USER INTERFACE DESIGN INFORMED BY AFFORDANCES AND NORMS CONCEPTS

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Abstract: Human interaction with Information and Communication Technologies relies on the manipulation of signs represented in different interface elements. While designing interfaces, several decisions may be taken as which interface elements will be added, where, which size, shape or color must have. More than context knowledge (as who is the user, devices' characteristics and environmental conditions), information from the system domain should be used to support interface design. This paper presents preliminary results of an exploratory study about how affordances and norms may inform user interface design decisions. The results suggest that some categories of affordances are represented in the interface by similar types of signs and are placed in specific positions. Moreover, MONA, a tool to help designers to structure user interfaces and determine the behavior of each element using norms, is presented.

1 INTRODUCTION

The pervasiveness of Information and Communication Technologies (ICT) in our daily lives emphasizes the necessity of technical systems aligned with people's intention, beliefs and social commitments. Therefore, the design of these systems demands a deep understanding about the complex interaction process between humans and ICT. This understanding is only possible with a socio-technical perspective that considers ICT as part of reality, which is socially constructed.

Semiotics has been effectively used as a theoretical framework for supporting the interaction design (e.g. Nadin, 1988; Andersen, 1990; deSouza, 2005). Interaction between users and the technical system can be considered a sharing-sign phenomenon influenced by several factors as familiarity with devices, intention of use, affective issues, devices' characteristics and environmental conditions. Such phenomenon, analyzed only according to the perspective of engineering, has been interpreted as purely syntactic. The analysis using Semiotics reveals the primary function of computer systems as vehicles of signs and supplies an adequate vocabulary that makes possible the understanding of computer systems in terms of other types of sign systems (Nadin, 1988).

Organizational Semiotics (OS), in particular, is a discipline that explores the use of signs and their effects on social practices (Stamper et al., 1988; Liu, 2000). OS provides a background that embodies knowledge and support collaboration and reflection among people from the different disciplines involved in interaction design (Baranauskas and Bonacin, 2008). In addition, OS supplies methods and artifacts that have been successfully used to clarify the design problem, extend context knowledge, formalize requirements and evaluate the design solution (cf. Liu et al., 1998; Bonacin et al., 2006; Rambo et al., 2009; Neris et al., 2010).

The human interaction with ICT relies on interfaces that allow the manipulation of signs which may be represented in different forms as text, pictures, sound and video, to name the currently popular ones. While designing interfaces, several decisions may be taken as which interface elements will be created to enable some type of interaction, where, which size, shape or color must have, among other characteristics. These decisions are generally left on the designers' hands or on user interface patterns detached from the application domain. Neris et al. (2008) have shown that the users' knowledge about the domain and their digital literacy highly influences the interaction. When users know about the system domain and the system design reflects the

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domain characteristics, the interaction process is facilitated. Therefore, we argue that more than context knowledge (as who is the user, devices' characteristics and environmental conditions), information about the system domain are influential for interface design decisions.

This paper presents an exploratory study to investigate how the concepts of affordances and norms may inform user interface design (UID). 17 designers were involved in a case study and 7 web design proposals were analyzed. The domain was modeled based on two methods from OS, Semantic Analysis Method (SAM) and Norm Analysis Method (NAM). Affordances and norms from the domain modeling were compared to those direct or indirectly present in the final UID. The preliminary results suggest a relation between some specific affordances and the place and presentation format of related elements in the user interface. Finally, a tool to structure interfaces is proposed and the interface elements characteristics are formalized by norms. The text is organized as follows: Section 2 presents the background concepts; Section 3 presents results of the case study to explore the relation of affordances and norms with UID; Section 4 presents a norm modeler tool as part of the process of constructing UID based on the concepts of affordances and norms; Section 5 concludes.

2 AFFORDANCES AND NORMS

The concept of affordance was initially created by the perceptual psychologist J. J. Gibson (1977, 1979) as a word for the behavior of an organism made available that "implies the complementarities of the organism and its environment". As Gibson defined it, "the affordances of the environment are what it offers the animal, what it provides or furnishes, either for good or ill". For Norman (1988, 2008), Gibson invented the word affordance "to refer to a relationship: the actions possible by a specific agent on a specific environment". According to Stamper (1988, 1996), the word affordance in Gibson's theory is related to the invariants we perceive that are significant for physical and biological reasons.

The term affordance started to be widely used in design after Norman's book (1988), in which he proposes the use of perceived affordances and the "thing" actual properties. According to him, affordances provide strong clues about how the thing could be possibly used, e.g. "plates are for pushing" or "slots are for inserting things". He argues that in graphical, screen-based interfaces, all that the designer has available is control over perceived affordances. The computer system, with its keyboard, display screen, pointing device and selection buttons affords pointing, touching, looking, and clicking on every pixel of the display screen. However, Norman clarifies later on (2004), even if users can click anytime and everywhere on an interface, it is strong to state that a graphical object on the screen "affords clicking". He emphasizes that the question is: "Does the user perceive that clicking on that location is a meaningful, useful action to perform?"

Stamper's (1988) extension to the concept of affordances better helps us to answer this question. According to Stamper et al. (2004): "All organisms, including human agents construct their perceptions of the only world they can know through their actions; they have to discover (or be taught, or inherit by instinct) what invariant repertoires of behavior the world affords them (= the affordances); then they populate their reality with those affordances that help them to survive". This perspective considers that the reality is socially constructed and relates affordances with patterns of behavior arisen from social interactions. Therefore, every affordance presupposes meaning and intention, what guides for example the click on an interface element.

OS proposes a method to support domain modeling by its affordances. SAM supports the analysis, specification and representation of a social system and is divided into four phases: problem definition, candidate affordance generation, candidate grouping and ontology charting (Liu, 2000). Considering a statement that defines the (design) problem, the main affordances in the domain are elicited. SAM also considers the concepts of agents and ontological dependencies. Agents are a special type of affordance which refers to those who are capable of assuming responsibilities. Ontological dependencies are links between affordances or agents representing that the element in the right can only exist during the existence of the element in the left. After identifying the affordances and agents and grouping them (if they have the same meaning), the ontology chart is drawn.

OS approach rescues the original sense of ontology as part of the philosophy that studies the nature of reality. It adopts a social-subjectivism stance and an agent-in-action perspective for ontology; i.e. each word or expression used is a name for patterns of behavior in the set of actions and events which agents experience. Therefore, the ontology chart is like a "snapshot" of the reality regarding that specific domain in which the prospective (software) system will be included. Moreover, the dynamic behavior in that reality can be modeled using norms.

Norms are the rules which determine how social organisms interact and control affordances (Stamper 1993; Stamper et al., 2000). They are related to how people behave, think, make judgments and perceive the world. Every norm can be written as IF <condition> THEN <consequence>. Behavioral norms, in particular, can be expressed in an extended format: WHENEVER <state> IF <condition> THEN <agent> IS <deontic operator: must, may, must not> TO <action>. With this last structure, it is possible to complement an ontology chart by specifying how agents deal with affordances. Indeed, affordances by themselves express perceptual norms. They concern the ways in which we divide up the world into the phenomena to which we attach names. We can only represent norms explicitly when we have words to represent the perceptions underlying them (Stamper et al., 2000). Moreover, evaluative and cognitive norms also compose a social psychological taxonomy of norms.

NAM consists of 4 steps for eliciting and formalizing norms: responsibility analysis, proto-norm analysis, trigger analysis and detailed norm specification (cf. Liu, 2000). Each step assists the identification of parts of the norm. In special, the responsibility analysis aims at assigning the agents in charge for each action. The trigger analysis focus on the conditions that should happen thus the action will be performed.

Both, affordances and norms, are powerful concepts to describe a domain and have been used to support the design of interactive systems (Bonacin, 2005; Neris and Baranauskas, 2009). Nevertheless, it is still necessary to investigate whether these concepts may support interface design decisions. The next section presents an exploratory study in this direction.

3 SAM AND NAM SUPPORTING UID

An exploratory study analyzed 7 user interfaces from prototypes developed by 17 (prospective) designers from the postgraduate course in Computer Science at UNICAMP-Brazil. The prototypes were developed following PLu*R*aL - a framework for the design of tailorable user interfaces based on Organizational Semiotic concepts (Neris and Baranauskas, 2010). PLu*R*aL is organized in 3 pillars: the 1st one brings out the signs of interest in the domain (being them related to users, devices or environment) and formalizes non-functional requirements that the tailorable system should cope with. The 2nd pillar benefits from SAM and NAM and allows a consistent view about the domain, including the norms that govern the agents' behavior, and assist the formalization of functional requirements. In the 3rd pillar, the tailorable design solution is build up and a norm-based structure formalizes the system tailorable behavior.

Designers worked in 7 groups (4 with 3 participants each, 2 with 2 participants each and 1 participant worked alone) and were free to propose a system design within the context of service applications for the Brazilian user. The systems chosen consider different domains: public drugstore, Portuguese learning support, social network about books, poll system for digital TV, traffic awareness, job guide and interaction monitoring system.

In this study, the ontology charts generated in PLu*R*aL's 2nd pillar were compared to the final user interfaces as described in section 3.1. The results observed and some preliminary conclusions are presented in section 3.2.

3.1 Method

The analysis aimed at evaluating if (and how) affordances and norms that represent the domain were expressed in the final user interfaces. Therefore, the adopted method considered the following steps: (1) the affordances represented in each ontology chart (an example is shown in Figure 1a) were divided into 4 categories: people (considering the roles derived from the affordance "person"), institutions (agents which are not person or person's roles), actions (affordances expressed by verbs) and substantives (affordances expressed by nouns); (2) Each final user interface was inspected and the main affordances expressed in the different interaction areas were elicited; (3) The affordances expressed in the interfaces were compared to those from the ontology charts, considering position in the interface and representation (which interface element was used: icons, links, buttons etc), as illustrated in Figure 1b.

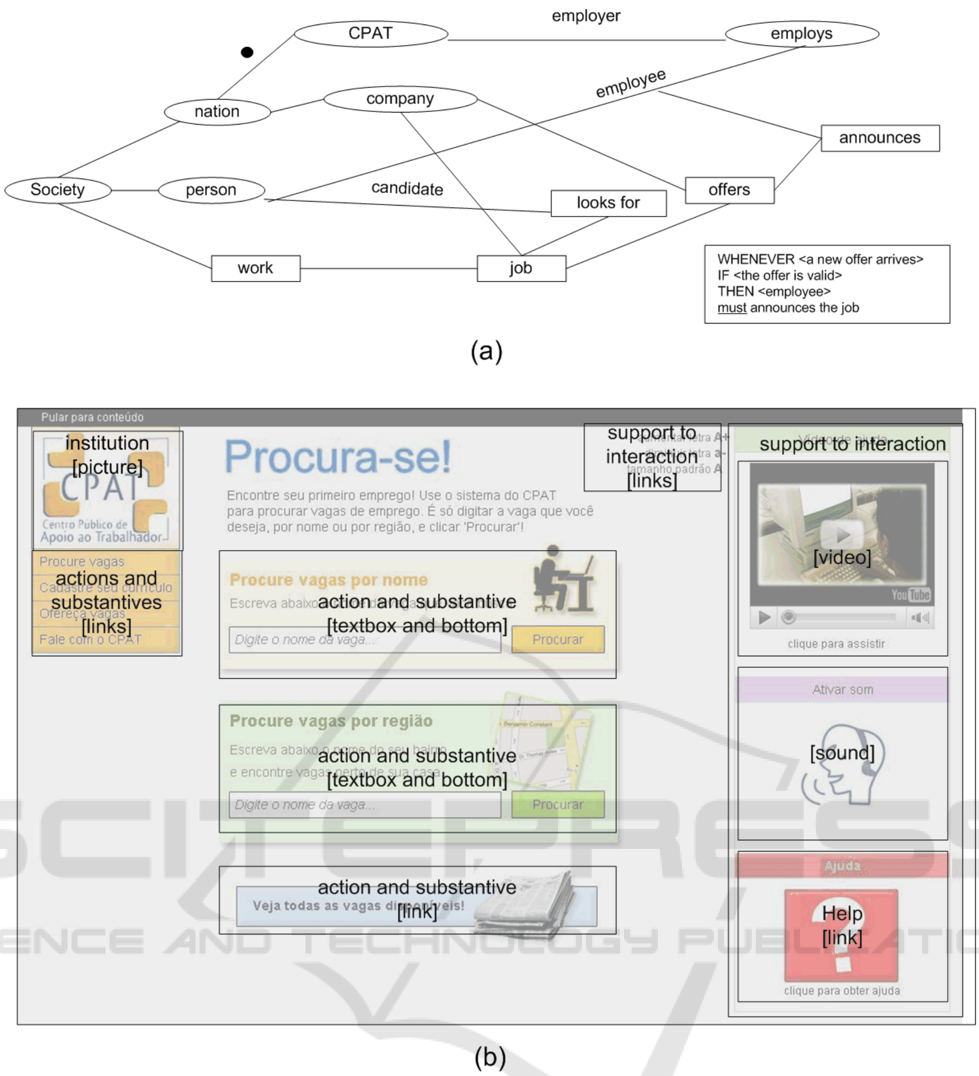

Figure 1: (a) Ontology chart for a job guide domain. (b) Final user interface with main reflected affordances.

3.2 Preliminary Results

From the analysis of the ontology charts and user interfaces, some quantitative data were obtained as summarized in Table 1. Each line in the table represents one of the seven prototypes analyzed. The affordances in the ontology charts and user interfaces were counted considering the criteria expressed in section 3.1.

The first fact that can be observed (and was already expected) is that the quantity of affordances related to the domain in the user interface is smaller than in the ontology chart. As the ontology chart represents a domain, fraction of a reality, the technical system can support only part of the actions that the agents perform. However, in the user interfaces other affordances, not related to the domain, but related to the interface itself, emerge. Figure 1b shows on the right some affordances that were added in the interface to support the interaction itself. They represent actions such as increase the font size, change contrast or play a supportive video or sound. Table 1 considers only affordances related to the domain.

The affordances regarding people are essential to clarify the responsibilities in the domain and support the elicitation of the possible users. Though, they did not appear explicitly in the interface. In most cases, they represent the implicit agent interacting with the system. The only 2 people (traffic agent guide and a clinic attendant) that appear in the interfaces (as

Table 1: Quantity of affordances related to the domain from the ontology chart vs. in the user interface.

Ontology chart				User interface			
people	institutions	actions	substantives	people	institutions	actions	substantives
2	3	5	2	0	1	3	1
2	0	5	3	0	0	3	3
4	2	11	3	1	0	2	3
2	5	6	4	0	0	2	1
4	2	5	4	0	1	4	1
4	4	4	5	1	1	1	2
2	1	6	4	0	1	1	1

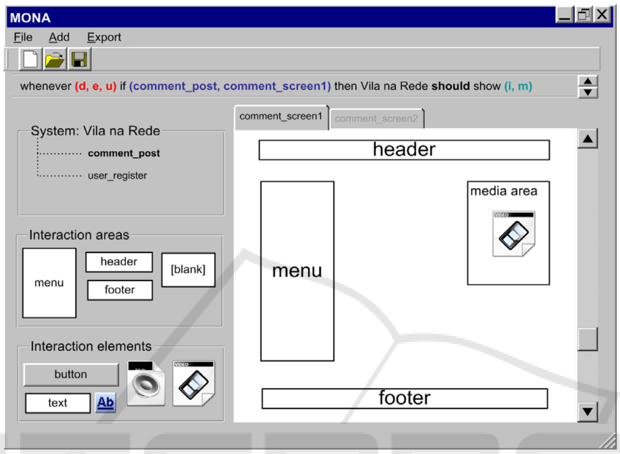

Figure 2: Mock-up of MONA.

pictures) were added to assist the users as elements to activate help options or provide affective support.

Institutions, on the other hand, were represented in the user interface; mostly by their logos and on the left upper position or in the footer. However, the number of institutions represented in the interfaces could have been greater. Some representations for institutions (as the traffic regulatory body or the healthy ministry) were not added by the designers; maybe because it was an academic exercise. In a real life situation, as the services are supported by governmental agencies, their logos should have been placed.

The actions from the domain supported by the system were mostly represented by links and buttons (as look for, announce or comment). Moreover, they were placed on the left hand side or in the middle area (in the case of the main functionality), while the actions related to the interface itself or affective support were mainly placed on the right side. The substantives were generally presented with the actions; therefore on the left hand side or in the middle. While on the left, they were represented by text; but when in the middle, different types of signs were used as icons and symbols, or more specifically diagrams and emblems.

Regarding norms, two main types were specified by designers: perceptual and behavioral norms. The perceptual norms appear directly when thinking about affordances. Each word chosen to form the ontology chart represents how the domain is perceived and in most cases, the same words adopted in the chart were adopted in the interface. However, sometimes designers selected other terms (or even new terms show up), what suggests the need of refining the chart. Thus, UID, supported by information from the domain, not only benefits from the use of significant terms but also helps in the model refinement. This is an observation which corroborates with an incremental process of building the ontology diagram.

Deliberately, designers specified behavioral norms, expressing the conditions and consequences related to the actions presented in the ontology chart. According to the designers, these norms were very supportive to clarify the system functions and assisted the specification of use cases. They commented: "the use cases generation was really immediate, as the two methods [SAM and NAM] helped a lot to understand the problem and the system" and "the ontology chart with norms really helped to specify the use cases, e.g. actions and pre and post-conditions". However, this study did not provide evidences that behavioral norms directly supported decisions in the user interfaces. In addition, further studies may aggregate evaluative and cognitive norms to the investigation.

The preliminary observations suggest that some categories of affordances are represented in the interface by similar types of signs and are grouped in specific areas (e.g. institutions by their logos in the left upper side or in the footer; actions by textual links or buttons in the left side or substantives in the middle by different signs). Moreover, perceptual norms supported design decisions regarding the terms added to the interface. The next section presents a tool to help designers to structure interfaces and to define the behavior of each element using norms. This tool added to an ontology chart builder and NBIC (Bonacin and Baranauskas, 2005) to support the construction of tailorable systems from SAM and NAM.

4 MONA – A NORM MODELER FOR USER INTERFACE

MONA (Portuguese acronym for norm modeler for tailorable interfaces) is a tool that helps designers to structure user interfaces based on the concept of wireframes. It allows the representation of interaction areas and support design consistency through several interfaces. Figure 2 shows a mock-up from MONA's main interface. Designers can specify the system being developed (e.g. Vila na Rede - an inclusive social network system that allows users to share products, services and ideas - http://www.vilanarede.org.br) and the functionalities being represented (e.g. comment_post). Some interaction areas as well as some interaction elements are available to compose the interface in a drag and drop style. The different interfaces for each functionality are drawn in individual tabs (e.g. comment_screen1).

However, only drawings are not enough to represent the diversity of facets a tailorable system may have, hence a more formal approach needs to be adopted. Once more, OS founded the solution and the norm concept was applied. As norms express how agents behave in society, the same structure was adopted to model the behavior of tailorable systems. An instance of the format proposed for behavioral norms is suggested considering context, functionality and interface elements, as follows:

WHENEVER (d, e, u) IF (f, r) THEN <system> IS <deontic operator> TO show ∑(i, m)

where:

d: device, e: environment, u: user
f: functionality, r: representation
i: interface element, m: mode (position, size, shape, color, type, instance)

The context is defined by a *tuple* formed by device, environment and user characteristics. When the condition is satisfied, i.e. the system starts a specific functionality in a specific representation (as the same functionality may have more than one user interface), then the tailorable system must, may or may not show a group of interface elements in a certain mode. The proposed format allows modeling a great variability of changes and designers can specify since simple situations as "every time the application is running on a cell phone, contrast option should be on" to more complex ones involving specific behavior of different interface elements (whenever (Computer, in the office, attendant) if (check appointment, appointment report) then drugstore_system should show [(language style, "formal_semantics.txt"); (logo, Healthy ministry)]. With MONA, designers can specify the behavior of each element by clicking on the interface element and specifying the norm.

It is important to mention that, in OS, the original concept of norms is related to the organization behavior and the structure of behavioral norms requires an agent (affordance with responsibility) as the responsible for the action. The same norm structure was adopted in MONA intending to represent a certain behavior; in this case, the system behavior. The software system is as an agent that will display a set of interface elements in a certain mode. This view considers the system as an active artifact capable of doing tasks in different contexts. However, it is known that the system software is not an agent in the sense OS proposes, since the responsibilities are always associated to the human agents behind the system.

Using MONA, designers start structuring the user interface from scratch. i.e. with no previous support. However, considering the results presented in section 3.2, MONA could support designers considering information from the domain. Figure 3 shows a process which considers 2 other tools as infra-structure: SONAR (Bonacin et al., 2004) and NBIC/ICE (Bonacin and Baranauskas, 2005).

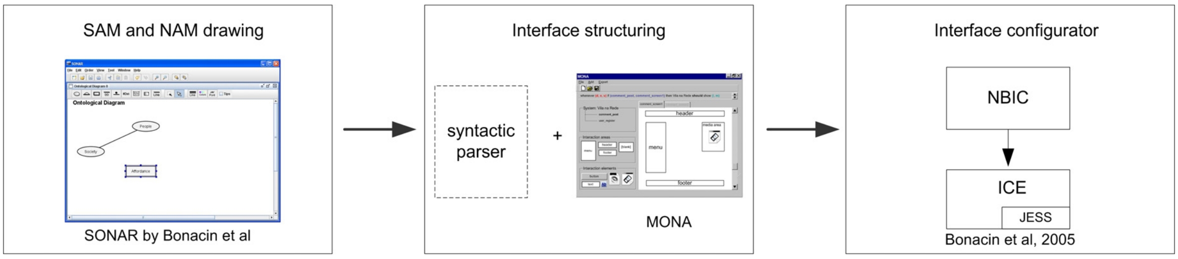

Figure 3: Modules to help designers to consider information from the domain in UID.

SONAR is an ontology chart drawing tool. It allows the specification of affordances, agents, roles, ontological dependencies and the norms related to them. In a drag and drop style, designers can rearrange the elements and may evolve the chart. SONAR also generates initial versions of UML class diagrams from the ontology chart (Bonacin et al., 2004). Adding a syntactic parser to MONA, which may base the affordances classification as verbs and substantives; it could suggest a first structuring for the interface. People and institutions could be directly obtained from the ontology chart.

MONA can export the interface structure and norms expressing the elements behavior in a XML format that can be read by the webservices offered by the NBIC/ICE infra-structure. The NBIC (Norm Based Interface Configurator) receives the norm specification in Deontic logic, manages the norms persistence, and also transforms them into a platform specific language that can be interpreted by an inference machine on ICE (Interface Configuration Environment). Then, the ICE receives context information from the application, evaluates the norms related to context by using the inference machine (JESS – JAVA rule engine) and returns to the tailorable application an action plan with the changes to be done.

As suggested by Figure 3, information from the domain (modeled through SAM and NAM) supports the interface structuring (suggesting interface elements and position and also terms to be used) directly influencing the technical system behavior.

5 CONCLUSIONS

This paper presented preliminary results from an exploratory study about affordances and norms representing the application domain and user interface design decisions. The results suggest that some categories of affordances are represented in the interface by similar types of signs and are placed in specific positions. Moreover, perceptual norms support design decisions regarding which terms may be added to the interface. MONA, a tool to help designers to structure user interfaces and determine the behavior of each element using norms, was presented. Moreover, the interface structuring of a tailorable system was proposed based on information from affordances and norms.

MONA mainly supports interaction designers in their task of representing which are the interface areas and respective interaction elements for a tailorable design solution. MONA allows the interaction designer to specify also the shape of some interface elements when it is already known (e.g. the logo of the site), although this is a task of graphical designers.

As OS artifacts have been successfully used to help several UID activities such as clarifying the design problem, extending the context knowledge, formalizing requirements and evaluating the design solution, this paper advocates a possible support to user interface structuring. Once it was a first approach to investigate how affordances and norms may inform UID, the study does not make any assumption about the quality of the interfaces, which can be assessed in future investigations. Moreover, other types of norms may be studied specially aiming at the elicitation of non-functional requirements and their reflection on the user interfaces.

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