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ANALYZING THE COGNITIVE PROCESSES OF AN INTERACTION DESIGN METHOD USING THE FBS FRAMEWORK

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ABSTRACT

The engineering design community is debating since more than two decades on the development of models and methods suitable for analyzing the cognitive processes that occur within design activities. An acknowledged model in this domain is the situated FBS framework that describes the design process as consisting of elementary sub-processes defined in terms of modifications on functions, behavior and structures. This framework has been successfully applied to the analysis of the information gathered within industrial innovation projects and to the related design activities. However, it is definitely unusual to use it for analyzing a design method itself, so as to highlight its potential shortcomings and suggest directions of further development. In this paper, the authors investigate this original application through a detailed examination of the IDIM, an interaction design integrated method aimed at generating and validating innovative design suggestions related to interaction issues. The highlighted criticalities are discussed and some suggestions for possible IDIM improvements are depicted.

Keywords: design methods, human behavior in design, user centered design, cognitive processes, FBS framework

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1 INTRODUCTION

The engineering design community is debating since more than two decades on the development of models and methods suitable for analyzing the cognitive processes that occur within a design activity. Indeed, the capability to formally represent thinking and acting processes involved in a design task has enlarged the possibility to analyze the design activities of individuals and teams, so as to identify typical patterns and behaviors (Bierhals et al., 2007), as well as to evaluate the impact of training activities (Gero et al., 2012).

An acknowledged model in this domain is the situated FBS framework (Gero and Kannengiesser, 2004) that describes the design process as consisting of elementary sub-processes, which are defined in terms of modifications on Function (F), Behavior (B) and Structure (S) variables. Since its first formulation in 1990, the FBS framework has been evolved both by his main author and by other scholars, so as to extend its applicability to diverse contexts. Among the others, the application of the FBS framework to the product use context requires to manage a series of different entities (actors, interactions and environments), so as to represent product affordances and their user’s perception, user’s knowledge and its relationships with failures and misuses (Cascini et al, 2010).

Recently, Cascini et al. (2012) have proposed the integration in the FBS framework of two further classes of variables, namely Needs (N) and Requirements (R), so as to properly represent reasoning about need identification and requirement definition. Such extended FBS model has been successfully applied to the analysis of the information gathered within industrial innovation projects and to the related design activities. However, it has been never tested as a means to analyze a design method itself, so as to highlight its potential shortcomings and suggest directions of further development.

In this paper, the authors investigate this original application of the extended FBS framework through a detailed examination of the Interaction Design Integrated Method (IDIM) proposed in (Filippi and Barattin, 2013). Indeed, a proper analysis of interaction and usability issues has become a crucial aspect for several product categories. Therefore, a design method in this domain should carefully support the analysis and the definition of all the features that impact the usability of a product, by properly guiding the interpretation of the user needs, the formulation of a clear set of requirements and the accomplishment of all the following design tasks with a continuous check of the satisfaction of the product specification. From this perspective, the extended FBS framework appears as more suitable than other existing models to analyze the IDIM. The IDIM has been already successfully tested on several industrial case studies, where no significant deficiencies appeared (Filippi and Barattin, 2013). In other terms, the study has been conducted without knowing in advance any potential limitation of the IDIM regarding the FBS analysis.

In summary, the twofold objective of the paper is:

- to show the applicability of the extended FBS framework to the analysis of design methods, specifically focusing on the cognitive processes concerning the interpretation of user needs and the related design choices;
- to identify shortcomings of the IDIM and suggest possible directions of further development.

The next section presents the background of this work, on the one hand with a description of the IDIM, on the other hand with a summary of the variables and processes represented by the extended FBS framework. Section 3 reports the original contribution of this work by mapping the IDIM steps with respect to the FBS processes, so as to highlight gaps and criticalities. Section 4 proposes specific directions for addressing each criticality emerged. The last section draws the conclusions of this research and provides some hints for future work.

2 BACKGROUND

This section introduces the essential concepts of the IDIM and the extended FBS framework, also providing detailed references for a more in-depth presentation of these background works.

2.1 The Interaction Design Integrated Method - IDIM

The interaction design method analyzed in this research is made by different sections developed by the authors' research group in the last years. They are the IDGL - Interaction Design GuideLines, the UEMM - Usability Evaluation MultiMethod and the ITRE - Interaction Trends of Evolution.

The IDGL (Filippi and Barattin, 2011; Filippi and Barattin, 2013) allows usable design solutions to be developed, starting from user needs and expectations and exploiting the TRIZ (Altshuller, 1999) and

QFD (Mazur, 1997; Cristiano et al., 2000) methods and tools. The UEMM (Filippi and Barattin, 2012) suggests the best usability evaluation activities for a specific design environment, based on available resources and product characteristics. The ITRE (Filippi and Barattin, 2013) exploits a knowledge base of trends of evolution about interaction to design innovative products.

The synergy among these three methods has been implemented in the new Interaction Design Integrated Method - IDIM. It covers the first part of the product development process, from gathering the user needs to the generation of validated design concepts. The algorithms and structures of the three methods have been integrated aiming at best exploiting the knowledge base, avoiding redundancy and optimizing the effectiveness. Figure 1 shows the IDIM architecture, highlighting the data flow.

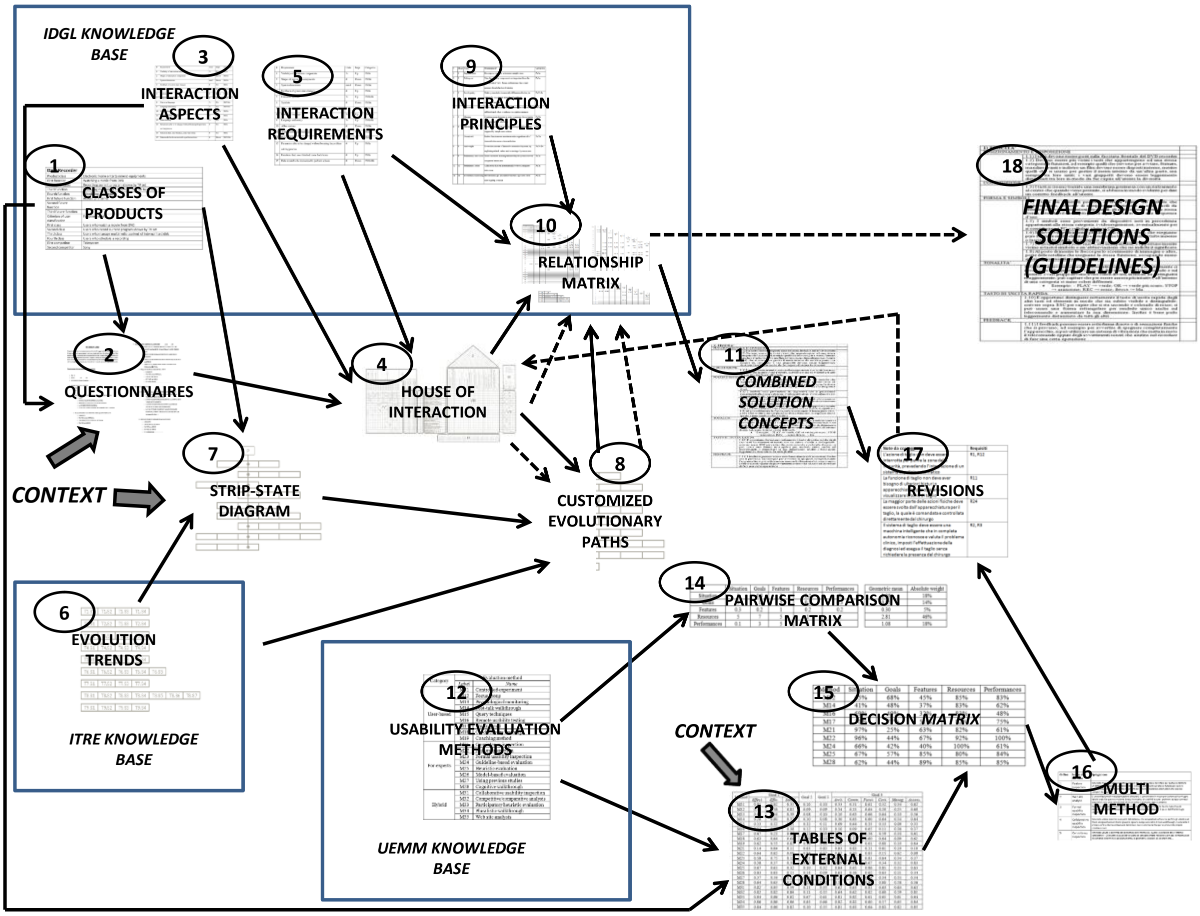

Figure 1. The IDIM architecture.

The IDIM adoption starts by exploiting nine product classes (1). These are pieces of information describing functions, criteria for user characterization and features of different categories of products e.g. "electronic home entertainment equipment" and "household appliances. After the selection of the most suitable class for the product under analysis, the designer collects the user characteristics and expectations through a semi-automatically generated questionnaire (2). The outcome of the survey is a selection of interaction aspects (3), listed as rows in the main IDIM data structure, the house of interaction - HOI (4), and derived from the house of quality in QFD. The HOI allows pieces of information to be collected and related to each other in a structured way, based on the questionnaire and on the knowledge base content. The core of the HOI collects the relationships between interaction aspects and requirements. The thirty-one interaction requirements (5) are quantitative indices to make usability concerns as objective as possible. Derived from the analysis of many projects where interaction design plays a significant role, they represent meaningful design constraints for the data collected during the survey.

In parallel with the exploitation of the HOI, the IDIM starts to help the designer in highlighting the best evolutionary path for the designed product. Nine trends of evolution about interaction (6) are present, focusing on nine different aspects of interaction. These trends are sets of ordered evolutionary

states, describing the characteristics of the interaction of a product. Every state has a definition and some examples helping in understanding and exploiting it at best. The time-ordered sequence of states in a trend defines the evolutionary path. The designer classifies the product against the states and this leads to the definition of the product strip-state diagram - SSD (7). The SSD has nine strips, one for each trend, made by the trend states. Once the product is classified in the states, the strips are rearranged in order to vertically align the states representing that product against the nine aspects of interaction. The interaction requirements highlighted thanks to the HOI are used together with the product SSD to define the customized evolutionary paths - CEPs (8). A CEP is obtained by mapping the generic definitions of the states in the specific product domain. It contains suggestions about possible evolutions to be picked up at a glance, given that the strip rearrangement in the SSD collects all the potentially useful examples to the right of the vertical line of states representing the current release of the product. By coming back to the interaction requirements highlighted thanks to the HOI, each of them has some interaction principles associated (9). There are forty-seven in all, derived from the forty principles of the TRIZ theory (Altshuller, 1999), and they suggest how to implement/solve generic interaction issues/problems. Starting from these suggestions and from the CEPs, the designer can easily develop the so-called single solution concepts. They constitute the first half of the final guidelines generated by the integrated method. Possible contradictions or positive connections among interaction requirements are managed and exploited by another data structure, named relationship matrix (10), derived from the TRIZ contradiction matrix (Altshuller, 1999). The rows and columns of the matrix represent the same full list of requirements. The entries in the main diagonal contain the links to the principles related to each requirement. The other entries refer to relationships between requirements and they suggest the most suitable interaction principles in order to solve possible contradictions or to enhance positive relationships. These suggestions contribute to the generation of the second half of the guidelines, named combined solution concepts (11).
The solution concepts need to be evaluated using the classic usability evaluation methods (12). A list of them is available in the IDIM knowledge base and their characterization allows selecting the best ones given the specific product development environment. This characterization considers dimensions like the goals of the evaluation and the resources (e.g. available equipment and skill of the personnel involved), mapped in the table of external conditions (13). Moreover, the designer must define some weights describing the relative importance of these dimensions. Thanks to these weights, the pairwise comparison matrix (14) puts the evaluation methods into relationship and the IDIM defines an ordered list of the most suitable evaluation methods by exploiting the last data structure, the decision matrix (15). This ordered set is the result of the process and is named usability evaluation multi-method (16). It contains all the information needed by the designer, even by the unskilled ones, to be able to perform the evaluation at best. Then the solution concepts are evaluated using the multi-method and all the suggestions for their possible improvement are collected (17). These suggestions are considered as a sort of further user expectations and trigger a new iteration of the IDIM process. The dashed arrows in figure 1 show this loop. When the evaluation phase tells that the solution concepts can be considered as satisfactory, the cycle breaks and the design guidelines (18) are available for the designer to develop the technological specification.

2.2 Function - Behavior - Structure

The situated FBS model (Gero and Kannengiesser, 2004) describes any design activity through three classes of variables and eight reference processes, which take place in three different types of environments. The reference variables are:

- Functions (F), which describe the aim of the object, i.e., what the object is for;
- Structures (S), which describe the object's components and their relationships, i.e., what the object is; and
- Behaviors (B), which describe the attributes that are derived or expected to result from the structure variables of the object, i.e., what the object does.

The three environments, where these variables are created and transformed, are: the external world (^{e}), made of representations outside the designer; the interpreted world (^{i}), constituted by sensory experiences, concepts and interpreted representations of that world with which the designer interacts; the expected world (e^i), the world in which the effects of the actions of the designer are imagined according to the current goals and the interpretations of the present state of the world.

The elementary sub-processes that the F, B and S variables undergo can be grouped into eight main design steps:

- Formulation is the process that produces the interpreted representation of the F^i, B^i, S^i variables from the list of explicit requirements and focuses on the initial design state space constituted by the expected Fe^i, Be^i, Se^i variables.
- Synthesis generates the external representation of the artifact structure (S^e) starting from the expected behavior Be^i.
- Analysis investigates the synthesized structure (S^e) so as to interpret the 'actual' behavior (B^i);
- Evaluation compares the latter interpreted behavior (B^i) with the expected (Be^i) behavior of the design solution.
- Documentation produces a design description, e.g. for manufacturing the artifact, after the achievement of a positive evaluation of the design solution.
- Reformulations (type 1-3) respectively address changes in terms of structure variables, in the behavior state space, in terms of function variables.

The extended FBS framework (Cascini et al., 2012) situates in the same three worlds two further classes of variables: Needs (N), an expression of a perceived undesirable situation to be avoided or a desirable situation to be attained, explicitly stated to the designer or perceived by the designer because of being extracted (or even postulated) by the observation of users' behavior; Requirements (R), a measurable property related to one or more needs consisting of a metric and a value. The introduction of these two novel classes of variables allows for representing with the same formalism two further main steps of a complete design process, i.e. need identification and requirement definition.
Overall, the twenty original elementary sub-processes defined by Gero and Kannengiesser (2004) are enriched by fourteen further sub-processes that span over need identification (new), requirement definition (new) and formulation (revised). These macro-processes and elementary sub-processes can be used as a reference to analyze the design steps of a method such as IDIM, as detailed in the next section.

3 ACTIVITIES

According to the research goals described in the introduction, the IDIM is first mapped against the extended FBS model, looking for correspondences and eventual discrepancies. Then, these discrepancies are collected, analyzed in detail, and some judgment about their validity and applicability is generated. The result is finally used in developing suggestions about possible improvements of the IDIM as described in section 4.

3.1 Mapping

The mapping between the IDIM and the extended FBS model is performed against each of the FBS main processes.

3.1.1 Need identification

The need identification addresses the collection, interpretation and formalization of user needs. The first, elementary process translates the real, external needs N^e, into the designer's interpreted ones N^i. The N^e of the IDIM are the user needs, highlighted through the automatically-generated questionnaire in the users' language. Their analysis allows the interaction aspects to be collected and these represent the designer's interpretation of the user needs N^i. The next elementary process translates the N^i into the interpreted interaction requirements R^i. In the IDIM, the R^i are the interaction requirements highlighted thanks to the HOI, starting exclusively from the explicit user needs. Then, the third elementary process transforms the expected requirements Re^i into the expected needs Ne^i and its correspondence in the IDIM is the transition from the interaction requirements highlighted by the designer based on supposed new functions to implement, to the related interaction aspects. Here, again, it seems that the IDIM satisfies the FBS model, but a first criticality arises. All of this happens before the two previous elementary processes, since part of the questionnaire is generated here. We label this criticality as CR1 and it will sound as "temporal order of actions in the need identification". The fourth elementary process deals with the transition from the Ne^i to the N^e. In the IDIM, this corresponds to the automatic generation of the questions used for the survey, starting from the new functions of the product. Here again, even if all of this finds correspondence in the IDIM, there is the same problem related to the temporal ordering. In fact, these IDIM activities are needed to generate part of the questions used in the survey to highlight the final interaction aspects. Given the clear analogies, this criticality is managed with the previous one as a whole in CR1.

3.1.2 Requirement definition

The Ne^i highlighted thanks to the previous elementary processes allows the Re^i to be defined as prescribed by the first elementary process here. In the IDIM, this corresponds to the transition from the expected interaction aspects, where both the users' and the designer's are considered, to the interaction requirements, obtained thanks to the HOI. The second elementary process consists in the transition between the Re^i and the R^e. The lower part of the HOI in the IDIM allows setting target values for the external and real requirements. This way, the generic interaction requirements become R^e, because their potentially arbitrary values become limited sets, customized on the specific product to design. Starting from the R^e, the designer interprets again the R^i as prescribed by the third elementary process. In the IDIM, this corresponds to the generation of the SSD starting from the interaction requirements.

3.1.3 Formulation

The formulation establishes the transition from the R^i to the expected functions Fe^i, the expected behaviors Be^i and the expected structures Se^i. The first elementary process transforms the R^i into interpreted functions F^i, behaviors B^i and structures S^i. In the IDIM the CEPs related to each requirement are defined, starting from the SSD. The CEPs are not classified by type (F, B or S) at the moment, and this generates the second criticality CR2 named “missing CEP classification based on F, B and S”. The second elementary process suggests the enhancement of the knowledge about the R^i. In the IDIM this corresponds to the update of the knowledge base regarding the interaction requirements, the interaction aspects and examples associated both to the interaction principles and to the CEPs. The third elementary process transforms the F^i, B^i and S^i into Fe^i, Be^i and Se^i respectively. In the IDIM, this elementary process is the generation of the solution concepts, the final design suggestions generated starting from the CEPs. Again, the solution concepts are not classified by F, B and S, so the third criticality CR3 arises, “missing classification of the solution concepts based on F, B and S”.

3.1.4 Synthesis

The synthesis allows moving from the Be^i to the S^e, representing the technical specifications of the product. Here only two elementary processes are present. The first transforms the expected behaviors Be^i into expected structures Se^i. In the IDIM, all of this could be identified in a translation from the solution concepts focused on product behavior to the ones regarding the product structure. This translation is not present at the moment because the solution concepts are not classified as behavioral vs. structural ones. Then, we highlight the fourth criticality CR4 “missing transformation from behavioral to structural solution concepts”. The second elementary process deals with the transition from the expected structure Se^i to the external structure S^e. This cannot find a correspondence in the IDIM as well, because at the moment the solution concepts are the ultimate result and there are no further steps towards the definition of the technological specifications. This represents the fifth criticality CR5 “missing generation of the technological specifications related to structures”.

3.1.5 Analysis

The analysis defines the B^i from the S^e generated before. Two elementary processes are present. The first defines the interpreted structure S^i starting from the external one S^e. In the IDIM this happens when the UEMM is applied in order to validate the solution concepts. The second elementary process, where the behaviors B^i are derived from the interpreted structure S^i, is not present in the IDIM, so the sixth criticality CR6 is set. It sounds as “missing transformation from solution concepts describing structural matters into those related to behaviors”. The criticalities CR4 and CR6 sound contradictory to each other, but this is not the case. In fact, both the elementary processes are present in the FBS model, and they coexist because they belong to different worlds, the expected world related to the CR4 and the interpreted to the CR6. In IDIM the world distinction is not present at the moment, so the two criticalities appear as contradictory.

3.1.6 Evaluation

The evaluation is made by a single elementary process, where the expected behaviors Be^i defined before are compared with the B^i coming from the analysis of the new S^e. This elementary process is present in the IDIM, corresponding to the adoption of the UEMM. It is performed together with the one described in the previous paragraph, since there is no separation between behaviors and structures at the moment. This is taken into account with the criticality CR4, because it refers to the missing translation of the structural solution concepts into the behavioral ones. Once the CR4 is solved, the UEMM will generate the best multi-method to evaluate and validate the new behavioral solution concepts.

3.1.7 Documentation

The documentation, consisting in one single elementary process again, generates the technical specifications F^e, B^e and S^e, after the evaluation of the corresponding items Be^i, Fe^i and Se^i. All of this is completely missing in the IDIM so it constitutes the seventh criticality CR7 “missing generation of the technological specifications related to functions, behaviors and structures”. The focus on structures is cited again, even if they already appeared in CR4.

3.1.8-9-10 Reformulation

There are three types of reformulation main processes, which imply progressively more radical modifications, since they involve respectively the S variables solely (Ref. I), the B variables then impacting also the structural characteristics of the design (Ref. II) and a full redefinition of the design problem starting from its functional expectations (Ref. III). In any case, the goal is to act on the S^i, B^i and F^i derived from the Se^i, Be^i and Fe^i, if any substantial gap has been registered between Se^i, Be^i, Fe^i and S^i, B^i and F^i. In the IDIM the reformulation main processes could find a correspondence in the adoption of the UEMM in evaluating the solution concepts. Unfortunately, the solution concepts are not the technical specifications as in the FBS model, so another criticality arises. Anyway, given the analogies, this is managed in the CR7 as well. Another elementary process in the FBS reformulation is the modeling of constructive memory. It consists in generating new pieces of information every time the design process takes place. This finds correspondence in IDIM, given that the designer can easily enrich the knowledge base every time he/she thinks that a meaningful piece of information is found.

4 RESULTS AND DISCUSSION

The seven criticalities are now analyzed to establish if these could be considered as valuable triggers to improve the IDIM. The possible improving activities suggested by each of them are then described in detail in the following.

Before proceeding with the analysis of each criticality, some general considerations are here expressed. The most of the criticalities are related to N and R variables. This is normal and comes as expected, because of the user centered character of ID. While the classic FBS model considered the user somehow implicitly, the focus on the differences between needs and requirements introduced by (Cascini et al., 2012) appears as particularly valuable here, because it allows evaluating some parts of the IDIM otherwise not verifiable.

CR1. Temporal order of actions in the need identification

The first criticality suggests the analysis of the survey outcomes, looking for implicit user needs, to be performed before processing them in the HOI. All of this could generate new interaction aspects and, consequently, new requirements and solution concepts. In order to satisfy this, a new table could be added to the IDIM data structures, collecting the relationships among the interaction aspects. Thanks to this table, when a specific interaction aspect appears in the users' answers, the linked aspects could suggest possible implicit needs. The selection of the potentially useful aspects cannot be automated, since everything is context-dependent. So the designer would need to select the meaningful aspect based on his/her own skill and knowledge, together with some consideration about the general outcomes of the survey. For example, the interaction aspects "clarity level about how to start an action" and "visibility of controls" are quite clearly related to each other, because the clarity level could be heavily helped by the presence of controls labeled with univocal colors and symbols. Then, if some user highlights difficulties in understanding how to start an action, the implicit problem could be the lack of clarity, positioning and/or distribution of the controls in the interface. So, the link between these two aspects, collected in the new relationship table, could allow the interaction aspects related to the visibility of allowed actions and controls, and this would enrich the knowledge content of the solution concepts.

CR2. Missing CEP classification based on F, B and S

The CEPs need to be classified in terms of functions, behaviors and structures in order to make them easier to understand, apply and effectively exploit. All of this would enhance the IDIM usability because designers would be helped a lot in conceptualizing its structure and functioning. But the generality of the state definitions in IDIM does not allow this at the moment. The suggestion could be to define the CEPs for every F, B and S, in addition to each requirement as it happens now. No new data structures or tools would be required to the IDIM; the existing knowledge would be simply widened and enriched. For example, consider an ATM cash card as the product needing improvement. Be one of the highlighted, meaningful requirements "data needed to memorize to perform actions" and consider the trend "long term memory usage". A cash card is in the first state at the moment - "users must memorize and recall fixed data, chosen by others" - because the secret code is delivered by the bank and the card owner cannot modify it. The next state of the trend suggests "users must memorize and recall data chosen by them". In generating the CEPs, the evolutionary paths would be defined as related to the FBS variables. The state definition of the CEP related to functions would sound as "a customizable secret code is desirable to prevent lapses of memory and unauthorized users of the card to withdraw cash". The state definition in the behaviors-related CEP would be quite different. It would sound as "the card owner needs to be free to choose the secret code format (composition, length, etc.) according to his/her own characteristics and needs (memory capabilities, age, etc.)". Finally, the structures-related state definition would be "the secret code should be constituted of a customizable number of digits between 4 and 8 more than one time".

CR3. Missing classification of the solution concepts based on F, B and S

The solution concepts are not classified against their functional vs. behavioral vs. structural character as highlighted by the criticality. But this could be very helpful in interpreting and applying the concept at best during the design activities, in particular in the generation of the technological specifications. What is needed is to classify the principles by the FBS variables, in order to have the deriving solution concepts labeled accordingly. The analysis of the principles and of the associated examples highlights that some of them refer to a single FBS variable, while others contain double references. Anyway, it seems possible to exactly specify these elements every time. Definitions can be let as they are, because they already contain precise terms that can be considered as univocal references. For example, the interaction principle "segmentation" suggests to "decompose complex actions into simpler ones". The "actions" term can be intended as a reference to behaviors, because it suggests modifying the user and/or product actions during interaction, so, in other words, their behaviors. By referring to the interaction principle "use flexible and/or thin interface components to make interaction lighter", reinterpreted from the original TRIZ principle “flexible shells and thin films”, it is easy to deduce that it refers to structures. The principle suggests introducing structural modifications, but it doesn't refer to any function or behavior related to them. Thanks to this new classification, the relationship matrix will highlight the principles based on the meaningful interaction requirements as before, but they will be filtered by the FBS variable type of interest time by time. In order to avoid misunderstandings and to enable a logical thinking process, the algorithm will force a time ordered generation of the solution concepts; the functional ones will be the first, then the behavioral, and the structural ones will close the guideline generation process.

CR4. Missing transformation from behavioral to structural solution concepts

The classification of the interaction principles described in the previous paragraph allows the principles referring to structural matters to be highlighted and exploited (with the related examples) in IDIM, aiming at analyzing and translating behavioral solution concepts into structural ones. The structural interaction principles suggest how to define the interface morphology (colors, shapes, materials, etc.) to achieve a specific behavior. By applying them to the behavioral solution concepts, the best implementation of a given behavior would be suggested. For example, consider the interaction principle "another dimension - move from a physical interaction to a contact-free one". This principle might suggest to move from a physical interaction to the one based on voice recognition. The product structure will have to be shaped consequently. This way, new solution concepts could be generated by exploiting the interaction principles from a new, different point of view, and the implementation of the process would get easier.

CR5. Missing generation of the technological specifications related to structures

Given the analogies of this criticality with the seventh one (CR7), please see the related paragraph.

CR6. Missing transformation from solution concepts describing structural matters into those related to behaviors

The sixth criticality can be seen as a sort of evaluation of the product structure. In fact, moving from structural solution concepts to behavioral ones requires a precise analysis of the behaviors allowed by physical components. This implies an evaluation of the impact of the structural solution concepts on the user-product interaction. This would define the goodness and effectiveness of the solutions in order to schedule time and resources for their improvement. The UEMM already allows this evaluation, thanks to the multipurpose collection of atomic evaluation methods it is based on. In particular, the model-based evaluation method and the expert cognitive walkthrough best fit this need, because they are focused on the evaluation of the user behavior allowed by the product structure, as suggested by the IDIM solution concepts. At the same time, these methods allow the suitability of the product structure and behavior to be quantified, given the user needs and expectations. For example, the expert cognitive walkthrough is based on questions aiming at analyzing the possible behaviors induced by specific structures, developed in the IDIM thanks to the related structural solution concepts. The first question suggested by this method asks: "is the correct action available and evident, as like as answering to the user intentions?". In answering to this question, the designer must analyze the product structure in detail and gather if the required user behavior will be intuitive, in one word "as expected", or if it will be forced away from the natural users' one.

CR7. Missing generation of the technological requirements related to functions, behaviors and structures

The fifth and seventh criticalities deal with the lack of technological requirements related to functions, behaviors and structures in the IDIM. These criticalities cannot be kept into consideration for improvements, since they go against the definition of the IDIM. In fact, this integrated method has been thought about since the beginning as a generator of suggestions, exactly as the TRIZ theory does, and not of technological specifications ready to be exploited in the field. There are not tools in the IDIM dealing with technological feasibility, resource requirements and availability at the moment.

5 CONCLUSIONS

The research described in this paper aimed at analyzing the IDIM from the cognitive processes point of view, thanks to the FBS framework extended to Needs and Requirements. As such, this resulted as the first exploitation of the extended FBS model with a design method. Seven criticalities arose during the mapping of the IDIM activities in the main processes of the FBS framework. These criticalities have been evaluated, aiming at establishing their importance as sources of suggestions for the IDIM improvement. The last section of the paper has described the possible implementation of these suggestions in the IDIM. In the near future these suggestions will be actually implemented and a new series of industrial tests will be performed using both the original and the new release of the IDIM, in order to measure the possible improvement. Several design teams will be involved aiming at widening the set of IDIM users to make the results of the tests as free as possible of the bias coming from previous experiences, skills, etc. Another important research direction will analyze the execution of the mapping activities and on the interpretation of the outcomes. The goal will be to generate a roadmap for the evaluation/validation (and, possibly, enhancement) of design methods using the FBS framework. Finally, some attention will be paid also to possible integrations of the FBS framework, in order to make the link FBS framework - design methods two-way.

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