The Alterations of Development in Human Computer Interaction

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Abstract

Design methodologies in Human-Computer Interaction (HCI) differ from their various design perspectives and circumstances. Several methodologies have carried out in HCI design and their role of activities are distinct. For user-centric interaction and user interface design, the methodologies indicated to holistic manner. Modern technologies have grown faster and the user connections with modern equipment have comprised brightly. In HCI the methodologies are user concerned, depended on task, user values and experiences. The methodologies are set of process, logical approaches, and instructions which follow in developments. The broadly used HCI design methods, models or approaches are Activity Theory (AT), User-Centered Design (UCD), Value Sensitive Design (VSD) and the Mental Model applied on interaction design. The modern aspects of technology have switched into extensive digital phenomena as touch and sensor-based technology from GUI and Physical user interfaces into Natural user interfaces. In this paper has been analyzed the existing design methodologies in HCI and extended advanced and simultaneous conceptual approach which referred to as future HCI design approach for next-generation application design.

Keywords: Interaction Design, Human Computer Interaction, AT, VSD, User Interface Design, UCD

1. Introduction

The computing technology has spread its applications into each and every technology, and the modern computing technology was begun whereas Microsoft Windows and Apple's Macintosh were revealed their professional and neoteric Operating Systems (OS). Although, not indicated the foremost operating systems, nevertheless advanced and simultaneous technologies in that era. In fact, different approaches and design elements have been tried in both experimental and commercial operating systems [1]. An operating system is a prominent criterion in computing technology being visual, graphical and operational user interactions agency on computer technology. Besides operating system, user interactions in computer technology argument several grounds principally Graphical User Interface (GUI) and User Interface (UI). Generally, an Interaction occurs with a system through virtually and physically with interaction medium. Considering that a UI is highly dependent on technology (platform or devices like smartphone, personal computer, etc.) [2]. These interfaces are most existent interaction mediums in modern computer technology. The GUI established interactions with the user through graphical menus, icons and other visible elements are displayed on computer screen. GUI systems' security, robustness, and usability are improved once they are tested for correctness [3]. The User Interface (UI) is merely criteria for constitutes interaction with computing technology, which could be graphical or physical user interfaces. For physical user interfaces such as mouse and keyboard are the most wide-spread interfaces. Recent developments in HCI are tracing priority form conventional interactions into Natural user interfaces (NUI), notable speech and gesture-based interactions. The natural interaction with computer supports a mix of real and virtual objects [4]. The user interface is most emergent research field in HCI consisting multidisciplinary field; it studies including computer science, media studies, ergonomics, behavioral science, psychology etc. Various methods, criteria, approaches, and principles exist in HCI and its applications have been discussed in the following sections. The key concern of this research is to analyze the development and alterations of existing HCI design methods and approaches and extended a conceptual approach for future application design in HCI.

Following sections have covered with related works as, the analysis of existing HCI design methods, model or approaches, principles and the interaction design approaches for the future applications, analysis, and discussion. The paper ends by pointing out the limitations and future works for further study.

2. Related Works

Numerous research conducted in HCI, few approaches have referred to their significance. For Activity Theory a research stated, activities are not static or rigid entities; they are under continuous change and development. The historical analysis of the development often needed to understand the current situation. Activities are longer-term formations and typically consist of several steps or phases. In HCI it's difficult for the formation of new operations, sense-making, and creation of new actions. [5]. Within HCI the highest level of contextualization is usually the task level and in the research designed computer interface by Activity Theory in a Usability Laboratory at Wollongong

University based on participants of war conflict. The interfaces used time-dependent maps to enable inquiries to follow up the progress of individual participants in the conflict [6]. This research has drawn an elaboration of activity theoretical HCI, particularly Human-Artifact Model intended current and future artifacts and provided on understanding interaction with multi-layered technology and dialectical. Exemplified the use of activity theoretical tools in Human-Artifact Model and iterative framework based on the future cases [7]. The avail of Activity Theory in HCI research created a taxonomy of five different ways as follows [8]:

- Analyzing unique features, principles, and problematic aspects of the theory.
- Identifying domain-specific requirements for new theoretical tools.
- Developing new conceptual accounts of issues in the field of HCI.
- Guiding and supporting empirical analyses of HCI phenomena.
- Providing new design illustrations, claims, and guidelines.

The User-Centered Design (UCD) process is widely practiced method in HCI. This book stated the UCD called User-Centered System Design (UCSD) as well and drawn a basic research in anthropology, sociology, information science, human-computer interaction, computer supported cooperative work, computer-mediated communication, user experience (UX), and ubiquitous/pervasive computing. The confusing of HCI is interface design and considerably broader and while HCI draws insights from the foundations of interfaces design (design sciences and graphics). The roots of HCI lie in the social sciences [9]. In addition, for user-centered system design HCI applies on website design which should be user-friendly to maximize user response. Herein, the user commands something by using keyboard or mouse, this activity is 'Interaction' and the Interface is the visible piece of a system that users see, hear and touch. If the usability is not highlighted in website design then users become frustrated with it [10]. The multidisciplinary team employment is important principles of UCD process. The research concerned positive influences of several aspects of the organizational context of UCD activities which linked that applied the concept of UCD to organizational theory. Moreover, the research found a holistic measure of UCD project success [11]. In HCI the interactions are different for various aspects. Past few years the interaction motives are far improved on the Tablet computer interactions and Multi-touch interfaces, etc. From GUI to multi-touch and speech to gestures have different interaction methods [12], and the design methodologies are varied from their perspectives.

Value Sensitive Design (VSD) is a method that accounts values of people who used the technology directly. This method may convey significant role after the AT and UCD approaches. When HCI was matured it's concerned the human values, and 'human values' indicated on a broad term. Defined "what a person or group consider important in life", and applied conceptual, empirical and technical investigations. Furthermore, VSD addresses design issues, necessarily involved differences in perspectives and in power [13]. This illustration goes in designing information and computational systems that support ensuring human values. Supporting human values through system design has emerged within four important approaches; *Computer Ethics*, *Social Informatics*, *CSCW,* and the *Participatory Design* [14]. VSD referred as a methodological framework to uncover what is important to people in design. The research was the connection between theory and the practice of VSD [15]. Moreover, VSD method considered as a constructive tool for the future design in HCI education and technology [16], and VSD still pressing few questions that need to be addressed for future work.

In Human-Computer Interaction the Mental Model plays a key role while designing interactions and interfaces as well. The intimation of the modern mental model was in 1970's and 'Philip N. Johnson-Laird' is one of the pioneer researchers in this area. The three key points of the mental model are, set of possibilities, iconic mental models and description represent [17]. For interaction design the human mental model vs system image divided into four types of gaps and the gaps are between user's mental model and the underlying system model, individuals must be balanced with the needs of a group, a person must be protected from oneself, and different conflicting design goals require making compromises. In many situations, interaction designer would like to control user mental model of the system [18]. People build an individual mental model for each object including technology, suggested, to studying users mental model need several approaches as, Interviews, Focus group, Coaching methods, Field observation, Question-asking protocol and Contextual inquiry [19]. Several methods consist for examining and changing mental model, the group learning plays an effective role in developing. This research conducted based on various styles of the mental model, also stated scenario planning is a tool for shifting mental model [20]. In the complex system for the people who control, the mental model is increasingly important. Several approaches exist for enhancing decision making of subjects in a complex system [21]. The mental model allows human to interact with a system, and the system model holds significance in mental model context. This research explained that an Agent has a mental model since it has a mind and mind consist mental model as well model concerns a system [22].

3. HCI and Its Design Perspectives

Human (user) interact with a system with diverse ways; Desktop applications, Portable and Tablet computers, Computer kiosks and Graphical user interfaces, etc. In computer technology relied on variant interactions media such as Graphical Interface, Voice over Interface, Haptic Interface, Gesture Recognition, and Hardware Interfaces. Interaction design in HCI is not young, instead of the classic problem that addressed in academic design principles. HCI methodologies are aimed to reduce complexity in some way, but the not simple task to reduce the design complexity. Moreover entirely time and energy

consuming approaches. Design practice in HCI as *Ultimate Particular*, the meaning of the two words is the design should be unique which could exist in one or maybe few examples. The measure of the successful interaction design is the quality of the outcomes [23]. Human-computer interaction design User Profile is the most important resource to trace user characters. The user data as the mental model, physical and demographic of user characteristics. The significance of the user data in interaction design is to recognize the real user and their attributes which supports the interaction designer. User profile has been differentiated into few categories such as 1). Age Difference, 2). Gender Difference, 3). Culture Difference, and 4). User Expertise [24].

Above categories played an important role during HCI design process for various design perspectives in interaction design. In HCI design human Mental Model is a widely used approach to realize the human psychology on a system. The concept of the mental model has been leading earlier 2000's. The mental model has created by the user as they interact with target system or system images [25]. The interaction design commenced on difficulties due to different users consist of a different mental model. According to the research of 'Bingjun Xi' et al., a mental model has five characteristics as follows:

- Incompleteness
- Vague Boundaries
- Being Unstable Over Time
- Contained Aspects of Superstitions
- Tendency to Parsimony

Various ways established to detect user mental model, one is sharing mental model between an individual and team members [26], it helps to recognize user mental model on a system. In HCI for Information Visualization Mental model defined as functional analog representation to an external interactive visualization system [27].

The AT theory is a wide-spread method that exercising in HCI design. It contains six elements as, Subject, Object/Outcome, Community, Rules, Labor, and Tools. The interaction between Subject, Object, and Community indicates importance due to leading elements, and the other interactions are Tools, Labor, and Rules [28]. For example, an interaction designer creates a computer application, where require a physical object (e.g., computer), needs community (e.g., groups/designers) and needs tools (e.g., software). By collecting and admitting all the essential elements a system builds successfully. Another significant method discussed shortly is UCD. This method or process holds several stages are pursuing during HCI development and the stages as follows:

- User Context
- User Requirements
- Design Solutions
- Evaluation

UCD concerned and focused on the usability of the product that satisfies the real user and defines how to meets user requirements. In UCD also consists of few principles as, User involvement, Iterative process, User experiences and User-centered evaluation [29]. Hence, the Value sensitive design (VSD) method plays to investigate the user values on technology. The VSD approach goes through conceptual, empirical and technical investigations to understand and identify the real user values on technology which carried out during the applications of VSD approach [30]. The mental model is referring to an individual mental model rather than a shared mental model. HCI described as the effect of how a person acts with existing experiences [31].

Table 1. Comparison among all the leading HCI design methods

Methods/Process	Role of activities
Activity Theory (AT)	Object Oriented of an Entire Activity System
User-Centered Design (UCD)	Focused on User Needs and Requirements
Value Sensitive Design (VSD)	User Values of Direct and Indirect Stakeholders
Mental Model	Focused on User Mental Assumptions

Table1 illustrated different approaches and comparison among all the leading HCI design methodologies with their role of activities in interaction design.

4. Future HCI Design Approaches

Existing HCI methods employed on a specific area as, user-centered, object-oriented, and values. Although entire existing HCI methods are exercising for many years. Several researchers claim certain methods have limitation and contradiction during development and occasionally decline to meets the user demand.
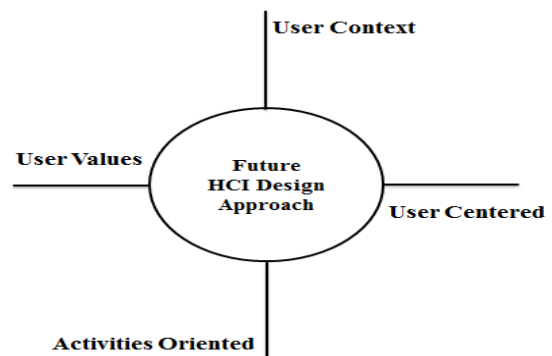

Fig. 1. Conceptual Future HCI design approaches

The conceptual HCI design approaches has revealed in fig 1. The approaches are four stages or terms that coined the development process in HCI. The terms are:

- '*User Context*' is the first stage which consist whole context of the user explanations and

demands of the user on advanced computer technology.

- '*User Centered*' is the second and earlier stage which exists in UCD methods as well. After analyzed and gathered data from user context the user centered stage follows up the process is user centered or not.
- '*Activities Oriented*' this stage or term performs through assuring the whole activities by ensuring each specific activities of the process are admits during HCI development procedure.
- '*User Values*' is the fourth and existing terms in VSD method as well. User values have interpreted the artifact from HCI design which indicated and favor user expectations on technology.

Therefore, the future HCI design approach is acts as sequential activity and the approaches begin from '*User Context*' stage and ends with '*User Values*'.

5. Analysis and Discussion

We observed AT is an object-oriented approach which differs from other HCI methods, UCD process is user-centered process or a framework, VSD investigated the user values or specific affairs and the Mental Model holds on the visualization of the human desire on technology. Moreover, the HCI methods act on a specific phenomenon in particular. In the proposed future HCI design approaches have four stages which move sequentially to meets the every stage activity. The sequence of the approaches as following:

User Context

⇩

User Centered

⇩

Activities Oriented

⇩
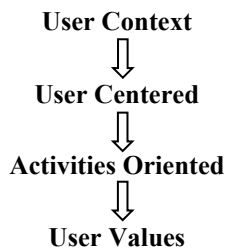
User Values

Being sequential activity, the proposed conceptual approaches in mathematical form should as follows. Let's consider the terms in the proposed approaches orderly as User Context = a_p, User Centered = a_q, Activities Oriented = a_r and User Values = a_s.

$$a_n = n\text{th element} \tag{1}$$

$$a_n = a_1 + a_2 + a_3 + \ldots\ldots + a_{n-1} + a_n \tag{2}$$

$$a_n = a_p + a_q + a_r + a_s \tag{3}$$

The sequence formula with sigma notation:

$$\sum_{n=p}^{s} a_n \tag{4}$$

$$\sum_{n=p}^{s} a_n = a_p + a_q + a_r + a_s \tag{5}$$

$$= a_{pqrs} \tag{6}$$

$$\sum_{n=p}^{s} a_n = a_{pqrs} \tag{7}$$

Equation (1) defined as the nth term as a_n = n elements. The expression (2) is a general formula for finite numbers besides, (3) is a series of $a_p + \ldots + a_s$ finite numbers (four elements or terms consisting in the proposed approach). The Greek letter Σ sigma stated as 's=sum', it uses for sequencing finite and infinite numbers. Equation (4) defined as 'sigma notation' or 'summation notation' for a number of series, where n represents the index of summation, a_n is an indexed variable in the term and $n=p$ is lower bound of summation which starts from and s is upper bound summation with the end. Expression (5) represents four numbers of series which is the sequence activities in the proposed HCI design approaches. Finally, the (6) represents entire internal values and the expression (7) has exposed the successful summation with sigma notation which demonstrated the entire terms have been followed in the HCI design through an order. Herein, the symbols a_p, a_q, a_r, and a_s instead of the four elements or terms in the proposed HCI design approach for leading out the activities with particular form.

The process moves in order to justify the prior stages or terms are ensure the respective activities as well as the whole approaches for future HCI design. The approach maintains the leading convictions which secure the development of future HCI application design aspect.

Conclusion and Future Work

The HCI design methods, principles, and approaches are aimed to design the interaction and interface. The usability of the interactions and interfaces goes through evaluation phases to ensure the efficiency and effectiveness of the artifacts. In addition, the terms interaction and interface design have been used in the research due to HCI emphasis both of the design perspective. We analyzed the existing HCI methods or approaches and their role of activities during development of, Activity Theory, User Centered Design, Value Sensitive Design, and Mental Model. Illustrated HCI methodologies activities and actions are indicated on a specific criterion which is the foundation of the respective HCI methods. The analysis demonstrated different methods aimed at different concepts and all HCI methods are not acting for identical perspectives. This research elaborated design thinking in human-computer interaction and the conceptual HCI design approach which is based on the advanced future design aspects that exist fundamental design principles. The limitation of the study is finite time. To evaluate efficiency and usability of methods or approaches is a long process. In a short manner, this is highly troublesome to experiment with the design approaches in the HCI ground.

This research is not the ultimate solution in HCI design area. In the future work will be carried out the activities for further development and the experiment on a real example by applying the conceptual design approach.

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