A framework for modeling Persuasive Technologies based on the Fogg Behavior Model

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***Abstract*—This research presents a work in progress in which we discuss the potentialities and challenges in the development of Persuasive Technologies (PTs) and the possible opportunities of use in the most diverse areas. However, we emphasize the impact of the use of Pts as a motivational agent of the teaching and learning process. More precisely, this work investigates the use of PT as a mediator of characteristics related to the individual's perception of emotions and behavior. More precisely we propose the the Fogg Behavior Model (FBM) transcription for a computer tool. To do this we use the Fuzzy Logic. In order to validate the framework, we present a application in a scenario focused on the reduction of electric energy consumption. The results validate the proposed modeling as it relates to the measurement of the indexes of ability and motivation.**

***Index Terms*—Ubiquitous space, Persuasive Technologies, learning process, Fogg Behavior Model, FBM, framework.**

I. Introduction

There is currently a growing trend of integration of computational technologies to individuals' daily lives. Thousands of data and information about people's natural behaviors are being collected and processed instantly for various purposes, such as: diagnosing, mediating, influencing, or educating. In these initiatives it is sought to make imperceptible the human-computer interaction in the environment of the individual's performance. Applications for educational purposes aim to modify behavioral patterns and actions through the learning process. In this context, *ubiquitous technology* emerges as a new form of human-computer interaction allowing the aggregation of computing into society's everyday "anywhere" and "at any time" [1]. From the user's point of view, collaborations can be established spontaneously through the use of computers, robots, and networks of actuators and sensors.

According to [2], [3], the society is changing and Education in particular is an area with potential to benefit from the possibilities arising from the ubiquitous technology paradigm. However, the study of the effects of ubiquitous technology on user behavior, and more specifically on how this human-computer relationship can trigger learning processes, constitutes a broad field of research characterized by a high degree of methodological complexity the confluence of areas of research, such as: psychology, computing, engineering, and education.

In this context, Persuasive Technology (PT), area that studies the relationship between Information, Communication Technologies (ICTs) and persuasion, has been gaining prominence. TPs constitutes an area of development of technologies that interact with individuals, with the objective of influencing their behavior. The use of PT in the field of Education has been observed mainly as a motivational agent of the teaching and learning process [4], especially when associated with the process of obtaining new knowledge or abilities [5], in solving problems related to study habits, and in the review and continuity of a given activity [6]. They can be adapted to different profiles and applied in a variety of pedagogical activities [7], acting directly and indirectly in the areas such as health [8], social relations [9] and marketing [10].

In this study we emphasize that even finding works with good results, there is still the need to promote publications that problematize the interfaces of PTs in Education, especially Architectures and Frameworks that involves students perception, such as development of environments that can extend the (physical) educational environment to the virtual world, so as to deal with the heterogeneity existing among the students and to compose a strategy to influence their behavior. In this way, we propose the development of a framework[1] to aid the process of elaboration of learning persuasion strategies based on the Fogg Behavior Model (FBM) [11].

The FBM associates the effectiveness of a behavior to levels of motivation and ability of the individual before a given task, indicating that the same can be persuaded from the intervention mediator of a trigger. According to [11], triggers

[1]Tools that are used to support software development. They are accessed by application programming interfaces (APIs), which specify sets of features that client programs can use to perform specific tasks

are stimulus (external or internal), capable of motivating the individual to perform a behavior at a given moment. Exists three groups of triggers: *i) Spark*, suitable for people who have little motivation and high ability to perform a target behavior. The trigger must be done in the form of a motivational element; *ii) Facilitator*, suitable for people who have high motivation, but low abilities. The goal of a facilitator is to trigger behavior while attempting to make behavior more natural, thereby enabling the achievement of a target behavior; *iii) Signal* when people have the same levels os motivation and ability. The signal only serves as a reminder.

The FBM strategies, when associated with the field of Education, can represent a valuable instrument of digital mediation of learning since they allow to keep the student motivated in their learning process. To do so, the main obstacle would be to infer the levels of ability and motivation of the individuals, since triggers trigger depends on their monitoring and categorization. As a solution we proposed the discussion of ability levels and motivation via technological artifacts from the mathematical point of view of Fuzzy Logic (FL). This method has as a pillar the linguistic treatment of numerical data applied to the questions of uncertainty and accuracy of the information [12], allowing the intuitive mapping of the complex relations between the ability and the motivation, observed in the user before the triggering of appropriate triggers (those who will have a greater chance of being accepted by having the individual perform the target behavior).

In this way, this work presents specifically a tool, named *SmartTrigger*, that offers a model to support the assessment of levels of ability and motivation, as well as the indication of the most suitable persuasive trigger according to the levels of motivation and ability of the users.

II. Methodology

This research represents a exploratory approach, that purpose was to understand the requirements associated with the elaboration of frameworks to support the development of PTs. We execute an adaptation of the methodology proposed in 13, *Design Research Methodology*. The research was carried out in four phases that occurred in an interactive and cyclical way: i) Research Classification; ii) Descriptive Study I; iii) Prescriptive study; iv) Prescriptive and Descriptive Study II.

In the first phase, of the Research Classification, we realize the *definition of the objectives and methods* associated with the existing and desired situation. During the descriptive study I, we make a literature review in order to obtain an understanding of the factors related to the achievement of the proposed objectives. The bibliographic review was performed at two levels, initial and systematic. In the first we make a general study about the topics associated to the Persuasion strategies [14], PT [11], design associated with behavior change [15] and concepts related to development of (*frameworks*) [16].

The systematic review was performed according to criteria established in 17. We considered works published in the last ten years, the search criterion (keywords): *persuasive systems framework, persuasive frameworks, persuasive technology framework, measure ability systems, measure motivation systems, persuasive technology FBM*. The reading of the works allowed to evaluate them as to the proximity of the content with the theme proposed in this work. For this research the works [18]–[22] were considered relevant. From the lecture of the works, we verified the need for research in this field, like as emphasized by [23], most of the works carried out in this area are conceptual or deal with methodologies.

Lastly, we started the prescriptive study, in which we propose a system of resolution, considering the analysis of the theoretical basis as subsidies for the elaboration of the initial proposal of the framework. Finally, in the ”Descriptive II” phase, a initial study was conducted in order to evaluate the operation of the framework (see section IV)

III. The Framework

The proposed *framework* represents a tool to aid behavior monitoring based on rules associated with FBM contexts. In the figure 1, the operation of the proposed framework is presented: *i) perception of environment variables:* Reading of variables such as response time, activity time, user goals, user actions in the system, such as sharing or tanned, errors and hits; *ii) classification of variables:* definition of which variables influence the ability and/or motivation; *iii) fuzzification:* linguistic treatment of numerical data dealing with questions of uncertainty and accuracy of information. These characteristics allow the intuitive mapping, by the user of the complex relations of observation of ability and motivation; *iv) selection and triggering of triggers:* based on the levels of ability and motivation the best trigger is selected and sended.

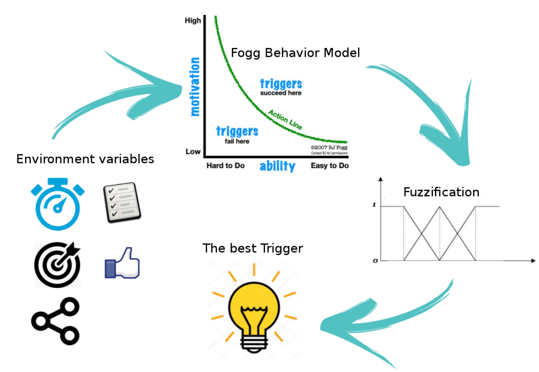

Fig. 1. Framework idea

In other words, the framework can be considered as a standalone application (server) that can be accessed via API by a client application (example: Moodle - https://moodle.org/, system or user application). Based on the processed data, the framework returns to the user the levels of motivation, ability and ideal trigger to be sent to the user. The application consists of three main modules: i) *parametrization*; *ii) monitoring*; iii) *selection* and the tool is based on *fuzzy* [24] systems.

The *parametrization module* has the purpose of providing the control of input variables related to the desired behavior, whether they are internal variables (predefined ones that implement specific functionalities in order to allow the user's perception: *i) Facebook*, likes and shares listing; *ii) OneSignal*, analysis of the access frequency of the individual in the application; *iii) sendMailer*, clicks on links; *iv) OpenWeather*, influence of climate; *v) Triggers*, time to respond to triggers, responses to triggers; *vi) Goals/subgoals*, assessment of the user in the accomplishment of tasks; *vii) User profile*, age, preferences; *viii) Time, Climate influence* and external variables (like log of accesses generated by the system that accesses the framework), as well as the management of conditionals (rules) that determine trigger triggers. In this module, two main actions are performed: *i) driver management*; *ii) antecedents management*. In this study, drivers are considered as a set of tables containing information of internal and external variables used in the application to measure levels of motivation and ability. Antecedents, in turn, will be considered as sets of rules that group variables and conditionals (true or false - example: if user's for x likes and average response time for triggers triggers) considered important for user perception and choice of time for triggering triggers.

The monitoring module provides the regular execution of triggers trigger during the time flow. Two main actions are performed: i) *checking the antecedents information*; *ii) converting this information into levels of ability and motivation* for M *motivational variables* and N *ability variables* (M and N bigger then 1). In order to make the treatment (obtain the degree of pertinence[2]) of these variables (fuzzification) fixed sets were used, only parameterized by their intervals. The figure 2, shows the adopted fuzzy sets: the x axis represents the parameters entered and the y axis the degree of pertinence. As the parameterization of maximum and minimum values passed to the variable (values parameterized by the user), the system automatically generates the pertinence function represented.

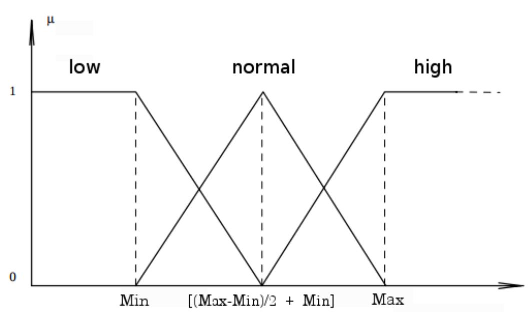

Fig. 2. Variables pertinence function

Having obtained the pertinence values of these variables, the different perceptions of motivation and ability are aggregated in two observations of these phenomena. In this step, initially, the operator E - modeled by T-standards of type *min* was considered. Then the degree of validity of the consequences of the triggers triggering rules (Table I) provided in the FBM by [11], and the combination of the results obtained in the aggregation by the ''inference"'. T-standards of the type *max* were also considered for this process.

[2]relation with the existing object to the fuzzy set

TABLE I
BASIS OF INFERENCE RULES OF THE PROPOSED FRAMEWORK

1: If (motivation is low and ability is low) so output is no trigger
2: If (motivation is low and ability is average) so output is spark
3: If (motivation is low and ability is high) so output is spark
4: If (motivation is average and ability is low) so output is facilitator
5: If (motivation is average and ability is average) so output is signal
6: If (motivation is average and ability is high) so output is spark
7: If (motivation is high and ability is low) so output is facilitator
8: If (motivation is high and ability is average) so output is facilitator
9: If (motivation is high and ability is high) so output is signal

Finally, in the module of " Selection ', the personalized choice of the trigger to be sent to the user is made. For this purpose, a defuzzification process is carried out by applying the Roulette Selection Method in two steps: i) selecting the trigger category, which is intended to find the trigger category (*Spark, Signal, Facilitator*); ii) *trigger selection*, in which once having defined the category of trigger, the selection between the triggers of that category is made. According to 25 in the selection method by *Roulette*, each individual of the population can be represented in roulette in proportion to his suitability index. It is important to mention that it was decided to use this method because it makes use of probabilistic and non-deterministic transition rules, due to the probability that a trigger of the same class is more accepted than another of the same category. In this way, the triggers with greater aptitude will have a greater chance of being selected, but also, not ruling out the possibility of the others being selected. In other words, the method reduces the likelihood of similar situations (in the event of two or more consecutive situations in which the pertinence indexes obtained by the rules are the same as in the previous event) the triggers triggered are the same.

IV. INITIAL RESULTS

In this session we present the first results obtained from the application simulation of the framework applied in a study of persuasion directed to the sustainable consumption of electric energy (Sapiens [26]). Initially, the resources planned for the client application (Sapiens APP) were mapped in order to demonstrate the feasibility of the tool, regarding the treatment of specific variables of the application. As the application's internal *drivers* were initially instantiated *Facebook*, *OneSignal*, *targets* and *trigger*. As external drivers the *drivers presence control*, *control of consumption* were created. As a antecedent, *waste identification* has been registered. It is important to mention that during the configuration of the Facebook driver, the key words " Electric energy, sustainability, environment " were instantiated as user observation criteria.

Afterwards, samples were taken in the application in four different moments in order to verify the operation of the proposed method regarding the measurement of the levels of ability and motivation and the choice of the appropriate

TABLE II
INPUT VARIABLES FRAMEWORK

Input variables	Sample 1	Sample 2	Sample 3	Sample 4
% Goals	0	0	40	100
Number of Facebook likes	0	0	5	3
Number of Facebook Posts	0	0	2	2
Presence	0	0	0	0
Consumption	1000	1000	1000	1000
Interest save energy	0	1	1	1
Interest in the environment	0	1	1	1
Interest financial matters	0	1	1	1
Time without presence	5	5	5	5

trigger. In the Table II has the description of the input variables collected by the framework during the execution of the tests.

During the fuzzing and aggregation process, the following values obtained for the pertinence, format - sample number (little, average , much), motivation: sample 1 (1,0,0); sample 2 (1,0,1); sample 3 (0.5, 0.65, 1); sample 4 (1, 0.65, 1). For the ability: sample 1 (1,0.65,0); sample 2 (1,0.65, 0); sample 3 (1,0.65;0); (1,0,0). The Figure 3 shows the results from the inference process (levels of pertinence -vertical axis, obtained for each of the rules proposed in table II) obtained in the four moments - horizontal axis in the execution of each test.

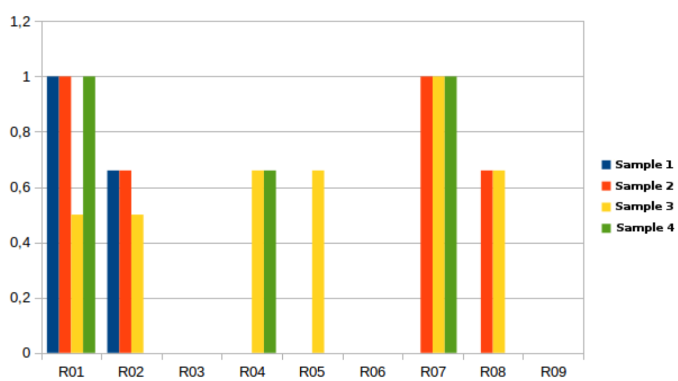

Fig. 3. Variation of the absolute indexes of the levels of pertinence obtained for the rules during the execution of the 4 samples: (A) Motivation; (B) Ability

Analyzing the pertinence indexes related to motivation and ability, the graph Figure 3 and the Table I, we can be made the following observations: i) During the first sampling it is noticed that the rules R01 and R02 present higher values for the indexes of aptitude. Even if R01 had a higher value, another rule was selected when the Roulette Selection method was applied, ie a spark trigger; ii) During the second sample, it is possible to observe that there was a significant change in the indexes of ability and motivation. The rules that presented the highest relevance index were rule R01 and R07, followed by rules R02 and R08. When executing the roulette, Rule 07 was obtained as the one with greater power of action on the user, that is, a trigger of the facilitator type; iii) When performing the third sample, it is noticed that the measured ability indexes remained constant while the motivation indexes changed. As can be seen, the rule that obtained the highest index was R07 followed by rule R04, R05 and R08. As an output R04 was obtained as true for the user. The execution of this test allowed to verify the importance of the method of selection by Roulette, since this one as previously mentioned, in the case of two or more consecutive situations in which the highest pertinence indexes obtained by the rules fall in the same rule of the previous event. In this way, it triggers the triggering of new triggers; iv) In the last sample it is indicated that there was no variation in the ability index, but also the change in motivation index can be observed. The highest indexes were R01 and R07. The rule R01 was obtained as an output. That is, it corroborates with [11] observations, in which the author does not predict triggers when the user fits into low levels of ability and motivation.

V. Final considerations

The main objective of this study was to create a *framework* to support the development of persuasive applications based on FBM. To do this, we tried to answer several questions: i) how to infer via *framework* ability and motivation of the user; ii) how to offer services in order to allow the design of a persuasive tool; iii) how to define categories of observation and perception of user behavior; iv) how to allow the establishment of a relationship between the observations of ability and the motivation and triggering of triggers.

The proposed modeling of the framework allowed us to transform observations into linguistic information associated with the characteristics of ability and motivation. With this linguistic information, the framework allowed the description of rules that involve linguistic levels of ability and motivation in triggers of triggers to be executed by the system. It is important to emphasize that the work contributes a deep approach to the operations performed to assess motivation and ability, unlike the approaches found in the literature, which are often conceptual or have a shallow approach to the operations.

The results presented here instigate the continuation of this study, since it is worth mentioning that the use of the textit framework points to the validity of the proposed mathematical and computational modeling.

As a hypothesis of this study, we pointed out that the framework can be used in conjunction with other tools allowing the teacher to have access to the students' motivational and ability levels during the performance of certain activities.

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