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BUILDING A REFERENCE META MODEL OF HUMAN BEHAVIOR

[1]KAWTAR ZINEBI, [1,2]NISSRINE SOUISSI, [2]KAWTAR TIKITO
[1]Mohammed V University in Rabat EMI - SIWEB Team
[2]Ecole Nationale Supérieure des Mines de Rabat, Computer Science Department
Email : kawtarzinebi@gmail.com , souissi@enim.ac.ma , tikito.ensmr@gmail.com

ABSTRACT

In this paper, we aim to build a generic Meta Model of human behavior. This genericity is justified by the concepts we employed. These concepts are derived from a variety of disciplines which are interested in understanding human behavior. The construction method of our meta model is to first collect all the parameters that control human behavior and classify them according to their type: human or environmental. Then, we propose a set of dimensions based on these concepts. And finally, we organize them in a UML Meta Model that consists of 3 packages. The advantage of this method and the level of abstraction adopted in our study is the possibility of extending our meta model with new concepts and project it in many fields of research and on all types of behavior (Psychology, sociology, simulation / artificial intelligence etc.)

Keywords : *Human behavior model, Generic concepts, Meta Model, Dimensions, Complex system, Psychology, Sociology, Environment, Social media, Person.*

1. INTRODUCTION

Human behavior is a complex system characterized by a wide variety of parameters. The description of such a system is not an obvious task, given the diversity of the activities and the functions performed by human beings. Many definitions of human behavior exists in literature, there is as many interpretation of the human behavior as the number of studies on this topic. This variety demonstrates the lack of a common and unified conceptual framework of research. For example, modeling the behavior of a "bank customer" is different from modeling that of a "car driver" behavior. Each case depends on the nature of the action performed and includes a set of parameters appropriate to its own system. This aspect of dependence between the model and "the performed action" is common in scientific studies [1,21,22,23,24,25] . Each study points out a specific side of behavior. In the modeling stage, human behavior is supposed to be "homogeneous" and its parameters are limited to the "lexical field" of the system studied. As an example, considering that the "account balance" is a sufficient variable to explain the transfers frequency of a customer is not completely true, but it is quite enough since that the study does not require deeper explanations outside the banking sector. These simplifying assumptions are criticized in the literature [2,3] because the majority of these behavioral models cannot capture the human nature complexity. This concern is due to the "microscopic" view; such approach causes mistakes when applying the model in a different environment of the studied domain. For those reasons, we consider it necessary to include parameters from different disciplines in human behavior models. The diversity of variables that control human behavior also contributes to the complexity of modeling. The environment is one of the fundamental factors affecting human behavior, it determines the action's nature and the conditions in which it took place, and it provides also the conditions of the surroundings and its status. Thus, in a behavioral simulation model, the simulated entity takes into account its environment and adapts itself constantly to its context [1]. Therefore, environment modeling is an important phase in the construction of a generic human behavior model as it is part of its dimensions and must be defined in parallel with the studied system [4,6]. To overcome this aspect of variability, we will analyze human behavior from a global point of view; we aim to be situated in a higher level of abstraction. The process of abstraction is crucial in modeling [5] In fact, this process is considered as the major mechanism that gives the model "its explanatory value." Abstraction is a key parameter in our study because it will allow us to define the complicated structures of behavior more easily. The interest of this approach is to optimize the stages of development while maximizing the representation of reality, as the systems deployment process is carried out at a higher level of abstraction, starting with analyzing

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the significant parts that define the purpose of the model and data resources [3]. How- ever, the current trend is developing a model that can fully collect information on human behavior. Therefore, we resort to Meta-modeling.

In this paper, we present in the second section, the methodology for the construction of our generic human behavior Meta Model. In the third section, we define the laws and rules that organize human behavior. In the fourth section, we present the dimensions chosen for the construction of the Meta Model. In the fifth section, we will build the different packages which are described in section six. Finally, we conclude with a conclusion and perspectives.

2. CONSTRUCTION METHOD OF THE META MODEL

Human behavior modeling is essential for a better understanding of human actions. Questions such as "what is this action? "; "What is involved in this action? "; "What are the reasons for this action? "; can found their answers in a model that describes the smallest actions and their relationships in the context of complex activities.

The human behavior is complex because it consists of several units (psychological, cognitive, social, etc.). This leads us to question about the projection of this behavior according to a single discipline, is it sufficient to make a reliable abstraction that captures enough information to explain human behavior ?

To accurately model human behavior while respecting its complex structure, we propose a method that will enable us to consider all the elements involved as well as their interactions in the Meta Model.

In this section, we present the method we adopted to construct the Meta Model, This method involves following four steps illustrated in Figure I.

- Step 1: Collecting models concepts

The input of this step is mainly the result of a state of art of the human behavior models. The principle is the aggregation of concepts related to human and environment in a single model. It turns out that the models proposed in the literature are using a limited number of concepts that relate to the studied behavior's nature. It is therefore important to define generic concepts that characterize behavior in whole.

- Step 2 : Defining the Meta Model dimensions

The output of step1 is a set of concepts that control human behavior.

In order to use them as dimensions in our Meta Model, we need to classify them according to several aspects.

- Step 3 : Building the Meta Model packages

In this step we define the main packages of the model. The choice of packages is an important decision, for this, we will mainly be based on the dimensions orthogonality in order to build a generic modeling space

- Step 4 : Building the Human Behavior Meta Model

The last step is to connect the packages together to build a generic Meta Model describing human behavior.

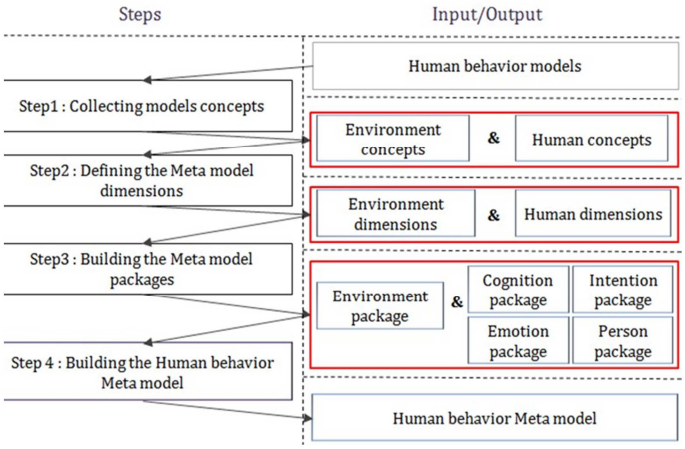

Figure 1 : Building method of the Meta Model

3. COLLECTING MODELS CONCEPTS

Many human behavior models have been proposed in literature. In this stage, we analyze these models as well as the environment impact, and then extract the specific concepts of each model. Table I summarizes the selected models. We notice that each of these models is "limited" to a specific behavior. To access the generic level modeling of human behavior, it is important to take into account a range of elements such as psychology, cognition, emotions and others. Besides, great importance is recently given to socio-psychological and complex interactions of individuals, and also to consider the impact of the environment [10,11].

This demonstrates that the adoption of a single discipline to explain human behavior is not sufficient enough. To overcome this difficulty, we will use other models from psychology and sociology. These models are described in [7] and summarized in Table II.

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Table I: Human behavior models

Model	Parameters
[8]	(Antonini, Bierlaire and Weber 2006) present a simulation model of people's movement based on the assumption that the person "chooses its trajectory according to a logical reasoning".
[14]	(Mead, Atrash and Mataric 2012) represent body movements and spatial position of people in social gatherings; they analyze physical environment (distance and orientation) and psychology (relationships between two or more agents).
[15]	(Stanton, Salmon and Rafferty 2013) describe individual's behavior in the human-machine interactions and explain that the parameters involved in this kind of inter- actions are the hardware environment (interfaces, indicators, engine controls) and the social environment (management policies, rules of business and cultural climate).
[9]	(Bouzat and Kuperman, 2014) define an evacuation model based on game theory, this study considers two parameters: the physical environment and the cognition.
[12]	(Yang et al. 2015) present a model that explains people's path choice. They considered the variables that characterize the person (gender, salary, occupation, level of education) and the physical environment parameters.
[10]	(Zhou et al. 2016) realize a model of people's movement from the "fuzzy theory" and based on the physical environment parameters. To do so, they decomposed the behavior into elementary actions.
[13]	(Rowe et al. 2016) demonstrate the link between "subjective norms" and the tendency to engage in risky behavior, they were based on the planned behavior theory. The main components of this study are personal beliefs and attitude.

Table II : Human behavior concepts

Model	Parameters
[11]	(Park and Burgess 1969) introduce the term "collective behavior" that refers to a set of actions in which a large number of people engage. This type of behavior is controlled by two aspects: cooperation and contagion
[20]	(H. Mallot 1997) describes the behavior as a result of the human cognitive process. Cognition includes all the functions that allow a being to apprehend their environment and to evolve in a sensible way.
[17]	(Ajzen 2002) presents the "Theory of Reasoned Action" as a discipline of social psychology, it suggests that a person's behavior is determined by his intention, and that intention is, in turn, evaluated by his subjective attitude toward the general context of the action.
[18]	(Vaa 2014) shows that the affective model is based on the person's personality, character, emotions and attitude. This type of models does not offer a standard definition since the person may behave in different ways, according to the context and mental state. This model is a combination of emotional characteristics, environment parameters, culture, belief, experience, physical condition (sick or healthy), etc.
[19]	(Wilde 2001) defines the "risk compensation theory", it suggests that people accept a certain level of risk for each activity, this risk is estimated subjectively in exchange with the benefits they expect to receive from the activity

According to the literature review presented in [7], human behavior models are mainly divided into four categories: (i) intentional model that considers intention as an essential parameter in determining the nature of human actions. (ii) Cognitive model that includes all mental processes such as attention, recognition, learning, intelligence, problem solving, decision making etc. Its main components are attention, memory and information processing. (iii) Affective/ emotional model that builds on four pillars that are the character, attitude, emotions and personality. (iv) Compensatory model that suggests people adapt their behavior according to the perceived level of risk. According to [7], the environment also plays a

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key role in modeling behavior, and it consists of two categories: (i) Physical environment that gathers the natural, built and material environments. (ii) Social environment which decomposes into context and situation. Interaction in a group of people is controlled by two aspects which are cooperation and the contagion of the group. According to this study, we present in Table III , all generic concepts that we keep for developing the human behavior Meta Model.

4. DEFINING THE META MODEL DIMENSIONS

The next step is to define dimensions based on the concepts collected in the third section. The main goal of this step is to formalize these concepts at the same level of abstraction.

Table III-a : Definition of human concepts

Model		Definition
Intentional model	Intention	A cognitive representation of a person's will to perform a given behavior.
Affective Model	Emotion	Emotional phenomenon connected to a "triggering object" that can be a thing (a painting), a living organism (a dog), a natural event (storm) the behavior of others (a threat), his own behavior (doing something forbidden), or a memory recall of an event.
	Attitude	A set of expressions such as attraction or avoidance to an element (person, thing or event) generated by the assessment and the subjective judgment based on several criteria; it depends on the ethical standards (what we must and must not do, what we can do) values etc.
	Personality	A structured set of innate tendencies and acquired dispositions under the influence of education, complex interrelations of the individual in the community, his past and present experiences, his expectations and his projects. It is a stable structure with certain constancy.
	Character	A combination of characteristics that define how to respond to an event. It depends on the environment, culture, belief, experience, physical condition (sick or healthy).
Cognitive model	Memory	A biological function that preserve and restore information.
	Attention	The mind ability mind to focus on an object.
	Information processing	The process of analyzing and developing information using cognitive abilities.
Compensatory model	Risk	The occurrence probability of an event qualified as dangerous or harmful.
	Perception	A feature that allows the feeling and recognition of environmental properties.
Collective behavior	Contagion	The spread of an attitude among individuals in a population through interactions between people.
	Cooperation	The participation degree of individuals in changing the characteristics of the environment

Table III-b: Definitions of environment concepts

Environment concepts		Definitions
Physical environment	Build environment	The entire infrastructure built by humans (buildings, roads etc.)
	Natural environment	The natural environment (water, air, noise, light, green space etc.)
	Materiel environment	Electronic devices, smart appliances, automated machines which people interact with.
Social environment	Context	The general framework that defines the action, it forms a "back-ground" that does not take into account the changes undergone by individuals, it contains the terms and conditions of the event.

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	Situation	A set of circumstances involving an organism, an action and interactions with external environment. It is not constant; it depends rather on activities of individuals.

The human behavior dimensions include everything related to the environment, interactions, and human factors. In [7], we classified these dimensions to "internal dimensions" and "external dimensions". The nomination "internal / external" Indicate the relation of the dimension regarding the studied individual; human factors (cognition, emotion, personality etc.) belong to the first category, while all components of the environment and interactions are part of the external dimensions. This classification is shown in FigureII.

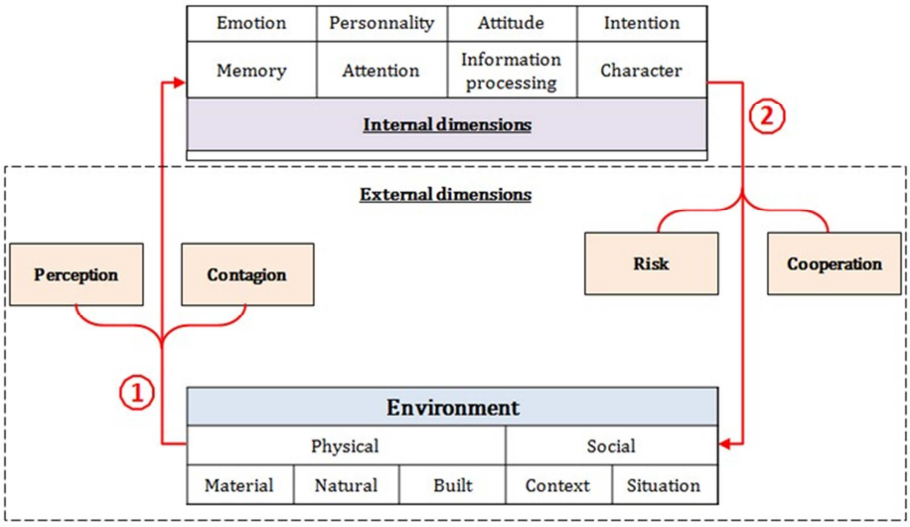

Figure II: Meta Model Dimensions

According to [7] people's interactions with the environment are realized in two flows. Flow number 1 is the impact of environment on humans. These effects are seen only after the person's perception of physical and social elements of the environment. Perception is considered as a "layer" allowing detection and sensation of external parameters. Contagion is also a parameter of this flow, according to its definition; it manages the environmental properties and reacts on human behavior through indirect communication between group members. The flow number 2 shows people's ability to change their environment. This is characterized by a risk level (according to the theory of risk compensation) and a degree of cooperation that people agree to participate in a collective behavior.

In the rest of this study, we propose the following classification presented in Figure III (i) Dynamic Dimensions: composed of internal and external dimensions (ii) static dimensions: personal characteristics (age, family status etc.)

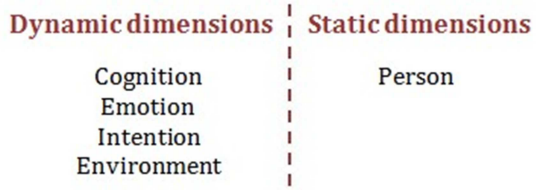

Figure III: Dynamic and Static Dimensions

Table IV shows the dimensions that we keep in our study.

Table IV : Description of the meta model dimensions

Dimension	Description
Cognition	Cognition is a set of structures that combine the various mental processes relating to human being knowledge. It includes all the processes developed by a system to analyze information and establish the appropriate action to address them.
Intention	Intention is a dimension issued from the theory of reasoned action, it determines the process of back thinking and the predetermination of plans before their achievements.

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Emotion	Emotion brings together all the elements related to affective model: attitude, personality, character and emotions
Environ - men	The environment is a fundamental element in human behavior modeling, it determines the action's nature and its conditions. People are constantly interacting with the environment in order to seize informations using perception and processing capabilities to perform a specific action and make decisions based on the perceived data. This environment is divided into two categories; social environment and physical environment. [7]
Person	Person dimension includes all the static characteristics of individuals such as age, gender, family status, etc.

5. BUILDING THE META MODEL PACKAGES

The goal of this paper is to build a multidimensional Meta Model of human behavior. In our previous work [7] we presented the literature review on this topic and we discussed each model's component ; We explained how it is important to consider a meta model as a reference for this kind of analysis seeing that human behavior is a complex matter. Focusing on a specific kind of actions isn't effective enough because this delimitation generates errors in the implementation of the model in various situations other than studied. This part of our work differs from other scientific papers by focusing on human behavior as a whole; we generalize its definition and context by considering dimensions that are abstract to a point where any kind of action performed by persons is included in our model. We aim to gather the dimensions defined in section IV into "orthogonal" packages that will form later a modeling space. The principle of orthogonality is very important because it makes the design of complex systems an easier task. The major advantage of this approach, issued from software architecture, is maintability.

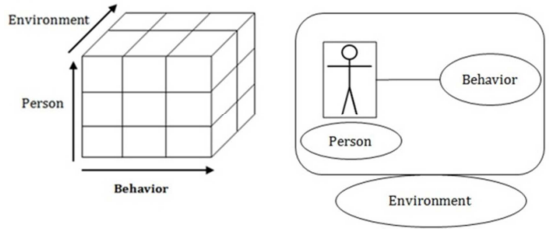

Figure IV: The Meta Model Packages

We will be based on semantical independence to classify the dimensions into different packages. The environment is an independent dimension and does not share any properties with others. However, Intention, Cognition and Emotion have common points and are not fully independent as they are all part of the mental process. To this end, we will group them into one package called "Behavior". The package Person highlights static dimensions that mainly describe a person's property (age, gender, family status, etc.).

The three packages are shown in Figure IV. In the rest of this paper, we will use UML to construct the three packages.

5.1. Environment Package

The environment package includes all the concepts that we have identified in section III. We classify the social and physical environment with all components in Figure V. Table V describes the package's components.

Table V : Description of the environment package

Area	Human behavior laws
Fig 5.a	The Environment here refers to the social and physical environments.
Fig 5.b	The Physical Environment includes three categories: Material, Natural and Built
Fig 5.c	The Social Environment contains two elements: the context and the situation. The Social Environment refers to the virtual and the real environments.
Fig 5.d	The Physical Environment includes connected and non-connected objects
Fig 5.e	The Virtual Environment contains social media
Fig 5.f	The Environment influences the person according to perception and contagion

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Table VI : Description of the behavior package

Zone	Human behavior laws
Fig 6.a	Human behavior is composed of several dimensions. These dimensions are divided into two categories: static and dynamic
Fig 6.b	Dynamic dimensions include internal and external dimensions
Fig 6.c	Internal dimensions are cognition, emotion and intention
Fig 6.d	Cognition includes memory, information processing and attention
Fig 6.e	Emotion includes feelings, character, personality and attitude

5.2. Behavior package

The package Behavior includes all the dimensions that influence behavior in the form of classes. We refer here by:

- Static dimension: refers to all parameters we consider invariant during the study and used as classification parameter. For example, classifying a sample of people by age, gender, family status, etc.
- Dynamic dimension: includes all factors directly related to the behavior, such as environment, cognition, etc.
- Internal dimension: includes internal elements related to the person.
- External dimension: represents the different components of the environment as it is an external factor.

Figure VI illustrates the Behavior Package and Table VI describes its components

5.3. Person Package

The package Person represents all the properties related to the individual studied. It contains the "characteristic" as age, name, address, occupation, etc. Figure VII shows the package and Table VII de- scribes its components.

Table VII: Description of the Person package

Area	Human behavior laws
Fig 7.a	Human impact on the environment is controlled by two parameters: level of risk and level of cooperation
Fig 7.b	Each person has several characteristics

6. BUILDING THE HUMAN BEHAVIOR META MODEL

In previous sections, we collected a data set that converges toward the building of a generic Meta Model of human behavior. The last step is to gather the packages that we presented in the fifth section. Figure VIII shows the associations made between the packages to form the Meta Model.

We were based on two main ideas to link the packages (i) the environment is one of the external dimensions (ii) people's features are part of the static dimensions. Figure IX presents the whole Meta Model. This Meta Model is useful to apply in modeling any human behavior as it contains all dimensions and concepts likely to influence this behavior.

7. CONCLUSION

In this paper we have described the difficulties and challenges of modeling and analyzing human behavior and we have shown the complexity and the diversity of its parameters. The construction method of our meta model is to first collect all the parameters that control human behavior and classify them according to their type: human or environmental. Then, we propose a set of dimensions based on these concepts. And finally, we organize them in a UML Meta Model that consists of 3 packages. We have devoted more attention to the human- environment interaction as this interference has an important role since that environment is one of the dimensions defining behavior. Then we defined all the components of each dimension used for building the packages. The advantage of our methodology is the maintainability; this quality will facilitate the addition of new dimensions if any future work presents them. This Meta Model can be considered as a reference for any human behavior modeling. Its adaptability is due to the high level of abstraction and the generalization of the chosen concepts.

In our knowledge, few studies have focused on Metamodeling human behavior. The literature lacks an effective reference system that defines the requirements, characteristics and elements to be respected during this type of modeling. We believe it is necessary to capture all the dimensions of this behavior and it is in this context that we proposed in this paper a UML Meta Model that will serve as "a reference" for any work aiming to model human behavior.

As future case study, one of the many appealing applications is modeling driver's behavior; it is as a complex system that consists of several units

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(psychological, cognitive, social, etc.) which we presented in our meta model. The understanding of such behavior is a key element for many organizations (insurance companies, ministry of transport, National Committee for prevention of traffic accidents etc.). To describe such a system, it is necessary to model it with precision while respecting its complex structure, and to consider all of its elements as well as their interactions. We note that the analysis of driver's behavior includes many aspects of human behavior, such as emotional, intentional and compensatory parameters. In order to solve this complexity, it is necessary to have a reference for human behavior, then project it onto the driving concept. As a conclusion the main purpose of this paper is to gather the dimensions of human behavior according to several modeling points of view in a single meta model, and to improve the data analysis process by providing a reference that contains all of the behavior "features". This contribution will help selecting the optimal parameters that best explain human behavior and therefore resulting better models.

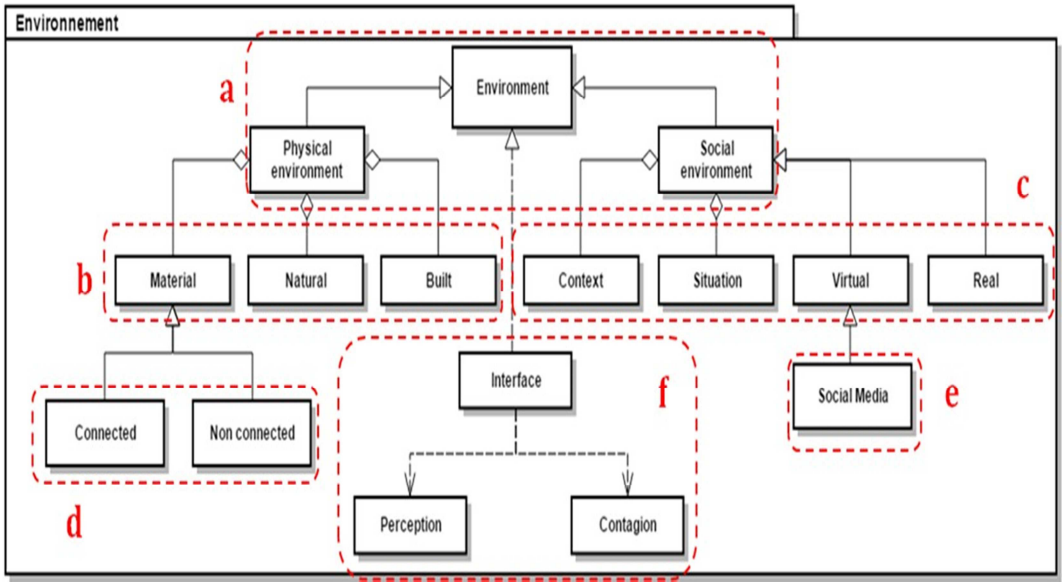

Figure5 : Environment package

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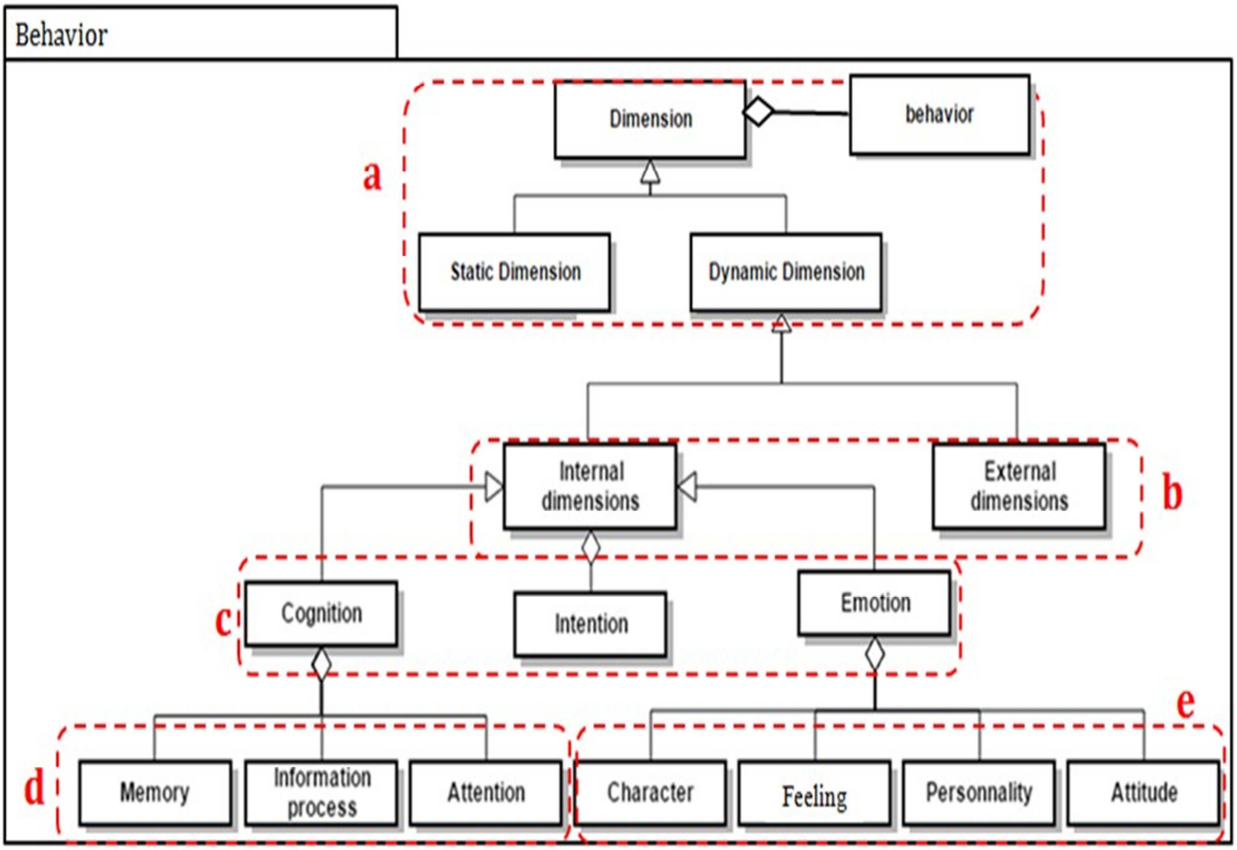

Figure 6 : Behavior package

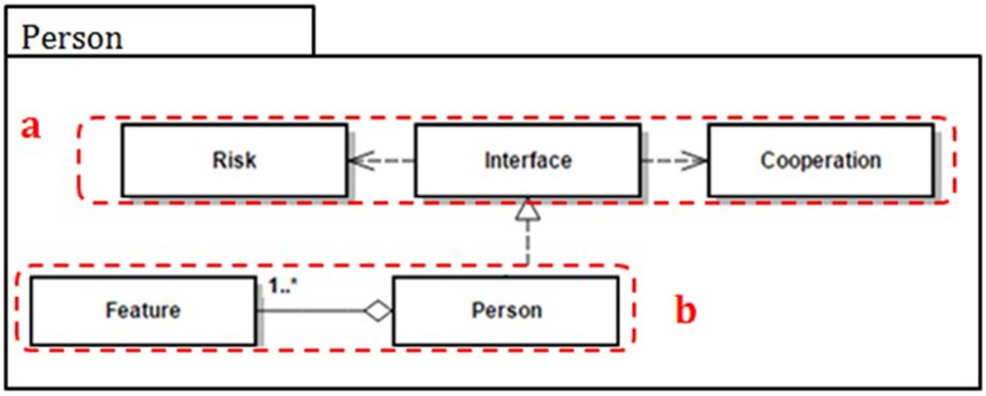

Figure 7: Person Package

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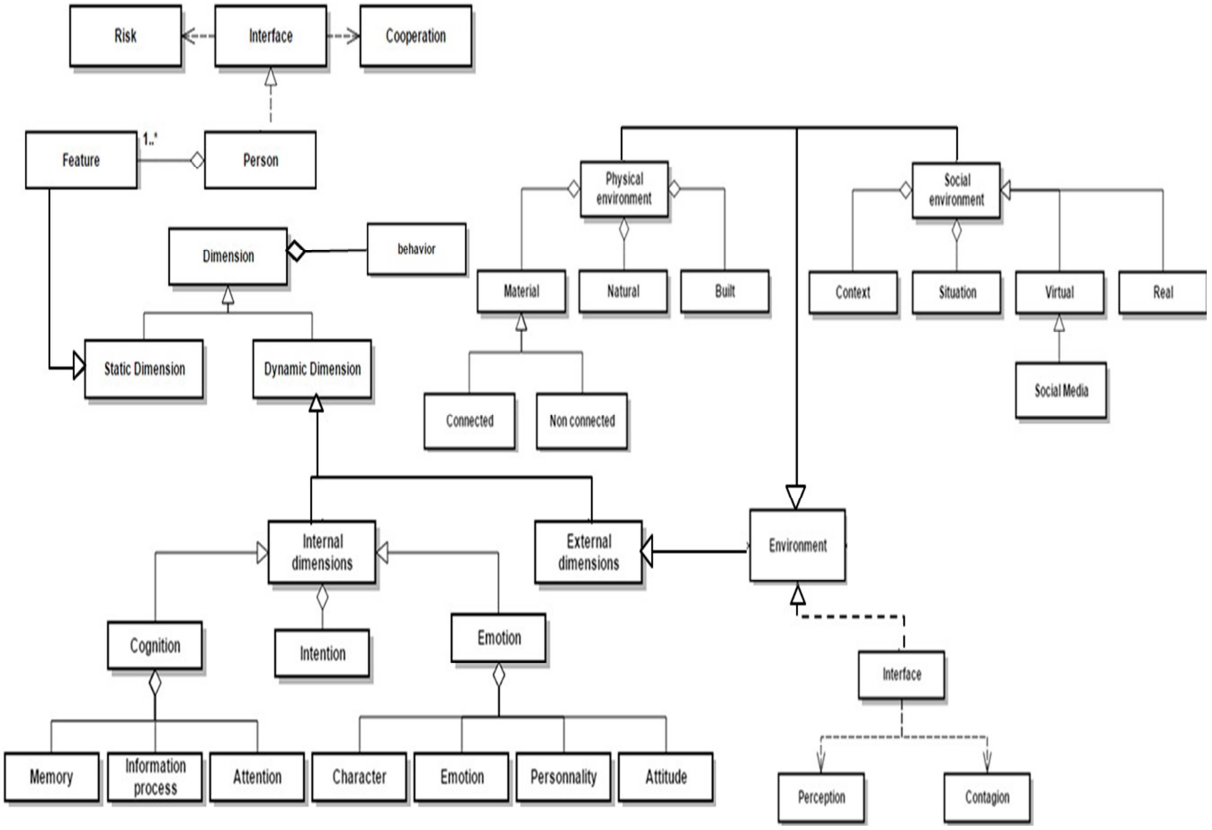

Figure 8: Packages of the Human Behavior Meta Model

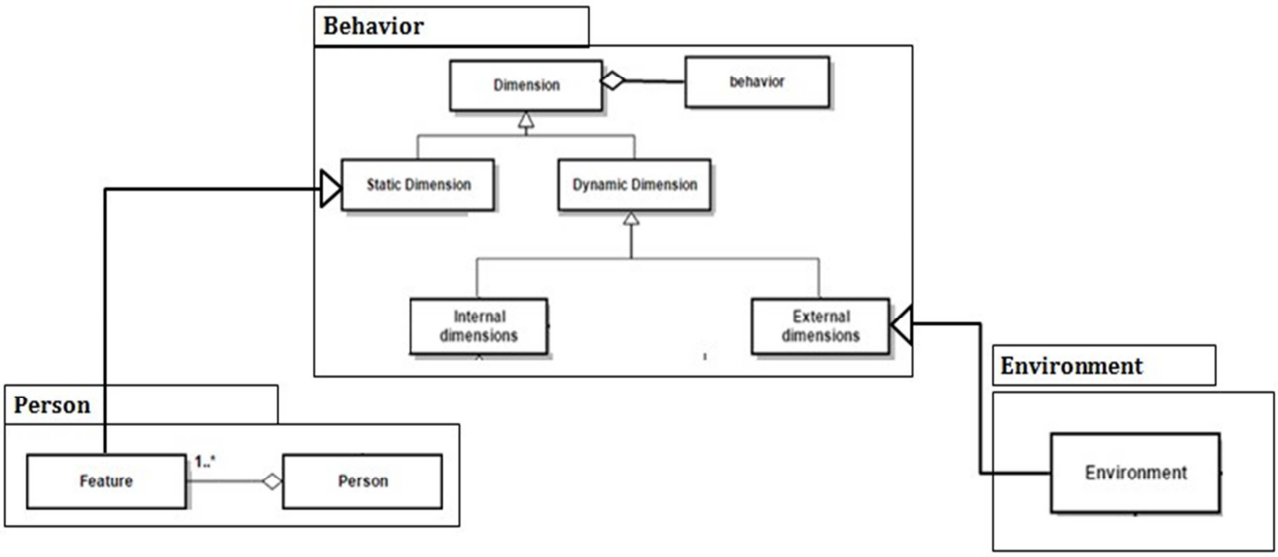

Figure 9. Human behavior Meta Model

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