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The Usability of HCI in Smart Home

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Abstract - *User interface is recent widely used to control and communicate with domestic appliances this can be by mobile apps, web apps and social media websites. Homes can be furnished by intelligent lighting, Heating, ventilation, and air conditioning (HVAC), theater, and security systems etc, as well as machines with many advanced features. We reach the new generation in the home industry, the generation of smart homes. Interface plays vital role in mobile apps as well, and it became very common nowadays, but still face some challenges. The involvement of HCI in user interface design has an increasingly significant impact in building an effective smart home. In this paper, we present mobile app principles design for smart home in terms of usability and attract more users. We believe that such design principles will be highly used and attractive for recent and future smart homes.*

Key Words*: *Smart Home, Human-Computer Interaction, Human- Computer Interface, Usability, Design.

1. INTRODUCTION

Smart home as the name suggests are intended for the safety, comfort and entertainment of the family or the people living in "smart home" thus making their lives less complex. According to Oxford Dictionaries (2014) [1] Smart Home is "a home that equipped with lighting, heating and electronic devices that can be controlled completely by smartphone or computer". The big challenge is usability issue-duty of an installer is to make simple and easily understandable system so that everyone finds it user-friendly. Smart home design approach of usability of HCI is important in the development of mobile app design in the connected home. Several interactive home products like video recorders, washing machines, and heating controllers are misused or under used because they are difficult to understand and operate. The development of connected products and online services has the potential for even greater complexity and problems for the domestic user [2]. It should also be remembered that in a domestic setting, users are often in a relaxed mode and do not want to spend long periods of time reading handbooks and trying to understand complex consumer products. A user-centered approach in smart home system helps to apply principles of interface design for mobile to home systems to ensure that they can be used by people with a wide range of characteristics and abilities [3]. User testing of prototype systems can be either in a controlled laboratory setting or within field trials to identify problems, with feedback to the design team.

High-tech communication systems within homes involve issues surrounding the nature, function and design of human computer interaction and these have become increasingly complex [4]. As machine-aided tasks become a part of our everyday lives, it is essential for Human-Computer Interface (HCI) designs to be integrative, effective and efficient. From an ergonomics perspective, it is essential to take a human-focused approach to design of user mobile interfaces, so that the system is intuitive, reliable and easy to use for the end user. For the user, an interface is the means by which a user interacts with the software to gain information or to perform the task [5]. In order to achieve good mobile design, the user population, characteristics, requirements of the system as well as the system design itself (i.e. hardware and software functionality) must be outlined. When an interface is poorly designed this could cause frustration for the user, increased risk of making errors, hence decreased satisfaction and maybe a minimal use of the software functions due to the inability to navigate through the system. Ultimately this leads to rejection of the system completely [6]. Good HCI design should allow the system to operate in a flexible and accommodating manner, without causing conflict amongst different users. It is essential to identify the users of the smart home as the user population will affect the specifications of the equipment and interfaces. Our aim from this paper to present the principles of mobile design interface that support the usability, comfortable, convenient design. For this purpose, we also propose suitable check list can be used for heuristic usability and evaluations. We aspire from this study to provide highly usable design according to AI in the future work.

The paper is organized as follows. Section 2 describes the literature review. Section 3 presents the principles of mobile user interface used for smart home. Sections 4 proposed chick list. Sections 5 and 6 present conclusions and future work respectively.

2. LITERATURE RIVIEW

Augmented reality frame work [7] for mobile app connected with allocated cameras in every home place, this technology gives the application 3D actions as it works. For example, when the light is needed to switch on by the user, real button on the wall will be given by the camera as virtual image, the user has to touch on mobile screen for lighting the rooms. This framework has a lot of advantages for supporting usability so, a lot of user training is not needed. Such

application can inform user the actual response from any appliance in real time without need any movement from user. The proposed frame work doesn't have consideration of safety awareness in case of any mistakes of actions. On other hand emotions buttons are proposed to be ignored by the application which keep the happens of user while talking some actions, in some case the real buttons on the wall doesn't and any emotional feedbacks. Getting visual image for any action before trigger is more time consuming. The system lack of any habitually learning of historical actions and This concept still under development.

The interface proposed named NISHA [8] is powerful of supporting usability and has many considerations of usability design for future smart home, such model can be implement and deployed on mobile devices and can be full controlled by touch buttons on small machines, the interactive communications can be supported by these features between user and all appliances that allocated at home. The proposed frame work considers many usability principles such as 3D presentation of devices provides great convenience, flexibility, and immersive visualization to users this Design of a touch screen interface, combination of voice and touch, Virtual Reality technology and provide historic methods of capture and evaluate usability but it's lack important issues such as virtual interaction and responding time, Voice recognition Problems, and assumption of one hand using.
Usability methods proposed by[9]provide and negotiate many principles design for mobile interface used in smart home such as easy to learn, effective interface, virtual test, safety and stability, consistency, habit, concision, emotions, assist through multiple ways and humanity but they neglect other principles of usability physical visualization for example if user control some appliances on other rooms how the feeling transform back to him. They don't describe how habit should be considered on such applications, for example habit can be converted to actions and stored for used later by artificial Intelligent models.

The research of [10] IoT (Internet of things) field which proposed to examine allowing technologies, interacting protocols, structural design and application issues it analyses IoT as a multifaceted situation resultant from the interaction of different areas such as telecommunications, computer science, electronics, etc., then, the Service Oriented Architecture is presented (SOA) for the IoT middleware and describe the allowing technologies provided at that time, finally, the responsiveness is put to the capabilities available by IoT for the implementing the applications in a diversity of fields, such as transport, healthcare, smart environments (including the home), personal and social domain. Also, a summary is provided of the greatest related protocols and application problems, by offering research studies to show how the diverse protocols grouped to provide required IoT services, they also explain the relation between IoT and other starting technologies such as big data and cloud computing. This proposal doesn't take the consideration tools and user interfaces precisely concerned with to end users, which means that the proposal doesn't have any HCI perception conversed in them.

[11] the greatest significant features to the users is offered by the outcomes of the research, like the interesting needs, interactions with the appliances in the home, simple administrate for regular habits, intervallic change of habits and removal of out-of-date rules, availability of different interfaces and AI features, possibly adapted depending on user's needs.

[12] design strategies is presented by the proposed for latest smart home using voice recognition. However, this work have no experiential or heuristic evaluations of these strategies.
The researcher in [13] noted that there is a bad use of simple electronic devices before the arrival of smart home systems market. This makes the researcher focuses on the most important aspects of usability in the appliance that communicated with smart home mobile design.

The Work in [14] focused on the fact that all usability problems are centered around the interface used in intelligent home systems and described and explained of the design approach suitable for designing a suitable interface for the user of smart home systems.

The effort on [15] adopted on aspects related to the appropriateness and usefulness of using smart homes for the elderly. So, [16] provided workable guidance to usability estimate in the smart home and described differentiates between ease of use and joy of use and, the importance aspects of usability was explained by the study such as, consistency, transparency, obtrusiveness, personalization, robustness, Absence of barriers, adequacy to multiple users, robustness of the input and interaction logic.

The research in [17] discussed usability principles for interface design and suggest a new framework for the HCI participation in smart homes, which is the concept of augmented reality. This concept still under development. Despite the importance of smart home mobile application usability, there is a lack of an agreed-upon list of guidelines. In this regard, the best way to evaluate the usability of mobile applications is through usability testing.

3. USABILITY PRINCIPLES AND EVALUATION METHODS

A. Emotional Design

The UI mobile design should meet the users' emotional satisfaction from side to side when controlling appliances such as exploration, accepting, thinking, updating, waiting for response, virtual visions, processing, rollbacks and excitement for helping users perceptive efficiency and support the usability of interface[9].

B. Responsive facilities

Most reliable mobile apps recently have responsive layouts provided form google martial design libraries or apple design this API's that is for user suitable in usability and inclusion in the events.

C. IoT Communications

The UI mobile design should consider Internet of things capabilities so, this technology administrates appliances requests such as updates, refresh, fill items, install, adapt, control remotely. User should notify about these appliance statuses so, UI design should be confederations of these issues.

D. Voice Recognition Technology

Sound capture quality to promote voice recognition according to the diversity of the ambient contexts via the integration of embedded microphones, sensors and echo cancellation devices (to compensate the user's position, the acoustic of the habitat and the presence of background noise). Interaction mode and multimodality conceive the vocal interaction in complementarity with the other existing modalities to favor a wealth of control and feedbacks (vocal, visual, remote control), propose vocal interactions favoring free speech.

E. User feedback

Encourage a relatively fast response time (between the order and the return to the user) favor the presence of an indicator light or a voice response confirming receipt of the touched command, integrate transparency of sources used for requests for information and miscellaneous referral services.

F. Adaptability

Ensure interface design of the system adaptation from the integration of the users with the appliance, through the order to inform the user about progress.

G. Confidentiality and security

Ensure confidentiality of the data collected and stored on a protected server, favor multi-user use (profiles, access rights), enable the control, and modification of his personal data and make visible the data collected by the system.

H. System Control

Include the ability for users to keep or regain control of the system in the event of a malfunction or preference. It can be the separation, the unstructured interaction or a forecast of automations according to the level of control of the system. Above all, it is a matter of informing users continuously, early or instantly about system status changes via a system of alerts and relevant notifications.

I. Customization

Provide the ability to modify the sources used for information retrieval and referral services, program and customize services with touch command, offer original customization of connected objects facilitate the use of programming to trigger single actions or grouped according to specific situations with IFTTT commands ("If This, Then That"); adapt the system to user contexts by integrating the understanding of the implicit.

J. Ubiquity

The design interface should support multitasking among members of the household, their various domestic concerns, the different spaces used, the many devices used and the other existing interaction modalities by proposing an ecosystem spread over a variety of media.

K. Multi-users

Favor a voice recognition system within the same household (to avoid the "diversion" of the system by external voices, TV, radio, etc.), provide a control setting for the primary user to maintain control over their own data and delegate any or all control of the device to other users if desired.

L. Humanizing dimension

Encouraging the humanizing dimension during interactions for interested users. This would involve choosing between a "functional assistant" or a "companion assistant". This last choice would propose a variety of criteria and attributes that the user could add, adjust or remove according to his preferences. Voice or timbre variation, integration of polite or humor marks, select a personality type for AI, expression and recognition of emotions, etc.

M. Safety Considerations

This principle requires system design to allow users to use and run the interface while a process is disabling. Interface design should consider every problem that may occur, reduce the likelihood of using errors as much as possible, and save processing to processes that can lead to severe results and avoid operations that are not as valid as possible to enhance stability. Stable system is reliable, and support usability of use [9].

N. Consistency

Mobile interface design should speedy change the status of emotional buttons to match the controlled orders that directed to any appliance of smart home and any transfer of information from place to place should consistent.

O. Habitually status

This principle considers implicit usability which mean any action will stored into the cloud as part of IoT technology for training. Which allows the UI mobile design to notify the user with any habits with time stamp, this requires machine learning model that directs the user interface. Such model will highly support the usability and reliability.

Concision

Agile manifest in software engineering industry "Make it simple as it work's should be presented on design, simple design according to Agile doesn't mean small or little of features but allow the design view to realize the customer needs early and hide other features not required for this period or action.

P. Flexible design

This principle of design includes many alternative ways to match the user needs and perform the order. This should relate to the habit so, it can be adapted automatically where only options needed can be viewed, user can be allowed to go back for main menu for original steps.

Q. Uses Memory

This principle highly realizes the usability of UI mobile design so, user should be able to vastly recognize and learn the features so, user memorize how it can be done with more than one way.

R. Predictability

Predictability is the kind of capability that a person expects the results, which always depends on the experience of the users. If the interface's productiveness is strong, operations will be more secure and efficient, this can enhance the usability.

4. CHEKLIST AND EVALUATION

Usability do not realize of using mobile design according to emotional buttons that can easy touchable and comfortable only but include the responsive appliance that controlled or directed by this design. Such design should be able to augment the emotional button with status of appliance for example when the user needs to open garage door the emotional door will synchronize progress as appliance hardware. This can be done technically by installing services on each appliance on smart home. These services running on background on appliance and continue sending its status into mobile application for synchronizing the emotional buttons. User can feel exact actions for any control process. Our aim in this section to list significant check list that can be heuristic usability as is we show in TABLE 1 and TABLE 2. This technique is mostly used on HCI evaluation for heuristic usability and can be done by experts of layout designs. The responsive from appliances is big challenge of this evaluation so, expert should not only look at the emotional buttons how changed while the action is triggered but also, they should consider the appliance responsive.

Table -1: Visual and Emotional Design

	Satisfy	**Don't satisfy**
Touchable images include extra text labels	□	□
Emotions that are touched are obviously pressed and changed according to the appliance status	□	□
Emotions or items that aren't touchable do not have appearances that recommend that they are	□	□
The layout supports focus attention on what is in the next	□	□
On all activities, the greatest important emotions such as frequently used features and purposes is existing on the above part.	□	□
The layout should not scroll horizontally (vertically if needed)	□	□
The layout density is suitable for the users and touched buttons	□	□
The functionality of emotion buttons and switches are apparent from their labels or from their design	□	□
Fonts used are dependable	□	□
The connection between order command and their actions is clear	□	□
Icons and graphics are emotional and/or natural	□	□
There is obviously visual starting to any activity	□	□
Each activity on the design shares a dependable layout	□	□
activities are formatted as emotional related appliance	□	□
Emotional buttons show that they have been touched	□	□
GUI components related to appliances are suitable	□	□
There are a lot of way to control or to order some appliance	□	□
Activates avoids italic text and uses underlining only for hypertext links	□	□

There is a good balance between buttons density and use of empty space	□	□
obvious labels, suitable background colors and appropriate use of borders and empty space help users to identify a set of items as an isolated serviceable chunk	□	□
The Layout is enjoyable to look at	□	□
The Layout avoids extensive use of upper-case text	□	□
The Layout has a reliable, clearly look and feel that will attract users	□	□
The colors graft well together and complex backgrounds are escaped	□	□
Layout have been designed to an underlying grid, with items and widgets aligned both horizontally and vertically	□	□
Flooded blue is escaped for fine detail	□	□
Standard components such as titles, navigation, policy of privacy etc. are easy positioned	□	□
Color is used to schema and group items on the layout.	□	□
Emotional graphics will not be disrupted with banner ads	□	□
Encouraging is used to emphasize the appliances categories	□	□
Attention attracting such as animation and colors are used carefully and only where relevant	□	□
Related touchable buttons organized together, so it can be memorized by user.	□	□

Table -2: Errors and feedback

	Satisfy	Don't satisfy
Information are brief and clear.	□	□
Users are given support in selecting appliance	□	□
Notifications activity are obvious.	□	□
The frequently questions provides step-by-step instructions to support users to perform the most important tasks.	□	□
It is easy to get support at the right time.	□	□
The user does not need to consult user guide or other external information to use the layout.	□	□
The layout provides suitable feedback such as progress indicators or messages when needed	□	□
User notification is need before performing potentially actions such as gaze, fire and electric appliance	□	□
Error message include obvious instructions on what to do next.	□	□
Where there is user request selection between different items such as in appliance the options are clear	□	□
The layout preserves users notified about necessary delays in the appliance response time.	□	□
Error messages are formatted in not irony tone and do not fault the user for the error.	□	□
Response time as quick as sustainable.	□	□
The layout provides speedy feedback on user touch or actions.	□	□
The user is warned about large, slow-loading process.	□	□
When giving instructions, activity tells the users what to do rather than what to escape doing.	□	□
The layout shows users how to do common operations where applicable.	□	□
The layout provides feedback such as "Did you know?" that support the user learn how to use the application.	□	□
Support is obvious and direct and simply described in plain English	□	□
The layout provides obvious feedback when a task has been finished successfully	□	□
Main directives remain on the screen while needed, and there are no quick time outs requiring the user to do something else	□	□
There is sufficient space between touched items to prevent the user from touching multiple or incorrect targets	□	□
There is suitable empty space between touchable items	□	□
The layout marks it clear when and where a mistake has occurred and there is safe rollback	□	□
It is easy to "undo" some jobs or actions	□	□
The layout prompts the user before correcting task	□	□
The layout guarantees that work is not lost	□	□
The layout can provide more details about error messages if required	□	□
The layout uses suitable option methods as an alternative touch such as speak recognition	□	□

5. CONCLUSION

The explanation of a smart home covers diverse areas, such as domestic appliances, surrounding intelligence, sensors and engines, networking, connecting home with internet world of IoT technology, remote monitoring and adjusting of functionalities and services, controlling home appliances to residents' request, and supporting the performance activities of everyday life. In our paper, we presented the most important principles of usability in designing mobile apps

used in smart homes such as emotional buttons, responsive layouts, IoT utilities, voice recognition, user feedbacks, controlling, consistency, humanizing, multi-users ubiquity, customization, concision, flexibility in design and memorizing considerations. These principles which manage and administrate such functionalities and give progress status to the user, according to the usability with convenient and comfortable layouts, this needs very large efforts of work. Therefore, we provide novel check list as evaluation procedures used by expert for infer usability. This evaluation criteria's viewpoint from our point of view after studying some of the related works.

6. FUTURE WORK

We believe in usability of design doesn't heuristic form check list by experts. Nowadays machine learning engines used for a lot of mobile application features. Mobile apps can sent habitually features that used by users in time stamp to cloud machine learning model. This model can enhance and adapt the design and push notifications for user according to the user habit for example user can't touch emotional button with wet hands. These actions can be addressed automatically when the whole system and services working to gather according to AI model which trained on the cloud this will our future work to integrate machine learning with HCI.

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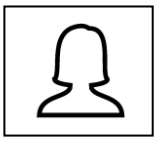
BIOGRAPHIES



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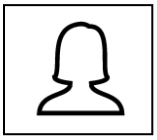

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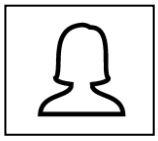

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