emotions

The participant in the experiment can mark with the pen an X at the point of the scale where he considers.

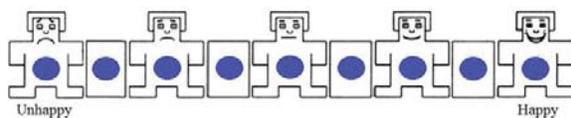


Figure 3. Possible values to score each emotion

In this way it is possible to specify in a more visual way for each picture displayed the emotional interpretation obtained with respect to the considered emotions.

The set of responses obtained by each participant in each experiment is considered as a data source for the following phases of knowledge extraction.

• **Knowledge extraction:** During this phase it is sought to discover which external factors are most influential during the emotional interpretation of visual stimuli. However, by combining different factors for the execution of a set of experiments, it is complex to detect which are the most influential.

For this reason, different soft computing techniques are used, such as dendrograms to obtain a first classification on the result of the experiments, similarity matrices, and CART decision trees, such as that proposed by Breiman [4], or ID3 as described by Quinlan [11].

• **Knowledge base:** From the knowledge extracted and the use of Soft Computing techniques, it is obtained a representation of the level of influence of each analyzed external factors.

• **Decision making:** Once it is discovered which factors are most influential in the emotional interpretation of each person, it is possible to take the right decisions to establish work or coexistence environments that offer greater well-being.

Through the extracted knowledge, it is possible to achieve environments that favor greater physical or mental health, or even higher levels of labor productivity.

4. Case Study

The present case study aims to expose a group of volunteers, all with similar characteristics in terms of age, sex and training, to the visualization of a set of images of different categories, and to evaluate how their emotional interpretation varies depending on the External factors. Following are described the phases carried out for performing the set of experiments.

4.1. Pictures selection

In order to carry out the experiments has been used a set of 1200 images provided by the International Affective Picture System (IAPS) [8] developed and distributed by the NIMH Center for Emotion and Attention (CSEA) at the University of Florida in order to provide standardized materials for researchers during study of emotion and attention. This collection allow: 1) study the selection of emotional stimuli, 2) facilitate the comparison of results across different studies conducted in the same or different laboratory, and 3) encourage exact replications within and across research labs who analyze basic and applied problems in psychological science.

This collection of images contains photographs of different categories: happy people, landscapes, animals, violent scenes, etc., with the aim of provoking different emotions.

For this case study has been prepared a total of 15 experiments (in which different environments are simulated; see point 4.2). Therefore, a total of 15 groups of 80 images have been prepared, covering all the categories.

4.2. Environments preparation

Following are described the external factors that have been established to define different environments for the 15 experiments carried out:

External factors	Possible values		
F1: Hour	1: Morning (9.00h)	2: Afternoon (15.00h)	3: Evening (19:00)
F2: Lighting	1: High	2: Medium	3: Poor
F3: Ambient temperature	1: Hot (82°F)	2: Comfort (70°F)	3: Slightly cold (66°F)
F4: Background music	1: No music	2: Classical music	3: Pop music
F5: Interruptions	1: No interruptions	2: Moderate interruptions	3: Numerous interruptions
F6: Color of the walls	1: White	2: Blue	3: Mix (white/blue)
F7: Food/drink	1: No food/drink	2: Drink (water)	3: Drink (water) & food
F8: Weather	1: Sunny	2: Cloudy	3: Rainy

Table 1. External factors

Considering the above factors, 15 experiments have been performed in which different values for these factors are combined. The following table shows the conditions under which each of the experiments was performed.

Experiment	Value for each external factor							
	F1	F2	F3	F4	F5	F6	F7	F8
Experiment.0	1	1	2	1	1	1	2	1
Experiment.1	1	2	3	1	1	1	3	1
Experiment.2	1	3	3	2	2	3	3	2
Experiment.3	1	1	2	2	1	1	2	1
Experiment.4	1	3	1	1	2	1	1	3
Experiment.5	2	3	1	3	3	2	1	1
Experiment.6	2	1	2	1	1	1	2	1
Experiment.7	2	1	2	3	1	3	2	2
Experiment.8	2	1	2	1	1	2	2	1
Experiment.9	2	2	3	2	2	1	3	1
Experiment.10	3	3	1	1	1	3	1	3
Experiment.11	3	2	3	1	1	1	3	1
Experiment.12	3	2	3	3	3	1	3	1
Experiment.13	3	1	2	1	1	3	2	2
Experiment.14	3	3	1	3	2	1	1	1

Table 2. Characteristics of each experiment

4.3. Data collection and processing

Once the environment was prepared to carry out the first experiment, each participant was explained how each perceived emotion should be assessed after observing each image. As explained in point 3, each image had to be scored in relation to the next pairs of emotions:

- Emotion 1: Unhappy/Happy.
- Emotion 2: Excited/Calm.
- Emotion 3: Controlled/In-control.

The following table shows a summary of the results obtained with the first experiment.

Volunteer	ImageID	Emotion.1	Emotion.2	Emotion.3
Volunteer.1	Img1	7	6	8
	Img2	5	4	3
	:	:	:	:
	Img60	8	8	9
Volunteer.2	Img1	8	7	7
	Img2	6	4	2
	:	:	:	:
	Img60	7	7	8
Volunteer.3	Img1	9	8	8
	Img2	6	5	6
	:	:	:	:
	Img60	6	8	7
Volunteer.4	Img1	8	9	7
	Img2	4	6	5
	:	:	:	:
	Img60	7	6	8
Volunteer.5	Img1	8	9	8
	Img2	4	6	6
	:	:	:	:
	Img60	7	7	6

Table 3. Results of the first experiment

After the 15 experiments were carried out, an average of the scores made by the participants was obtained, obtaining in this way an overall assessment for each experiment regarding the 3 groups of emotions considered.

Experiment	Emotion.1	Emotion.2	Emotion.3
Experiment.0	6,62	7,23	8,03
Experiment.1	6,21	5,42	6,05
Experiment.2	5,91	5,35	4,39
Experiment.3	8,11	6,86	6,55
Experiment.4	4,83	4,26	4,60
Experiment.5	5,15	4,35	4,12
Experiment.6	6,47	7,41	4,72
Experiment.7	7,36	7,35	7,20
Experiment.8	7,59	7,44	6,78
Experiment.9	6,14	6,15	4,58
Experiment.10	4,42	5,29	4,40
Experiment.11	4,62	5,90	6,15
Experiment.12	6,31	5,20	5,65
Experiment.13	6,55	7,58	6,86
Experiment.14	3,81	4,91	4,31

Table 4. Results of each experiment

It can be observed that the results obtained for each experiment vary appreciably, due to the influence of the different external factors.

4.4. Selection of most influential factors

The analysis of the above table by means of clusters consists of finding homogeneous groups of components. Using a function of similarity between vectors (in this case the Manhattan distance), it is possible to construct a matrix of squared proximity, where each component measures the similarity between the row and column component, and in that which the dark tones show great similarity between components and the light tones show a great difference. The similarity matrix is the basis of the cluster analysis.

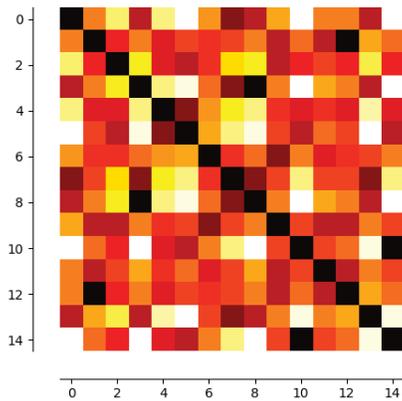


Figure 4. Similarity Matrix

By applying a hierarchical clustering algorithm, a dendrogram can be obtained, using the policy of re-calculus of distance between clusters "the most far away neighbour" to get homogeneous groups of values.

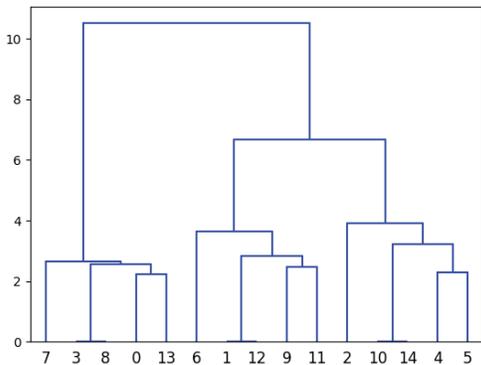


Figure 5. Dendrogram

According to the dendrogram, three quite homogeneous groups exist.

The following table shows the cataloging obtained by applying the dendrogram with the results obtained from the 15 experiments performed.

Experiment	External factor								Classification
	F1	F2	F3	F4	F5	F6	F7	F8	
Experiment.0	1	1	2	1	1	1	2	1	Good
Experiment.1	1	2	3	1	1	1	3	1	Medium
Experiment.2	1	3	3	2	2	3	3	2	Bad
Experiment.3	1	1	2	2	1	1	2	1	Good
Experiment.4	1	3	1	1	2	1	1	3	Bad
Experiment.5	2	3	1	3	3	2	1	1	Bad
Experiment.6	2	1	2	1	1	1	2	1	Medium
Experiment.7	2	1	2	3	1	3	2	2	Good
Experiment.8	2	1	2	1	1	2	2	1	Good
Experiment.9	2	2	3	2	2	1	3	1	Medium
Experiment.10	3	3	1	1	1	3	1	3	Bad
Experiment.11	3	2	3	1	1	1	3	1	Medium
Experiment.12	3	2	3	3	3	1	3	1	Medium
Experiment.13	3	1	2	1	1	3	2	2	Good
Experiment.14	3	3	1	3	2	1	1	1	Bad

Table 5. Classification of each experiment

It is considered that the best environments are those which promote better feelings of happiness, control and calm.

Once the different groups have been obtained, the objective is to try to determine which factors are most influential. With this intention, an analysis is carried out, based on decision trees.

The following figure shows a decision tree taken from the classification obtained by the dendrogram. To calculate this, an extension of the ID3 [11] decision tree algorithm has been applied, establishing a maximum level of entropy of 0.1 for each leaf.

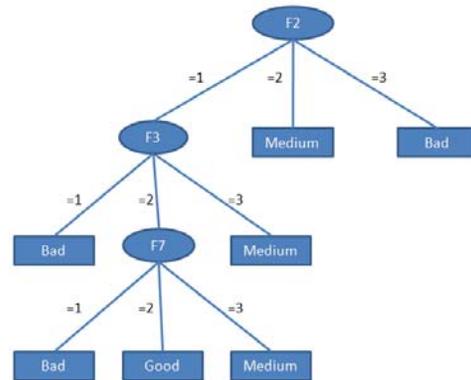


Figure 6. Decision tree with 0.1 entropy

With this representation, it can be clearly observed that the factors F2 and F3 are the most influential. In a similar way, at the next level of influence, the F7 factor it is also relevant.

5. Conclusions and future work

In this study has been performed a set of controlled experiments, simulating different environments, with the aim of detecting which external factors may be most influential in the emotional interpretation of visual stimuli.

To achieve this, a wide range of free-access images has been used [8] , distributed by the NIMH Center for Emotion and Attention (CSEA) at the University of Florida in order to provide a standardized Valuation of emotions.

However, determining which factors are most relevant from the results obtained with the performed experiments is complex. For this reason, a set of different Soft Computing techniques, such as clustering algorithms, similarity matrices, dendrograms and decision trees have been applied. Through the use of these techniques, it has been possible to know which factors are more determinant, and therefore more relevant. According to the experiments carried out, good lighting, a comfortable ambient temperature, and the presence of drink (water), are the factors that allow us to achieve a better environment.

This knowledge can be used to try to create better living or working environments, capable of offering greater well-being or even promoting greater productivity (if we refer to working environments).

In future work, a greater number of external factors will be considered, and a larger number of emotions will be assessed in order to gain a broader understanding of the factors that are most influential in determining an optimal environment.

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