**Chapter 2: Related Work**

In this chapter we will present some definition about the adaptation and the evaluation of user interface. In addition, we will define the context of use in adaptive user interfaces, and we will conclude this chapter by a definition of the evaluation of adaptive user interfaces, the different method of evaluation described in the literature and an overview of existing metrics that will be used to evaluate the adaptive user interface.

* 1. **utility of adaptation:**

Following to the new generation of interaction tools and the multiplicity of sources of information, the problem for users is not how to access to the information rather than how to access to the right information at the right time and in the right way. So to solve this issue, we need to adapt application to user’s perspectives.

The adaptation consists in simplifying the use of the computer systems by presenting to the users information that wish to have and by reducing the complexity of this systems in order to make it more usable (Rouillard, 2008).

According to (Dyche, 2002), adaptation is the abilities of systems to provide services adapted to user’s needs and expectations by using knowledge based on the preferences and behavior of the user at the time of interaction with the system. So adaptive systems has many benefits for users:

* It meets the need of users.
* It improves the interaction between users and the system.
* It enhances the usability of systems by making it more efficient, effective and easy to use.

There are several factors that have influence on the process of adaptation, so (Van Setten, 2001) regroups it into four major factors which are:

* User: it concerns the specific information of users such as: their centers of interest, their preferences, their physical characteristics, their purposes, etc.
* Content: it describes the characteristics and properties of the contents which define the process of adaptation of information.
* Context: Defines the technical environment of system as well as the environment of the user which have an influence on the process of adaptation.
* Method of adaptation: Present the method and the tools used to realize the adaptation which has an influence on the possibilities and the results obtained from this adaptation.

As we are mentioned, the adaptation of user interface depends on the context of use which is considered as one of the major factor which has impact on the adaptation. So it became necessary to define and characterize this notion.

* 1. **The context of use:**

The notion of context is defined in (Dey et al, 2000) and (Dey, 2001):“*The context represents all the information which can be used to characterize a situation or an entity. An entity is a person, a place or an object which is considered as significant at the level of the interaction between the user and the application, by including the user and the application itself there.”*

According to the definition of adaptation proposed by (Ledoux, 2001), the process of adaptation modifies systems to perform adequately in a specific context, which means that it suits perfectly user needs in this context.

(Brossard, 2008) classify the context in the field of interactive application in two level :

* The adaptation of the interface, it is described by the Plasticity. Then, (Thévenin and Coutaz, 1999) define plasticity, by *« the capacity of the interfaces to adapt itself to their context of use in the respect for their use. The context of use defines itself as the triplet the user, the platform and the environment»*
* The content adaptation or *awareness context*. Then, the awareness context is "*The use of the context to supply appropriate information and/or services(departments) to the user; the context was any information which can be used to characterize the situation of an entity which can be a user, an environment, a physical or IT object*".(Abowd *et al.*, 97)

According to (Van Setten, 2001), we can present the context in tree levels:

* An application level: wherein the proposed adaptation can depend on the performance of the adaptive system’s application.
* A technical level: wherein many technical constraints (such as: the used platform of consultation, the networks capacities and technical infrastructure of the application) are considered during the process of adaptation.
* An environmental level: wherein many environmental factors (the physical environment in which the application is used, the place of access to the application and the moment when the application is performed) can impose several constraints on the process of adaptation.

In our work, we consider the context of use as a triplet ***“User, Environment, Platform”***:

* The user represents the person who interacts with the system that can have an impact on the context of use in terms of his needs (Akiki, 2014).
* The platform establishes the set of the material and software resources which the user during the interaction has. Variability in screen size is an example of aspects that simulate the behavior of platform (Akiki, 2014).
* The environment represents the set of objects, people and events which can have an impact on the system, such as distance from display devices that require an adaptation of user interface (Akiki, 2014).

**2.2.1 User Profile:**

Each user has specific characteristics, which may be associated to physical and cognitive factors. So it is fair to say that users are not homogeneous. To highlight these differences, many researchers consider user as the basis of the process of adaptation, and they classify his characteristics to identify their influence in the user’s performance during his interaction with the system.

Thus, the user profile is represented by attributes and functions (such as age, experience, education level, competence.etc.) which describe the supposed person to use the system.

The use profile is collected into five major categories that describe the interaction between user and system, (Bacha et al, 2011):

* Demographic information: include the demographic data of the user which do not chage in time (UMO, 2003), (Kostadinov, 2008) and (Jrad et al, 2007).
* Contact information: contains personal data that can be changed (Rousseau et al, 2004) and (Lin et al, 2007).
* User preferences: contains the preference and the interests of user .Some authors use only the term “preference” ( Kostadinov, 2008), (Preuveneers et al., 2004 ) and (UMO, 2003) while others use the term “interest” (Rousseau, 2008).
* User state: represents the state of user during the interaction with the system. This state may be emotional, physiological (Schmidt et al, 1999) and (UMO, 2003) or an activity practiced by the user (Kim and Choi, 2006).
* User abilities and proficiencies : contains the knowledge, skills and abilities (UMO, 2003)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Categories | Demographic information | Contact information | User preference | User state | User abilities |
| Descriptions | -date of birth  -Gender  -occupations  -affiliations | -the city  -country  -email  -phone number | - preference profiles  -Interest… | -physiologic state  -emotional state  -mental state… | - ability to talk  - ability to see  - ability to hear … |

**Fig 2.1. Concepts of User Profile Dimension**

**2.2.2 Environment:**

This Environment describes all information where the interaction between the user and the platform takes place. Most of the information related to this model are dynamic and can impact the content to be presented.

(Korpipää et al., 2003; Kostadinov, 2008; Arabshianand and Schulzrinne, 2006 and Preuveneers et al., 2004), noted that this dimension is composed of two main categories. The first is “*Location”*, refers to the place where the user is located at the time of interaction with the platform. The second considers the “*time”*, which indicates the moment of interaction with the platform (Arabshianand, 2006; Korpipää et al., 2003 and Hobbs and Pan, 2006).

|  |  |  |  |
| --- | --- | --- | --- |
| Categories | Location | Time | Excremental event |
| Descriptions | -Geometric (GPS)  -Geographic place  -Absolute position  -relative position | -Temporal entity  - Interval  - Duration  -Description | - Sound  - Light  - Temperature values |

**Fig 2.2. Concepts of Environnement dimension.**

**2.2.3 Platform:**

It describes the platform that the user will interact with it .According to (Preuveneers et al., 2004),( Kostadinov, 2008),( FIPA, 2001), (W3C, 2009) and (UsiXML, 2007), the platform include two parts hardware and software:

* The *hardware* represent the physical aspect of the platform and it is composed into four parts (Memory, CPU, Network, User interface) (Taconet and Aoul,2008), (FIPA, 2001) and (Preuveneers et al., 2004)
* The *Software* part defines the software side of the platform and is composed of four subparts ( virtual machine, application system , Operating System, Rendering engine) (Preuveneers et al., 2004).

|  |  |  |
| --- | --- | --- |
| Categories | Hardware | Software |
| Descriptions | -Operating System  -Virtual machine  - Runtime Environment  -Edition, Version | -Memory  -CPU  -Connection  -Keyboard types, network interface, screen size |

**Fig 2.3. Concepts of Platform dimension**

* 1. **. Adaptive User Interface:**

The user interface is the important part of a computerized system; it is the components of software applications which are localized between the user and the system. (Langley, 1999) define the adaptive user interface by the software entity that improves its ability to interact with a user by constructing a user model based on past experience with that user.

The adaptive user interfaces interacts with users in order to reach their needs more easily, faster and with a higher level of satisfaction.

(Faria et al, 2012) classifies the knowledge obtained by an adaptive interface in four distinct domains: knowledge of the user, knowledge of the interaction (modalities of interaction and dialogue management), knowledge of the task/domain and Knowledge of the system characteristics (Norcio and Stanley, 1989).

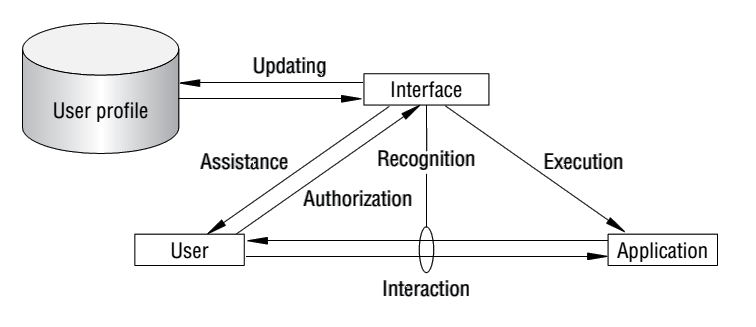
(Wooldridge, 2002) classifies the adaptive user interfaces into three main classes:

* The first class involves the addition of adaptation to an existing direct manipulation interface.
* The second class is established of interfaces which are considered as an intermediary between the user and the interface of direct manipulation while filtering information.
* The third class is composed by the agent interfaces which provide support to the user.

Thus, in the review of state, there are another class of adaptive interfaces which is designated as Programming by Demonstration since it produce commands with arguments (Cypher and Halbert, 1994) (Ross, 2000).

There are different examples of adaptive user interface in the literature, which focus on the task of *information filtering* (Langley, 1999):

* S YSKILL & WEBERT (Pazzani et al, 1996) presents the user with a list of web pages and it encodes each user model as probabilities that calculate the occurrence of certain words that determine if the person likes or dislikes the topic proposed by the search engines. Moreover, it lets the user mark pages as desirable or undesirable, and the system records the  
  marked pages as training data for learning the user’s preferences
* RINGO (Shardanand and Maes, 1995) is an interactive system that recommends movies a person might enjoy, it requires the user to rate a series of sample movies, from which it constructs a simple profile. RINGO then finds other people who have similar profiles to the current user and recommends films that they liked but that the current user has not yet rated.
* FAB (Balabanovic, 1998) retains profiles both for individual users and for topics, and that combines their predictions to give both content-based and collaborative behavior.



**Fig 2.4. A schematic of an adaptive user interface (Liu et al, 2003)**

* 1. **Adaptability/ adaptativity:**

(Jameson, 2003) classifies adaptation into two principal categories which are:

* Adaptation to the environment or also *Plasticity* “*Denote the capacity of system to adapt itself to the material and environmental constraints in the respect for its usability*.”( Thévenin et al, 2003).
* Adaptation to the user profile that can be done in two ways:
* Static adaptation: denote the adaptability of a system that is based on a static model of user which is used to give proposed options for the user.
* Dynamic adaptation: denote the adaptativity of a system that is based on transparent adaptation proposed by the system itself which has the initiative of evolve the behavior of user interface.

The term adaptability refers to the system that is customized by an explicit intervention of the user which can act on the parameters fixed by the designer. In this type of system, the decisions of adaptation are taken by the user because he changes the features of the system. (Brusilovsky and Milán, 2007)

The term adaptativity refers to the system that perform adaptation automatically without intervention of the user. In this type of system, the decisions of adaptation are taken by the system itself. (Brusilovsky and Milán, 2007)

According to (Moisuc, 2007), the adaptability is the capacity of the system to adapt itself to the customizations expressly asked by the user, whereas the adaptativity indicates its capacity to meet the needs of the user without an explicit intervention from him.

**2.5. Evaluation:**

**2.5.1. Definitions of evaluation:**

In this section, we try to present the definition of adaptive user interface evaluation and the set of criteria that are used to evaluate it. Moreover, we going to extract form the literature the set of metrics which are used as the measure of evaluating user interface.

Nowadays, the evaluation of adaptive user interface became a challenge for many researchers who try to develop their own method to evaluate interactive systems based on their context of research .As a result, we find in the review of literature a diversity of definition and method of adaptive user interface evaluation.

(Grislin, 1996) define evaluation as “*a mechanism that verifies if interactive systems correspond to the specifications stemming from the definition of user’s needs. It is validated if it corresponds to needs by respecting the constraints of the field of application; otherwise, its inadequacies with regard to criteria identified in priori must be put in evidence*”.

(Paramythis, 2009) considers that adaptive systems were evaluated using methodologies, techniques and assessment tools intended for general interactive systems. The evaluation of user interface consist to verify whether the user is able to achieve his task using a given communication system.

(Gena and Weibelzahl, 2007) classifies evaluation into two types:

- **Summative evaluation:** this type of evaluation aims at implementing the evaluation approach during the cycle of development of an adaptive system. It is considered as an empirical validation of the final results of the execution of this system.

-**Formative evaluation:** this type of evaluation aims at verifying the choice of conception from the beginning of cycle of development before the real implementation of an adaptive system and to obtain indications to revise the conception during the iterative process of development.

According to (De Jong &Schellens, 1997) the evaluation of adaptive interface can serve three goals:

* Verifying the quality.
* Detecting problems.
* Supporting decisions.

(Senach , 1990) classifies the evaluation of user interface in two dimensions:

* **The utility:** it concerns the functional adequacy by answering the question: the interface does allow the user to reach his goals?
* **The Usability**: it concerns the adequacy of the Human-machine interface by answering the question the interface is it easy to learn and to operate?

These notions establish the pillars of the ergonomically evaluation of user interface.

**Utility**

* **functional ability**
* **system performance**
* **quality assistance**

***Evaluation of user interface***

**Usability**

* **ease of learning**
* **ease of use**
* **quality of documentation**

**Fig 2.6. Evaluation of user interface (Senach, 1990)**

**2.5.2. Criteria of evaluation:**

In this context, (Bastien et al, 1993) present eight ergonomic criteria to evaluate and organize the user interface by measuring their utility and usability.

These different criteria are organized as following:

* **Adaptability** “*refers to its capacity to behave contextually and according to the users ‘needs and preferences*”.

The given interface must be adapted to the potential users to achieve their goal.

* **Consistency** “*Certain aspects of an interface should behave in consistent ways at all times for all screens; terminology, icons, colors… should be consistent between screens or within a screen*”.

(Bastien et al, 1993) indicate that the lack of consistency can increase the search time and cause the rejection of users.

* **Compatibility** “*refers to the match between users‘characteristics (memory, perceptions, customs, skills, age, expectations, etc.) and task characteristics on the one hand, and the organization of the output, input, and dialogue for a given application, on the other hand*”.

The given interface must be presented in a directly usable form to enchance the best performance of system.

* **Error Management** “*refers to the means available to prevent or reduce errors and to recover from them when they occur. Errors are defined in this context as invalid data entry, invalid format for data entry, incorrect command syntax, etc*”.

The given interface must increase the number of interruption which have a negative impact on user’s tasks.

* **Explicit Control** “*concerns both the system processing of explicit user actions, and the control users have on the processing of their actions by the system”.*

The given interface will be better if user can have control on it during the interaction.

* **Guidance** *“refers to the means available to advise, orient, inform, instruct, and guide the users throughout their interactions with a computer (messages, alarms, labels, etc.), including from a lexical point of view”.*

The given interface must have a good guidance to facilitate the interaction between user and system and to lead the better performance.

* **Workload** *“concerns all interface elements that play a role in the reduction of the users‘ perceptual or cognitive load and in the increase of the dialogue efficiency”.*

The given interface must have a less level of density to let user accomplish their goal efficiently because the higher level of density causes the higher probability of errors.

* **Significance of Codes** *“qualifies the relationship between a term and/or a sign and its reference. Codes and names are significant to the users when there is a strong semantic relationship between such codes and the items or actions they refer to”.*

The given interface must have a meaningful code to be easier in use.

**2.5.3. Method of evaluation:**

In this section, we present an overview of methods that can be used to evaluate adaptive user interface and to provide a reviews that modify the adaptation of this user interface.

(Gena, 2005) presents a classification of evaluation methods as following:

* **Collection of user’s opinions:** that gathers a several method that are used to extract a qualitative and quantitative information from the real user of adaptive user interface in order to evaluate the success of user interface’s adaptations. This methods are :
  + Interview: that collect user’s experience, opinions such as their satisfaction with the adaptive user interface and it’s considered as qualitative information.
* Questionnaires: Those arrange information for user by collecting knowledge from user and the used adaptive user interface.
* **Observing and monitoring usage:** that gathers a several method that collects information from usage of adaptive interface and to analyze it in qualitatively and quantitatively manner:
* The systematic observations: this method used to quantifying the user’s behavior in a real context.
* Logging use: it aims to analyze quantitatively the log files that are considered like a register of all the actions of users during their accomplishing task.
* User Observations: it is characterized by the direct and indirect observations of users during their usage of user interface. It is considered like a qualitative method.
* Verbal protocol: it aims to record the reactions of user when they accomplish a task in experimental sessions.
* **Predictive evaluation:** That gathers a several method that predicts the usability of adaptive user interface from models or specifications.
* Expert review: it is an evaluation method that considers experts like a less experienced user. It aims to identify the usability issues of adaptive user interface.
* Heuristic evaluation: it is an evaluation method that invites users to examine the adaptive user interface in order to extract problems from it.
* Parallel design: it consist on exploring different solutions for adaptive system proposed by several designers before implementing the further proposal.
* Cognitive walkthroughs: it is an evaluation method in which an evaluator proposes task scenarios then play the role of user.

**2.5.4. Overview of evaluation metrics:**

Usually, many researchers use a set of metrics, which may be adopted in their own research, to evaluate user interface.

The set of metrics that we are going to consider are proposed by (Ngo et al, 2000), (Vanderdonckt and Gillo, 1994), (Shneidermanand et al.1994), (Perlman, 1987), (Hartmann et al, 2005) and (Miyoshi.al, 2001).

* (Hartmann et al, 2005) proposed several metrics of aesthetic attributes these are used to enhance the visual balance of an initial label layout through an efficient real-time optimization process (Buanga, 2011).
* (Perlman, 1987) proposed an “axiomatic model” of information layout for alphanumeric displays (Buanga, 2011).
* (Shneidermanet al.1994) proposed thirteen metrics for checking the consistency of a graphical user interface. He works with General Electric Information Services and a group of researchers at the University of Maryland to generated a set of 40 metrics (Buanga, 2011).
* (Vanderdonckt and Gillo, 1994) proposed thirteen visual techniques grouped in five categories (Physical, Composition, Association and dissociation, Ordering, Photographic techniques) to help designers to classify elements of layout in such a way that it is visually attractive (Buanga, 2011).
* (Ngo et al, 2000) proposed fourteen metrics presented in his works (e.g. (Ngo et al., 2000); (Ngo and Byrne, 2001) and (Ngo, Teo and Byrne, 2003)) in which we focus our studies. Ngo proposed initially four metrics (Ngo et al. 2000), (Balance, Equilibrium, Symmetry and Sequence) and he try to evaluate them in an empirical study to prove if these metrics correlate with users’ perception of aesthetics. Then he extended his measure to fourteen (balance, cohesion, density, economy, equilibrium, homogeneity, order and complexity, proportion, regularity, rhythm, sequence, simplicity, symmetry, unity) (Purchase, 2011).
* (Miyoshi et al, 2001) who consider that in GUI design, the measure of complexity of screen layout is achieved by size, local density, grouping and alignment which are influenced on the screen usability. (Fu et al, 2007).

We have just placed our work in the context of the adaptation of the adaptive interfaces by using metrics of quality quoted to develop metrics adaptable to the user interfaces adapted to realize the evaluation of these interfaces.

**2.6. Conclusion:**

In this chapter, we introduce the review of literature to define the adaptation and evaluation of adaptive user interface.

First, we present the definition of context of use in the field of adaptation by describing the user profile, platform, environment .Then we indicate the concept of adaptive user interface by presenting a example of it occurred in several reference .Moreover, we determine the comparison between adaptativity and adaptability. Then, we define the notion of evaluation presenting in the literature by determining the criteria of evaluation used to evaluate user interface. Finally, we present asset of metrics used to measure the utility and usability of user interface.

In the next chapter, we will discuss the set of metrics adaptive to our study. Moreover, we will describe the process of evaluation by defining the rule evaluation form and to present the meta-heuristic approach that will be used to evaluate a set of adaptive interfaces.