Journal of Electrical Engineering 6 (2018) 116-123
doi: 10.17265/2328-2223/2018.02.008

Use of Soft-Computing Techniques to Study the Influence of External Factors during the Emotional Evaluation of Visual Stimuli

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Abstract: At present, all people know that, during the performance of any activity, each person is always under the influence of a set of external factors that can influence in their results. In fact, all people know that factors such as hour, accumulated fatigue, or mood, can be very influential in the 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.

Key words: 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 that, assessing the influence of certain external factors on a person’s mood or productivity is a widely studied area [1, 2]. 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 have 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 [3], 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 an important help in establishing environments that favor greater physical or mental well-being.

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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 [4] 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 Ref. [5] have focused on analyzing the individual reactions of each person.

Similarly, other researches such as Refs. [6-8] having been 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 Refs. [6, 7] 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, Ref. [8] 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 Refs. [9, 10] 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 Ref. [11] the influence of ambient light is investigated, and in Ref. [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 [13] 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 identifying 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 analyses' data from performed experiments for detecting the most influent factors is proposed.

Fig. 1 shows a diagram of the different phases that make up the proposed process.

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

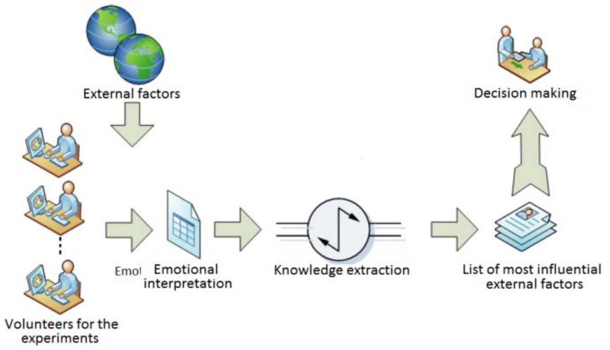

Fig. 1 General frame.

• Volunteers for the experiments: In order to carry out the experiments, a group of seven volunteers with similar characteristics were selected. All of them are men, aged between 25 and 37 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, and 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.

To make easier the valuation of each image, a scale is proposed (Fig. 2) for each pair of feelings [14].

The participant in the experiment can mark with the pen an X at the point of the scale where he considers (Fig. 3).

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 is 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 [3], or ID3 as described by Quinlan [15].

• 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.

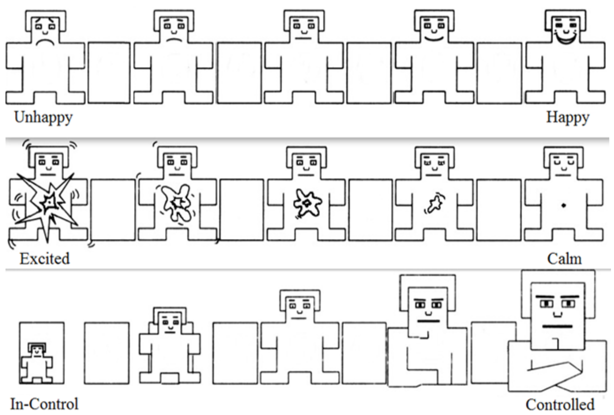

Fig. 2 Scale to evaluate different emotions.

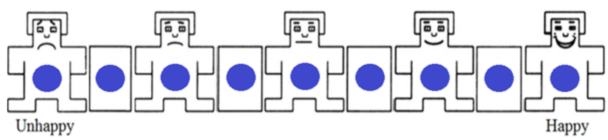

Fig. 3 Possible values to score each emotion.

• 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. Followings 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 1,200 images provided by the International Affective Picture System (IAPS) [14] 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 allows: (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 21 experiments (in which different environments are simulated; see point 4.2). Therefore, a total of 21 groups of 55 images have been prepared, covering all the categories.

4.2 Environments Preparation

Followings are described the external factors that have been established to define different environments for the 21 experiments carried out (Table 1):

Table 1 External factors.

External factors	Possible values		
F1: Hour	1: Morning (9.00 h)	2: Afternoon (15.00 h)	3: Evening (19:00)
F2: Lighting	1: High	2: Medium	3: Poor
F3: Ambient temperature	1: Hot (82ºF)	2: Comfort (70ºF)	3: Slightly cold (66ºF)
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

Considering the above factors, 21 experiments have been performed in which different values for these factors are combined. Table 2 shows the conditions under which each of the experiments was performed.

Table 2 Characteristics of each experiment.

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
Experiment.15	3	1	2	1	1	2	2	2
Experiment.16	2	1	2	2	1	2	2	1
Experiment.17	3	2	3	2	1	1	3	1
Experiment.18	3	2	3	3	1	1	3	1
Experiment.19	2	3	1	1	3	2	1	1
Experiment.20	2	3	1	2	3	3	1	1

These 21 different experiments will allow the simulation of different environments and external factors, in order to analyze and detect which factors are the most influential in the interpretation of visual stimuli.

4.3 Data Collection and Processing

Once the environment was prepared, 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:

Emotion 1: Unhappy/Happy.

Emotion 2: Excited/Calm.

Emotion 3: Controlled/In-control.

The following table (Table 3) shows a summary of the results obtained with the first experiment.

Table 3 Results of the first experiment.

Volunteer	Image ID	Emotion. 1	Emotion. 2	Emotion. 3
Volunteer. 1	Img1	7	6	8
	Img2	5	4	3
	...	...	...	...
	Img55	8	8	9
Volunteer. 2	Img1	8	7	7
	Img2	6	4	2
	...	...	...	...
	Img55	7	7	8
...	...	...	...	...
Volunteer. 7	Img1	8	9	7
	Img2	4	6	5
	...	...	...	...
	Img55	7	6	8

After the 21 experiments were carried out, an average of the scores made by the participants was obtained (Table 4).

Table 4 Results of each experiment.

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
Experiment.15	6.38	7.42	6.91
Experiment.16	6.35	7.48	4.95
Experiment.17	4.51	5.89	6.07
Experiment.18	4.43	5.74	6.01
Experiment.19	5.01	4.15	4.10
Experiment.20	4.95	4.05	4.06

The results obtained for each experiment vary appreciably, due to the influence of external factors.

4.4 Selection of Most Influential Factors

The analysis of Table 4 by means of clusters consists of finding homogeneous groups of components. Using a function of similarity between vectors, it is possible to construct a matrix of squared proximity, where each component measures the similarity between the row and column component. The dark tones show great similarity between components (Fig. 4).

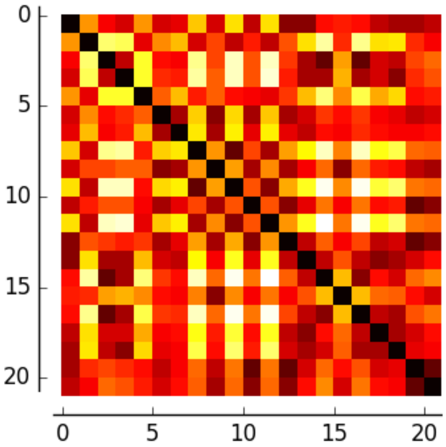

Fig. 4 Similarity matrix.

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 neighbor" to get homogeneous groups (Fig. 5).

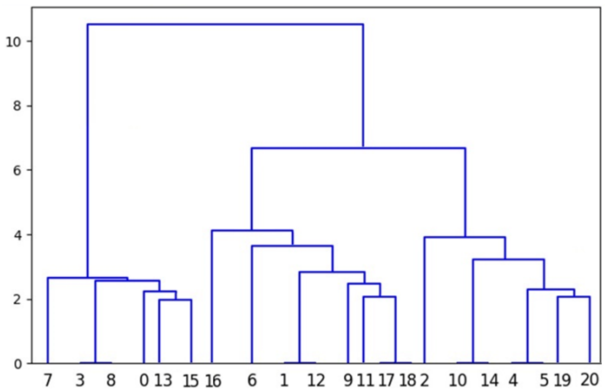

Fig. 5 Dendrogram.

According to the dendrogram, three quite homogeneous groups exist.

The following table (Table 5) shows the cataloging obtained by applying the dendrogram with the results obtained from the 21 experiments performed.

Table 5 Classification of each experiment.

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
Experiment.15	3	1	2	1	1	2	2	2	Good
Experiment.16	2	1	3	2	1	2	2	1	Medium
Experiment.17	3	2	3	2	1	1	3	1	Medium
Experiment.18	3	2	3	3	1	1	3	1	Medium
Experiment.19	2	3	1	1	3	2	1	1	Bad
Experiment.20	2	3	1	2	3	3	1	1	Bad

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 (Fig. 6) shows a decision tree taken from the classification obtained by the dendrogram. To calculate this, an extension of the ID3 [15] decision tree algorithm has been applied, establishing a maximum level of entropy of 0.1 for leaf.

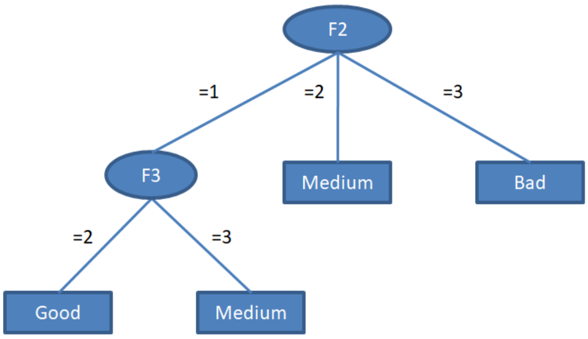

Fig. 6 Decision tree with 0.1 entropy.

However, with this entropy level, some of the values are erroneously classified. On the other hand, with a lower entropy level, such as 0.01, the resulting tree is too complex and unmanageable.

For this reason, and due to the real goal it is to determine which factors are the most influential, it is considered more interesting to represent the previous information by an influential diagram (Fig. 7) .

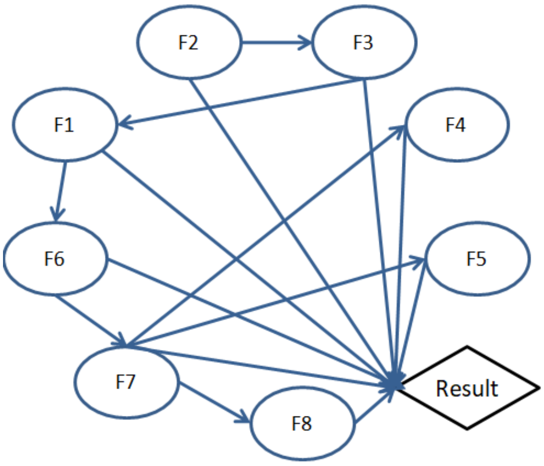

Fig. 7 Influence diagram.

With this representation, it can be clearly observed that the most influential factors (in order) are F2, F3, F1, F6 and F7. At the next level, the F4, F5 and F8 factors share the same influential level.

5. Conclusions and Future Work

In this study has been performed a set of 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, distributed by the NIMH Center for Emotion and Attention (CSEA) at the University of Florida [14] 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, decision trees and influence diagrams have been applied. With that, 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.

In the future, a larger number of emotions will be assessed in order to gain a broader understanding of the factors that are important for determining an optimal environment.

References

[1] Castillo, J. C., Castro-González, A., et. al. 2016. "Software Architecture for Smart Emotion Recognition and Regulation of the Ageing Adult." *Cognitive Computation* 8: 357-67.

[2] Fernández-Caballero, A., Martínez-Rodrigo, A., et al. 2016. "Smart Environment Architecture for Emotion Recognition and Regulation." *Journal of Biomedical Informatics* 64: 55-73.

[3] Breiman, L., Friedman, J., et al. 1984. "Classification and Regression Tree". Wadsworth.

[4] Bradley, M. M., and Lang, P. J. 2007. "The International Affective Picture System (IAPS) in the Study of Emotion and Attention." In *Handbook of Emotion Elicitation and Assessment.* 1: 29-46. Oxford University Press.

[5] Zhao, S., Yao, H., et al. 2016. "Predicting Personalized Emotion Perceptions of Social Images." *Proceedings of the 2016 ACM on Multimedia Conference*, 1385-94.

[6] Bradley, M. M., Codispoti, M., et al. 2001. “Emotion and Motivation II: Sex Differences in Picture Processing.” *Emotion* 1: 300-20.

[7] Lungu, O., Stéphane, P., et al. 2015. “Sex Differences in Effective Fronto-Limbic Connectivity during Negative Emotion Processing”. *Psychoneuroendocrinology* 62: 180-8.

[8] McManis, M. H., Bradley, M. M., et al. 2001. “Emotional Reactions in Children: Verbal, Physiological, and Behavioral Responses to Affective Pictures.” *Psychophysiology* 38: 222-31.

[9] Jalil, N., Yunus, R., and Said, N. 2012. “Environmental Colour Impact upon Human Behaviour.” *Procedia-Social and Behavioral Sciences* 35: 54-62.

[10] Kwallek, N., Lewis, C. M., and Robbins, A. 1988. “Effects of Office Interior Color on Workers’ Mood and Productivity.” *Perceptual and Motor Skills* 66: 123-8.

[11] Jones, C., and Gordon, K. 2004. “Efficient Lighting Design Office Worker Productivity.” *Proceedings of the 2004 ACEEE Summer Study on Energy Efficiency in Buildings* 3: 112-23.

[12] Seppänen, O., Fisk, W., and Lei, Q. H. 2006. “Effect of Temperature on Task Performance in Office Environment.” Proceedings of Cold Climate HVAC.

[13] Adhvaryu, A., Kala, N., and Nyshadham, A. 2015. “The Light and the Heat: Productivity Co-benefits of Energy-Saving Technology.” *Proceedings of IGC Conference on Energy and Development*, 1-28.

[14] Lang, P. J., Bradley, M. M., and Cuthbert, B. N. 2008. “International Affective Picture System (IAPS): Affective Ratings of Pictures and Instruction Manual”. Technical Report A-8. University of Florida.

[15] Quinlan, J. R. 1987. “Simplifying Decision Trees.” *Journal of Man-Machine Studies* 27 (3): 221-34.