The State of Art in Website Usability Evaluation Methods

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Chapter 15
The State of Art in Website Usability Evaluation Methods

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ABSTRACT

Measuring the usability of the website is a key metrics which all designers always tries to maximize. Compared to other software it is very difficult to estimate the website usability as each website has many objective and wide range of visitor with different learnability. The objective of this study is summarizing different approaches used to measure the usability of website. The current study includes the different approaches proposed in literature in last two decades. Approaches are classified in six broad categories and a comparison between them is done. Trends in web usability of evaluation approaches are understood in light of changing needs of website.

INTRODUCTION

Designing a technology or any system it is always a demand to consider capabilities and characteristics of the person who are going to use it. A lot of research had been carried out to study how to improve the interaction of human (Saeed & Bajwa 2014) with the system. These studies are categorized under different heads namely User Centered Systems Design, User Experience, User-Centered Design, Interaction Design and Human–Computer Interaction. Websites are platform which bring the world to the organization. Designing a user centric website that will provide the easy retrieval of information available on the website is a big challenge. Usability studies are related to designing and measuring the user satisfaction of the system. The website has a wide range of visitors and understanding their needs and designing a system satisfying the requirement can be interpreted in term of usability of website.

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Usability is one of the key metrics used to identify the extent to which a computer system enables users to achieve the intended goals in effective and efficient manner for a given context. The prime objective is that to measure the level of satisfaction user feels using the system. Usability evaluation (UE) for any software consists of methodologies for measuring the usability aspects of a system's user interface (UI) and identifying specific problems. The website is designed with an objective to let the information move to the all possible end user. Thus usability study is key indication to the success of e-presence of the organization.

A wide variety of Usability Evaluation Method (UEM) are proposed in literature. 250 research paper of different journals of repute and conference paper were reviewed to investigate these approaches. A number of research paper focus of understanding the usability concept and used existing approaches in evaluating the website. Several papers discussed the factors (Saeed et. al. (2013), Saeed & Shabbir (2014), Hasan (2009)) affecting the usability of website. these studies range on websites for different sectors. Need of website may differ and hence the factor and evaluation approach may also differ. Approximately 90 research papers are considered in this study of which mostly discuss on the new approaches for usability evaluation of website. The focus of the study is on understanding various methods used to evaluate the usability of the website.

Before discussing them in detail in section 2 a brief introduction to various definitions and standards are discussed. In section3 approaches proposed in literature are discussed. These approaches are broadly classified in six categories namely evaluator based, user based, tool based, model based, MCDM approaches and soft computing approaches which are further clubbed as subjective and objective approach. Subjective approach focused mainly on the judgement of the people which van be an expert, end user, developer, manager etc. These approaches centers on the human judgment and hence uncertainty and collecting the data is a major concern. Objective approach focuses on collecting the crisp value and applying different models available. Subjective approach is usually performed manually where computer aided software is used to evaluate the task performed by the human evaluators. Objective approach usually is automated where tools are used evaluation and experts are used for interpreting the result. In section 4 comparative analysis of these approaches is done and need of combined approach is justified. In section 5 the syudy is concluded and future scope for the UEM''s is discussed.

BACK GROUND OF WEBSITE USABILITY

A large number of researchers proposes a wide range of definitions of usability and standards.

Definition of Usability

The fundamental of any website design is usability or "ease of use". Nielsen (1993) defines usability in terms of five characteristics:

- Learnability
- Efficiency
- Memorability
- Errors
- Satisfaction.

Rosson and Carroll (2002) identified three more perspectives that add to the definitions of usability (Ballard (2010):

- Human performance, time and errors
- Human cognition, mental models of plans and actions.
- Collaboration, group dynamics and workplace context.

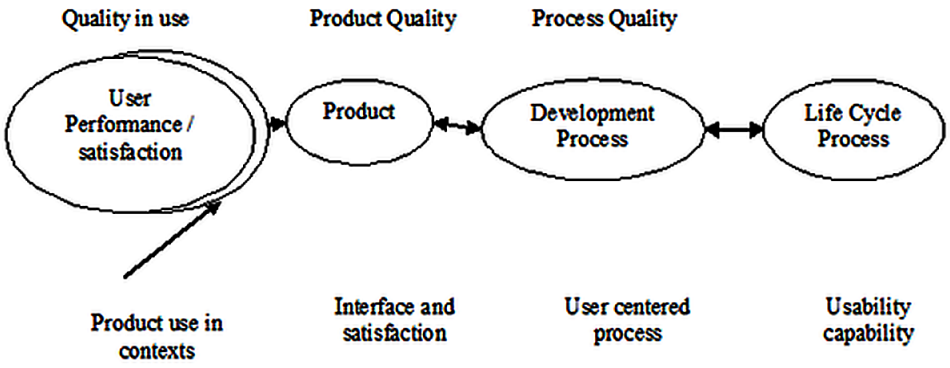
Some of the popular definitions of usability that exists in literature are:

Bevan et. al. (1991) defines usability as "the ease of use and acceptability of a product for a particular class of users carrying out specific tasks in a specific environment". As per Nielsen (1993) usability is "a part of usefulness that is a part of practical acceptability and, finally, a part of system acceptability". Preece (1994) defined usability as "a measure of the ease with which a system can be learned or used". According to Redish (1995) "Usability means that the people who use the product, can do so quickly and easily to accomplish their own tasks". Brinck et al. (2002), usability is defined as "the degree to which people (users) can perform a set of required tasks". As per Rosson and Carroll (2001) usability is "the quality of a system with respect to ease of learning, ease of use, and user satisfaction". Abran et. al. (2003) defined usability as "The capability of the software product to be understood, learned, used and attractive to the user, when used under specified conditions." According to Krug (2005) "Usability is making sure that something works well: that a person of average (or even below average) ability and experience can use the thing – whether it's a website, a fighter jet, or a revolving door – for its intended purpose without getting hopelessly frustrated." The standard models for understanding the website are given are given in the following section.

Usability Related Standards

Standards for usability and Human Computer Interaction (HCI) are developed under International Organization for Standardization (ISO) and International Electrotechnical Commission (IEC). ISO and IEC standards related to usability is categorized by Bevan (2001) in Figure 1:

Figure 1. Categories of usability standards



- Quality in use
- Product quality
- Process quality
- Organizational capability

According to ISO/IEC 9126 (1991), standard usability refers to "the capability of the software product to be understood, learned, used and attractive to the user, when used under specified conditions." ISO 9241-11 (1998) defines usability as "the extent to which a product can be used by specific users to achieve specified goals with effectiveness, efficiency, and satisfaction in specified context of use". This definition of usability does not imply necessarily of user interaction with the system and can be measured at early stage of development. ISO/IEC 25010 (2011), a quality model which replaces the previous standard ISO 9126-1, uses the same definition as ISO 9241-11: "The extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use". This quality model also includes a broader concept of quality in use: "The degree to which a product used by specific users meets their needs to achieve specific goals with effectiveness, efficiency, safety and satisfaction in specific contexts of use" (Bevan, 2010). "The ease with which a user can learn to operate, prepare inputs for, and interpret outputs of a system or component." (IEEE Std.610.12-1990). These definitions and models helps one to judge the website, but for better understanding these websites should be evaluated. As website has multiple dimensions, it can be evaluated in numerous ways. More than thirty approaches were studied and grouped into four categories, discussed in the subsequent section.

USABILITY EVALUATION METHOD (UEM)

The different definition of usability impacts various aspects of usability and the historical transition of interface from Command Line (CLI) to Graphical User (GUI). This transition raised the usability and accessibility problems which forced the researchers for developing UEM's for the friendly system. Websites are presently the backbone of any business to exchange information and present products and services. Success or failure of these websites depends on the user satisfaction level. Website usability evaluation, if performed at the designing stage can improve the quality of the site, but the website designers hardly do it because of perceived high cost. To deal with the arduous task of developing more usable websites, varieties of UEM's and tools exists to gather interaction of end-user with the software product. There is no universally accepted categorization of UEM's. Different authors classify UEM's in various categories. Ivory (2001), Fernandez et. al. (2011) classify UEM's into five general categories: Testing (evaluator observes how a user completes its task), Inspection (evaluator uses certain set of guidelines to inspect the user interface), Inquiry (Feedback on the interface is provided via user interviews, observations, etc.), Analytical modeling (different models are used for predicting usability) and Simulation (Simulation algorithm used to mimic and report the user interaction with the interface). Mack and Nielsen (1994) categorized usability into four groups: Automatic (Software evaluates the usability of the interface), Empirical (Interface is tested with real users), Formal-usage of models for evaluating user interface, Informal (thumb rules, experience for measuring the usability). UEM's are classified into three categories by Hasan (2009) as Evaluator based, User based and Tool based. In the current study,

UEM's are classified into majorly six categories based on Evaluator, User, Tool, Model, Multi Criteria Decision Making (MCDM) and Soft Computing as discussed in the following section.

Evaluator Based Usability Evaluation Method

Usability problems in a interface are identified by the set of evaluators and improvisation is done based on the evaluators feedback. These methods are known as Evaluator based UEM's (Mack and Nielsen (1994).

Heuristic Evaluation

Usability is evaluated by the experts and identifies the problem in the user interface based on compliance with well-defined usability principles known as "heuristics". The list of heuristics given by Mack and Nielsen (1994) are:

- Visibility of system status
- Match between system and the real world
- User control and freedom
- Consistency and standards
- Error Prevention
- Recognition rather than recall
- Flexibility and Efficiency of use
- Aesthetic and Minimalist design
- Helps users recognize, diagnose and recover from errors.
- Help and documentation

All the above mentioned heuristics are critically analyzed in the literature. Later on, these heuristics are modified for websites and given by Nielsen (2000) known as HOMERUN i.e. "highly quality content, often updated, minimal download time, ease of use, relevant to users' needs, unique to the online medium and adhering to net-centric corporate culture". In literature, many heuristics guidelines are tailored as per market research, new research findings and design guidelines (Kostaras & Xenos, 2007; Sharp et. al., 2007; Hasan, 2009; Hasan, 2013; Torrente et. al., 2013; Cheng & Mustafa, 2014; Yáñez Gómez et al., 2014).

Pluralistic Walkthrough

In this UEM, the interface is inspected by the group of evaluators which includes users, designers and evaluators (usability experts), to perform the set of tasks for presenting the new idea about the interface. Five major characteristics of pluralistic walkthrough is given below:

1. It involves users, designers and usability experts in same walkthrough session as participants.
2. The interface of the screen is presented in the form of hardcopy panels and presented to evaluators in the similar order as it would be submitted on the web.
3. The participants will assume themselves as users.

4. As per the task for each screen, the participants provide their feedback in detail.
5. The solution is discussed by the group on their opinions.

The benefit in performing the pluralistic walkthrough is that it provides the feedback even before developing the complete interface resulting "on-the-fly" (rapid iteration) design as it involves the direct users (Hollingsed & Novick, 2007). The downside of this method is that because of time constraints only a few scenarios and their corresponding paths can be investigated (Hollingsed & Novick, 2007); Hasan, 2009). This method is still popular for evaluating usability which involves users walkthrough without experts involvement.

Cognitive Walkthrough

The Cognitive walkthrough is a task specific UEM to predict the usability issues. This method evaluates the ease with the user can perform the task without formal instructions (Wharton et. al., 1994). Designers and developers of the software evaluate the interface step-by-step "walking through" to accomplish specified tasks. For each step, the team of evaluators tried to find the response to the question given by (Wharton et. al., 1994) (Table 1). Cognitive Walkthrough was studied by multiple authors and many improved versions were discussed in the literature and adapted in different domains (Mahatody et. al., 2010).

Sears (1997) combined benefits of two inspection method i.e., cognitive walkthrough and Heuristic Evaluation based on prioritization of task and obtained results are analysed to inspect any aspect of the system. Streamlined Cognitive Walkthrough (SCW): Spencer (2000) proposed SCW that divides the usability evaluation into five phases starting from the input--role definition of team member and do's and don'ts for evaluators--inspection-recording problems--fixation of problems identified. Cognitive Walkthrough for Web (CWW) (Blackmon et. Al., 2002), Kitajima, 2006) detects and fix errors that comes while browsing the information on the website. Users surf the web page with an objective in his mind which consists of choosing (i.e. clicking on a link) and assessing the output as a goal.

Other methods that are available in the literature are The Norman Cognitive Walkthrough Method (Rizzo et. al., 1997) (high level interaction problem are addressed), Groupware Walkthrough (complexities of team work) (Pinelle & Gutwin, 2002), Activity Walkthrough (aim to include context and history of use) (Bertelsen, 2004), Interaction Walkthrough (Ryu & Monk, 2004) (low level interaction), Cognitive Walkthrough with Users (end users involved for evaluating interactive systems), Extended Cognitive Walkthrough (identifying the problems regarding accessibility and usability), Distributed Cognitive Walkthrough (communication between personages, artefact, and information across dimensions such as time, space, and social structures), and Enhanced Cognitive Walkthrough (confirms whether the as-

Table 1. Questionnaires

Will the user try to achieve the right effect?
Will the user notice that the correct action is available?
Will the user associate the correct action with the effect that user is trying to achieve?
If the correct action is performed, will the user see that progress is being made toward the solution of the task?

sumed user's generated goal and prior knowledge directs to the subsequent correct action). Cognitive Walkthrough helps to classify the usability problems quickly as the design is specified. The main aim of all the cognitive approach is to prepare goals, suitable actions to achieve goals, correct interpretation of system responses, and accomplishment of targets.

Guideline Reviews

This method is analogous to Heuristic Evaluation Method with a difference that this UEM contains long detailed guidelines as compared to the short list available with heuristic evaluators. This process may take a longer time to review an interface and hence not preferred as compared to heuristic evaluation (Hasan, 2009).

Consistency Inspections

In consistency inspections, evaluators ensure the consistency across the interface so that design is reliable regarding functions, design, and color. Before developing the product, the consistency inspection is being performed so that users' performance and satisfaction can be increased (Lazar (2005)).

Standard Inspections

As per the other interface standards followed in the same market, experts examine the compliance of an interface. The expert who is familiar with the formal language, written in the standards is usually taken for inspection (Hasan, 2009).

User Based Usability Evaluation Method

User based UEM's involves the users for evaluating an interface and records their performance while interacting with it. Some user based UEM's are mentioned below:

User Testing

According to Dumas and Redish (1999), the user testing method is "a well-organized way of inspecting actual users trying out a product and collecting information about the specific ways in which the product is easy or difficult for them".

Think Aloud

Participants are asked to "think aloud" and say whatever comes to their mind while performing the set of tasks. Evaluators can analyze the thought process of the participants about an interface and helps to identify mistaken belief of the users. For library catalogue, Van Den Haak et.al.(2003) categories think aloud protocol into concurrent, and retrospective think aloud method for usability test regarding detected usability problems, the overall performance of a task, and participant experiences. The major limitation of think aloud method is that while collecting data user can behave unusually in the presence of data collection equipment (Hasan, 2009).

Question Asking Protocol

Question Asking Protocol is another user testing method in UEM's where the user is directly interrogated by the evaluator about an interface so that user thought process can be well understood Ivory (2001).

Co-Discovery Learning

Co-discovery Learning is an extension of Think Aloud method where instead of a single user, two or more users interact with the user interface to complete their task. As the number of users is large, more comments can be obtained from the users Holzinger (2005). The limitation as compared to think aloud method is the cost of incorporating more users Van den Haak et. al. (2004).

Retrospective Testing

In Retrospective Testing, the responses from the user are analyzed while watching their recorded video sessions. Users can add their comments while reviewing their sessions (Nielsen, 1993; Ivory, 2001; Lazar, 2005). More information can be gained from the user with a limitation of additional cost and long duration for conducting this test.

Questionnaires and Interviews

This method is used to analyze the user's subjective satisfaction with the interface (Ivory, 2001). It can only be used to collect information regarding the user's opinion about an interface but user actual behavior cannot be analyzed which always has priority over the opinion (Holzinger, 2005; Hasan, 2009; Saeed et. al., 2013). The response rate for the questionnaire distributed is usually low (Bidgoli, 2004) and conducting the interview is a time-consuming process. This method is an indirect method of evaluating usability and cannot be used alone.

Focus Groups

A focus group is a meeting of a group of usually six to nine users wherein users are asked to give their opinion related to the interface. The users are free to discuss his opinion with other group members, and evaluator plays the role of the moderator discussing predefined issues and collects the information required. It can provide the information regarding the problem with the interface but can't analyze the direct user interaction with the system (Ivory, 2001; Hasan, 2009).

Barefoot Approach

"Software development practitioners are instructed to drive usability evaluations" (Bruun & Stage, 2015). Earlier some of the studies has tried to include software developers' practitioners in usability evaluation without giving them formal training, raising the awareness for usability issues. In Barefoot approach, the software practitioners who have little or no knowledge about the usability evaluations are trained to analyze and fix the usability issues (Bruun & Stage, 2015).

Crowd Sourcing Approach

"End users are given minimalist training to enable them to drive usability evaluations" Bruun & Stage (2015). In this method, the usability experts and the users are separated.

Tool Based Usability Evaluation Method

Software tools are used to evaluate the usability of an interface instead of employing users or experts. Some of the methods are listed in the following sections.

Automatic

In automatic evaluation, tools analyze whether an interface complies the usability set standards. It verifies quality of HTML code in compliance with the guidelines. Website Analysis and Measurement Inventory(WAMMI) (Kirakowski, J et. al., 1998; Chiew & Salim, 2003) is a website evaluation tool based on the questionnaire filled by the user of the website. It helps to analyze the website based on five critical parameters i.e., Attractiveness, Control, efficiency, Helpfulness and Learnability. Other tools available today for assessing the usability of the website is OpenHallway that records usability sessions and recorded sessions can be evaluated remotely by the evaluators, ClickHeat is an open source software tool for observing the click pattern of actual users. Google Analytics is a free usability testing tool to identify behavior, trends, and issues which includes user sessions, visits, page views.

Web Analytics

Usability issues are measured by collecting and analyzing the usage data in different logs using different software packages (Web Mining). Web Mining has been vastly used to uncover the knowledge of web documents and services. It is broadly divided into three categories: Web content mining used for mining the information present on the site, Web structure Mining that helps in improving the design of the website by finding the useful pages and associating important page links to it and Web usage mining which mines the patterns of usage of the website. The data used for it are the logs of the client server transaction and are available in the server log, referral log, agent logs and client side cookies. These patterns are also mapped with the user profiles to predict the user behavior Srivastava et. al. (2000).

Log files, as the data source for web analytics has a major limitation regarding usage of caching techniques and IP address to recognize unique visitors (Kaushik, 2007; Hasan et. al., 2013). To cover this limitation page tagging methods i.e. java script code is added to web pages to collect user statistics over the extended period of time. The accuracy of this method is more as it is based on cookies to identify the unique visitors. One of the popular tools that use page tagging approach that has an impact on Google industry is Google Analytics(GA) (Fang, 2007; Hasan et. al., 2013).

Remote Testing

In Remote testing, the users and the testers are at different locations. This method is applied in conjunction with log analysis (Fernandez et. al., 2011).

Analytical Modelling

Analytical modeling employs users and models to predict usability issues of Human Interaction with the interface while completing a task. Examples of Analytical Model are: GOMS, WUSAB, GLEAN (Atterer et. al., 2006; Atterer, 2008).

GOMS Approach

Card et. al (1983) proposes an approach GOMS (Goals, Operators, Methods and Selection rules) and is defined as "model that describes essential interactions that users have with a user interface while completing tasks to reach a goal." Depending on the complexity of a "goal", it is divided into sub-goals. To achieve the goals, the model consists of "operators" that are applied by the user on a perceptual, subjective or motor-act level which can lead to internal and external changes. Execution times are bound to these operators to predict the overall interaction time. To achieve goals, "Methods" describe sequencing of operators. Depending on the task, "Selection rules" are applied if more than one method exists representing the user's knowledge, Task analysis must be performed to identify the goals. GOMS method represents the procedural aspects of usability. The variety of GOMS models are available For e.g. Keystroke Level Model (KLM) for modeling human performance by "predicting the execution time taken by the user to perform a specified task" Card et. al.(1980), Davis (2010). GOMS Language Evaluation and Analysis(GLEAN) Application of GOMS model is automated by GLEAN, which takes the model as an input. GLEAN predicts "how long user takes to perform the task to complete a goal."Other methods are: Critical-Path Method GOMS (CPM-GOMS), Natural GOMS Language (NGOMSL) (John & Kieras, 1996; Davis, 2010).

Web Usability (WUSAB)

WUSAB is an approach that "tests conformance of interfaces to Web pages with prerequisite" (Atterer et. al., 2006; Atterer 2008). WUSAB permits any of the different existing layouts to arrange contents as accepted by the validator. With the development of the web application, WUSAB compares the actual characteristics of the web application with the existing one and report the inconsistencies and also alerts the developer with any tricky change in the application. It inspects models, and logs produced and the HTML code of the web application.

Programmable User Model (PUM)

PUM is based on a problem-solving model for navigating problem spaces. PUM deals with "knowledge needed by the user" i.e. the knowledge the user should have for interacting with the interface and also with respect to given interface predicting the behavior of given users (Butterworth et. al., 1997).

Metrics for Usability Standard in Computing (MUSic)

Macleod et.al. (1997) develops a model for measuring the efficiency and effectiveness of a software system at National Physical Laboratory(NPL), UK for measuring the qualitative and quantitative data.

It is based on the observation that while using the system how user achieves the task objective, and performs a task while using the system.

Software Usability Measurement Inventory (SUMI)

To measure the quality of the software system as per user's point of view Kirakowski & Corbett (1993) develops SUMI as a part of MUSiC Project at University College Cork Software Usability Measurement Inventory. The standardized set of internationally structured 50-item questionnaire available in the different language is given to the user to answer according to whether they "Agree, Don't Know or Disagree".

Diagnostic Recorder for Usability Measurement (DRUM)

Macleod & Rengger (1993) within MUSiC project develops a software tool, DRUM, for usability evaluation at NPL, UK to meet the requirement of the user in an effective, efficient and satisfying manner. Video recorded session is used for usability evaluation increasing the speed of analysis and automating the activity to the extent possible. Log Processor processes the log in the database and evaluates the performance based usability metrics like task time, snag, effectiveness, efficiency, relative efficiency and productive period. The results are saved in the database numerically and graphically for further analysis and used by designers for usability defects.

Multi Criteria Decision Making Based Usability Evaluation Method

Multi-Criteria Decision making (MCDM) is a process of making decision by choosing the best alternative involving multiple criteria and defined Zardari et.al.(2015) "The study of methods and procedures that incorporates the multiple and conflicting criteria into the decision process." Multi-Criteria Decision Analysis (MCDA), Multi-Attribute Decision making (MADM), Multi-Objective Decision Making (MODM), and Multi-Dimensions Decision Making (MDDM) are the alternate terms used for MCDM. Researchers commonly employs MCDM approaches as they are considered to be a transparent approach. A systematic algorithm is framed to enhance the objectivity and accuracy of results. The ranking obtained has shown a reasonable level of satisfaction and hence, MCDM approaches are considered as an integral part of Decision Support system. However, Mutikanga (2012) has identified considerable criticism to MCDM. The majority of various MCDM method provides the contrary conclusions for the same dataset. Thus, selecting a suitable MCDM method or combining two approaches that produce trade-off between the good performance of criteria and poor performance of other criteria. In literature, there exists several MCDM methods, the most famous among them are summarized by Velasquez and Hester (2013).

Analytic Hierarchy Process (AHP)

Saaty (1990) (2008) defines AHP as "a theory of measurement through pairwise comparisons and relies on the judgments of experts to derive priority scales". AHP uses pairwise comparisons to compare different alternatives available on criteria to estimate the criteria weights.

Elimination EtChoix Traduisant la REalite (ELECTRE)

Roy (1991) gives a MCDM approach which helps experts to take vagueness and ambiguity while making the decisions.

Preference Ranking Organization Method for Enrichment Evaluations (PROMETHEE)

PROMETHEE is one of the MCDM approach similar to ELECTRE. PROMTHEEE was given by Brans et. al (1984) for partial and complete ranking of the alternatives and with time, the iterations of this method have improved.

Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS)

One of the most popular MCDM approach given by Hwang et. al. (1993). It is defined as (Qin, 2008) "an approach to identify an alternative which is closest to the ideal solution and farthest to the negative ideal solution in a multi-dimensional computing space".

Multi-Attribute Utility Theory (MAUT)

MAUT (Peter C. Fishburn, 1967; Dyer et.al., 2005) deals with the problems having the considerable amount of uncertainty and risks. Utility is assigned to each possible consequence, thus calculating the best possible utility.

Analytic Network Process (ANP)

According to Saaty (2001) ANP is "generalization of AHP" and is considered as network structure for better handling of interdependence and feedback. It uses network relations for evaluating the interrelationship between the criteria and decision levels.

Goal Programming (GP)

Goal programming is one of the oldest MCDM technique. The main objective of GP is to covert Multiple objectives into a single goal. Multiple objective goals are optimized, minimizing the divergence for each of the objectives from the desired target (Orumie U.C. & Ebong, D., 2014).

Simple Additive Weighting (SAW)

SAW is defined by Qin et. al. (2008) as "a value function is established based on a simple addition of scores that represent the goal achievement under each criterion, multiplied by the particular weights".

Case-based Reasoning (CBR)

CBR uses prior experience for solving the case/problem (Aamodt & Plaza, 1994). CBR uses a cyclic process to solve a problem. Solution to a problem is given by "retrieving" similar experienced case / cases, "reusing the information / knowledge, "revising the solution and "retaining" it for the future use.

Grey Theory

Grey Theory given by Julong (1989) focuses on problems having the small sample size and inadequate information. It deals with uncertain structure with incomplete information through producing, excavating and selecting valuable information from what is available (Liu et. al., 2012).

Data Envelopment Analysis (DEA)

Relative efficiencies of comparable units are measured with multiple inputs and outputs (Charnes et. al., 1978). DEA is based on Linear Programming model. It also helps to analyze the cost and resource savings when an inefficient unit is transformed into an efficient one.

Best-Worst Method (BWM)

Rezaei (2015) developed a new MCDM method known as BWM. The aim of this method is to select the best alternative amongst given set of options. It produces more reliable results with less number of comparisons as in AHP.

Soft Computing Approaches Based Usability Evaluation Method

According to Lofti Zadeh (1994), Soft computing is a "collection of methodologies that aim to exploit the tolerance for imprecision, uncertainty, and partial truth to achieve tractability, robustness, and low solution cost". When compared with Hard Computing, Soft Computing deals with approximation giving the solution to complex problems. The computational effort, time and cost required in a traditional approach can be replaced by replacing with soft computing approach without affecting the solution (Cabrera et. al., 2009). The main components of Soft Computing Approach are "Fuzzy Logic, Probabilistic Reasoning, Neural Computing and Genetic Algorithms" sharing common features and are complementary rather than competitive and can be combined in models offering the solution to more complex problems. The most popular combined approach is neuro fuzzy systems employing the combination of Neural Network and Fuzzy.

Artificial Neural Network (ANN)

Information processing system that models human brain to perform task much faster as compared to traditional systems. According to Caudill (1987), simplest definition of a neural network, more properly referred to as an artificial' neural network (ANN), is "...a computing system made up of a number of simple, highly interconnected processing elements, which process information by their dynamic state response to external inputs".

ANN learns by example. Large number of units/nodes/neurons operating in parallel having their own internal (activation) state are connected via connection link associated with weights. The connection links contain the information about input signal as shown in Figure 2. X1 and X2 are input neurons connected to another Y neuron over weighted connection link W1 and W2 with x1 and x2 as output of input signals. Finally, output y can be applied by applying activation function to the net input.

Neuro Fuzzy Hybrid System

A hybrid intelligent system is given by Jang (1993) that combines the advantage of fuzzy systems (natural language description) and Neural Network (learning properties) with explicit and implicit knowledge respectively. It utilizes learning and training algorithms from neural network with human like reasoning style of fuzzy system to find parameters (fuzzy sets, rules, etc.) (Nagpal et. al., 2013).

Neuro Fuzzy system is generally represented by three layers i.e., first second and third, feed forward neural network model that corresponds to input variables, fuzzy rules and output values respectively as shown in Figure 3.

Fuzzy MCDM

There may be circumstances where decision support system may not work effectively because of inadequate information, thus usage of expert system becomes necessitate. Expert system can give satisfactory solution processing uncertainty of different kinds. Fuzzy theory is best solution for this purpose which can deal with uncertainty, vagueness and also with large quantity of information (Zimmermann, 2012). There may be a situation in which the goal or attribute cannot be defined within set of boundaries. Classical MCDM approach cannot be applied in such situation as they are suitable to handle the problems having well defined set of boundaries i.e. crisp values (Kahraman, 2008). The presence of vagueness in a MCDM problem will definitely increase the complexity because of the computational effort involve to rank different alternatives. In literature Bellman & Zadeh (1970); Zimmerman (1978) dealt with such complex problems, there has been successful application of fuzzy set theory in MCDM problems known

Figure 2. Artificial neural network

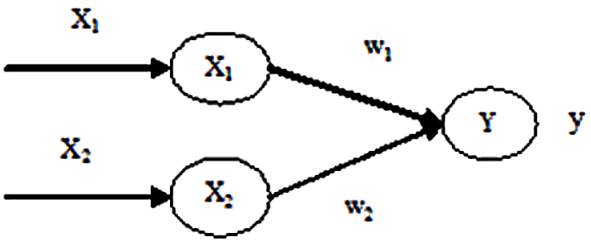
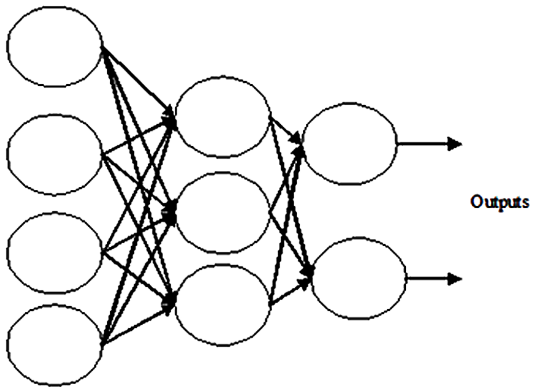


Figure 3. General Architecture of neuro fuzzy hybrids



as fuzzy MCDM. In fuzzy MCDM approach, one or more DM's assess different alternatives (Nagpal et. al., 2015) with respect to predetermined criteria, where weights of the criteria is evaluated using linguistic values represented by fuzzy numbers.

COMPARATIVE STUDY

Figure 4 represents the number of paper referred for each UEM's. It is clear from the figure that Expert based evaluation UEM is the most preferred approach. Now in recent years, the trend is changing and evaluators have started using the MCDM approach for usability evaluation. In MCDM approach, the complex problems are solved by taking the feedback from the decision maker (DM) who can be an expert or a user.

The comparative analysis all six approaches in done. A brief discussion of each with their advantage and disadvantages are given in Table 2.

UEM's are broadly grouped into two categories Subjective Method and Objective Method. Subjective Approach includes user's perception to view and understand website. The expertise of Decision Makers (DM's) is considered as input to assign subjective importance. Uncertainty and Biasness of DM's is one of the major weakness of subjective approach. Objective Approach uses mathematical models and tools to evaluate the crisp values. Objective methods do not include user's perception, which is one of the major drawback of this approach. Usually authors have adopted subjective or objective approach but we feel that with combined approach, a new model can be designed which can give better insight to the picture Figure 5.

Figure 4. Graphical representation of papers distribution for UEM's

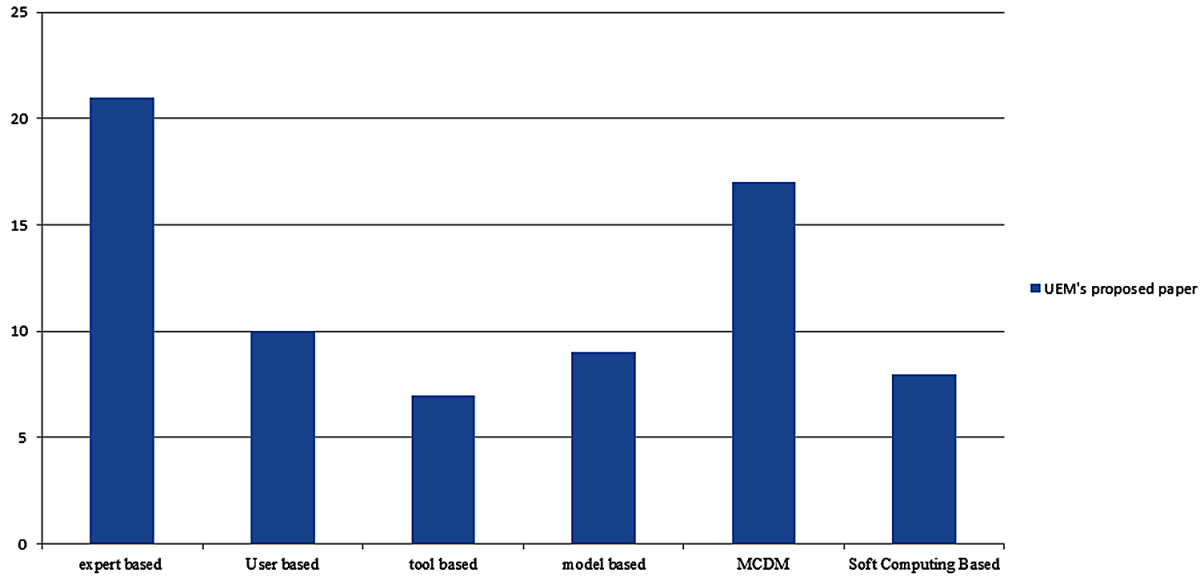
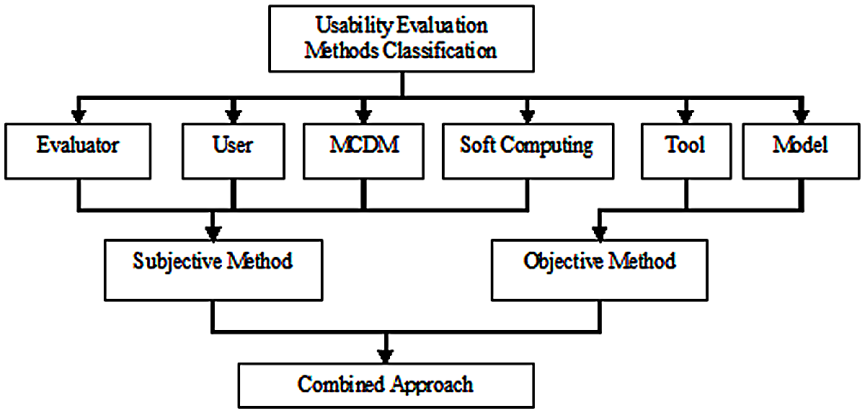


Table 2. Comparative analysis of different UEM's

UEM	Description	Advantages	Disadvantages
Evaluator Based	Experts of usability make the assessment	Can be performed iteratively and anytime throughout the development process, Less cost.	reliance on expertise of the evaluators, usability problems identified is more towards interface features rather than task performance i.e." usefulness".
User based	Assessment of the interface is done by the actual users	Exploring the user's interaction directly, collects firsthand information about the usability problems and user preferences.	The feedback of the user may get influenced by the group activity thus actual behavior of the users cannot be determined. The issues related to representation of information in the system is not addressed. Cost of conducting the experiments is high.
Tool Based	Automatic calculation of the required metrics	Easy to use, multiple users at different locations	Different tools are required to measure different metrics
Model Based	Formal methods are employed for the prediction of criteria of user performance	Usability criteria can be accurately estimated	User testing required to unfold the critical issues.
MCDM based	Decision makers' preference is required to distinguish between alternatives.	Consider uncertainty; handles large scale problems with multiple alternatives	Interdependence of criteria and alternatives leads to rank reversal.
Soft Computing Based	Provides solution to imprecise problems	Consider uncertainty and vagueness; nonlinear problems are solved	Crisp values cannot be attain

Figure 5. Classification of usability evaluation methods



CONCLUSION

This study focus on finding the different evaluation method that are currently in practice in domain of web usability. Each approach has its own advantages and disadvantages and hence proving any one of them to be most effective is not justified. Currently the websites are dynamic so evaluating website should be a continuous process. Hybrid approaches evaluates the metrics of the system including the user preference giving better results as compared to This chapter presented the concepts about Usability Evaluation Methods and factors affecting the usability. Researchers have identified large number of factors, some of

them are common to generic model of website and some are specific for a given website. Usability being a multi criteria problem, MCDM approaches can be suitably used for predicting the usability. Various MCDM approaches are discussed in detail with advantages, disadvantages and their application area. MCDM approaches relies majorly on subjective measures. To overcome the uncertainty of the subjective measure, the fuzzy approach is combined with MCDM approaches and are discussed in detail.

Usability is a measure of the interactive user experience associated with a user interface, with the website. A lot of approach is available in the literature to measure how user friendly interface of website is design with respect to easy-to-learn, supports users' tasks and goals efficiently and effectively, and is satisfying and engaging to use. Analysis of usability provides an insight of User Experience that helps to recommend the website designer how and where to re-design the interface in order to improve its level of interaction and user satisfaction.

Evaluating the usability of website is crucial for their success of an organization and in current scenario the website applications are very dynamic and complex contain a large variety of information, allow huge amount of information exchange there by making speed and security a critical factor for making people use it. People today want to use the web applications on mobile phones making the designing it more challenging. Further as per business need the organizations are changing their website designs very frequently, in, so developers can learn how to adapt them considering the dynamicity of current scenarios. Thus the future evaluation approach should focus on different requirements when judging those applications, such as objective metrics (quantitative data), subjective evaluation (users' impressions). An attempt should be made design a single methodology that be take a look on both of them. Also this approach should support the environmental change (e.g. hardware platform device used, software platform) The model should automatically monitor and collect objective data and also collect users' and expert feedback and analyse it. Future approach should be centred around Figure 5 for holistic evaluation.

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