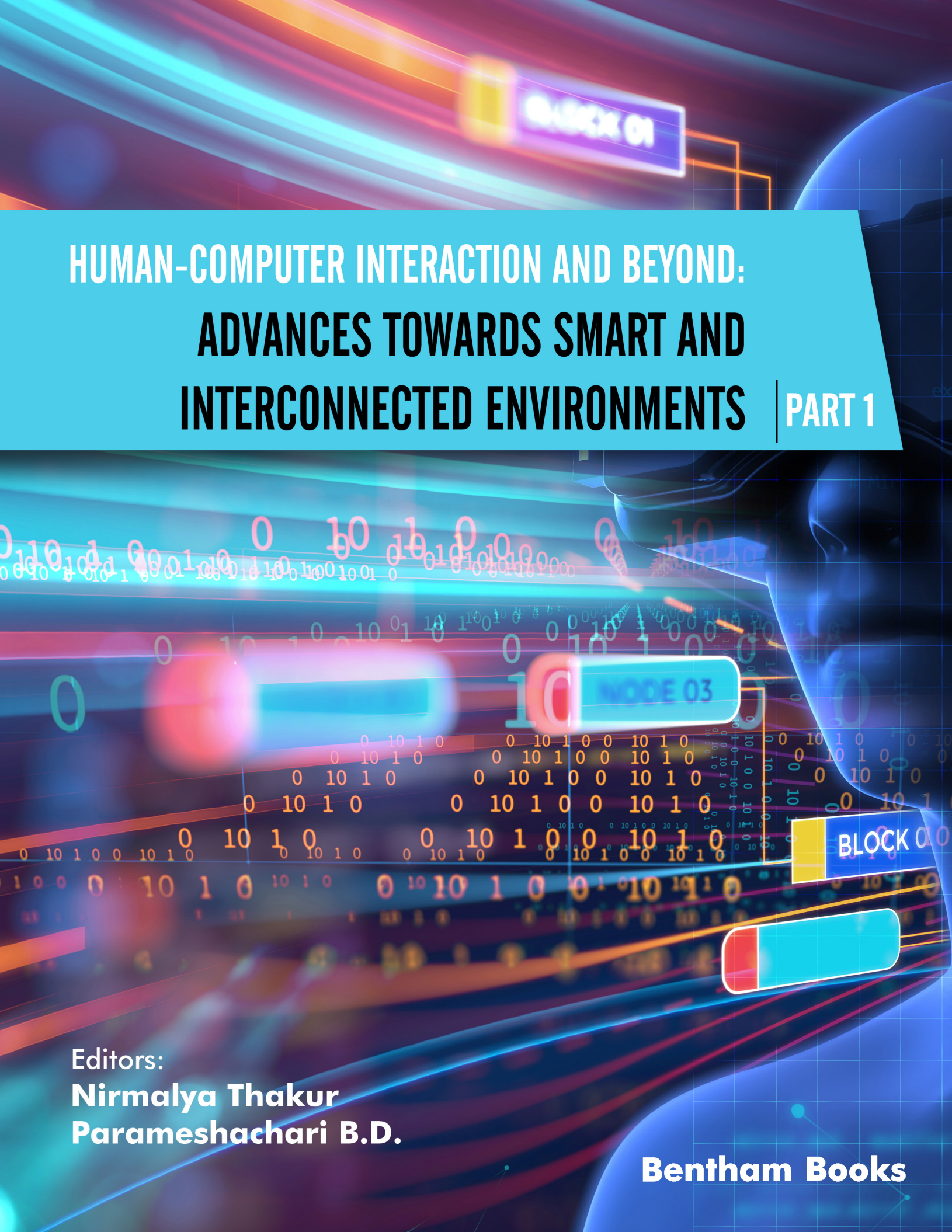

HUMAN-COMPUTER INTERACTION AND BEYOND: ADVANCES TOWARDS SMART AND INTERCONNECTED ENVIRONMENTS | PART 1

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Human-Computer Interaction and Beyond: Advances Towards Smart and Interconnected Environments (Part I)

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PREFACE

In this age of rapidly advancing technology, the future of living and functional environments would involve humans interacting, coordinating, and collaborating with computers, machines, robots, and various technology-laden systems in a multitude of ways. Examples of such smart and interconnected environments include Smart Homes, Smart Industries, Smart Workplaces, Smart Buildings, and Smart Cities, just to name a few. There are two parts of the edited book that presents discoveries, innovative ideas, concepts, theoretical findings, practical solutions, improvements, and novel applications in Human-Computer Interaction (HCI) aimed at developing trust, user acceptance, augmenting user performance, improving quality of life, and fostering human-technology partnerships in the future of technology-laden living and functional environments.

The topics covered in these books include the following:

- Applications of HCI for Smart Homes, Smart Cities, and Smart Vehicles
- Design of Technology for special user groups – elderly, disabled, *etc*.
- Prototypes of Interactive Systems with a focus on Human-Centered Design
- Applications of Artificial Intelligence, Machine Learning and Data Mining in HCI
- Computer Vision, Image Recognition and their applications in HCI
- Novel works in mobile or web development related to HCI for Smart Environments
- Applications of HCI in healthcare, education, entertainment, and games
- Applications of HCI and related technologies focusing on COVID-19

The current part of this book, Part 1, presents a unique and diverse collection of the global advancements in HCI in the above-mentioned application domains. It consists of chapters authored by experts and scientists in the field of HCI and its interrelated disciplines from 8 different countries – Chile, China, Croatia, India, Iran, Malaysia, Peru, and South Korea. This book is aimed at scientists, researchers, and developers in Academia and the Industry who wish to learn, design, implement, and apply the emerging technologies, concepts, and applications from the field of Human-Computer Interaction in different application domains, with a specific focus on the future of technology-laden living and functional environments. Each chapter has an abstract and keywords followed by the introduction, methodologies, and other sections. Readers can determine their interest level in any chapter quickly based on the keywords and the abstract.

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CHAPTER 1

A Survey of Approaches for Facilitating Rich User Experience in Healthcare Domain

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Abstract: HCI is a discipline concerned with designing, evaluating, and implementing interactive systems for human use. HCI focuses on the fact that "people should come first." The healthcare industry has more rapid influence and development with HCI in recent days. Healthcare systems with improved HCI would benefit the industry in terms of quality of service and throughput. In the healthcare domain, the Interaction possibilities are spread in a broad spectrum, *i.e*., from tangible interfaces to wearable and implanted devices. The survey of the diverse device interactions in various healthcare systems from technological aspects is a significant area of research, useful to the medical fraternity and ordinary people. The presented survey will open up the doors for exploring novel approaches related to the rich User Experience in the healthcare domain for the benefit of society.

Keywords: Artificial Intelligent, DSS, Embodiment, HCI, Health Care, ICT, Implanted devices, Literature Review, Medical Services, Mobile Applications, Multidisciplinary, NLG, PRO, Quality Parameters, SHT, Tangible Interfaces, Ubiquitous Computing, User Experience, Voice Assistants, Wearable devices.

INTRODUCTION

Human-Computer Interface (HCI), also known as User Experience (UE), is the Computer science and engineering domain that focuses on the systems' Human-Centric Development. It influences and incorporates all the major Computer Science domains like Artificial Intelligence, Ubiquitous Computing, Database management, *etc*. With the tremendous advancement in these technologies, HCI has also flourished to enhance the user experience of almost all the systems used by human beings.

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HCI is also a multidisciplinary domain that facilitates human services in many fields like healthcare, gaming, social and organizational management systems, various tangible and auditory interfaces, *etc*.

HCI is a perfect reflection of how machines can make human beings' lives more comfortable and happier through various handy interfaces. Healthcare is an essential domain. It exploits all the different approaches, tools, and techniques in the medical field to help humans survive and cope with the various health problems arising from genetic issues, improper lifestyle, or health problems due to unforeseen and unavoidable accidents pandemics. As HCI systems are built keeping humans in the center, they prove to be a boon to humankind as right from motor organs to internal organs. Technology can be blended with medical techniques to create beneficial machines and tools. The use of HCI can be witnessed in the smooth functioning of almost all organs and senses. Various Information and Communication Technology (ICT) devices are built to handle multiple human feelings. Some of these ICT modalities include cameras for sight, various input/output devices like touch screens and keypads for touch, pointer devices for haptic control, microphones for hearing, different chemical sensors, and analyzers for smell taste. To enable human interaction with the outside world, different types of interfaces can be designed like gesture interfaces for expressing meaning or idea through various gestures by body parts like fingers, hands, arms, head, face, tangible interfaces, and organic interfaces to facilitate manipulation of object in three-dimension space, auditory and Natural Language interfaces, wearable and implanted device interfaces like pacemakers, *etc*. With this context, the importance of HCI to support healthcare services can be understood. The literature survey in this chapter encompasses the various possibilities and approaches of enhancement in medical facilities with the help of HCI. The survey considers the various health aspects, including the mental and physical health and use of various wearable and implanted devices for the well-being of humankind.

LITERATURE REVIEW

The literature review focuses on the approaches by researchers on various health aspects. Nowadays, we observe that people are getting more inclined towards a healthy lifestyle and diet due to awareness of junk and processed food. HCI can play a significant role in managing the dietary needs and constant monitoring of the patient. Luca Anselma and Alessandro Mazzei have designed an app, Multimedia Application for Diet Management (MADiMan), for diet management. MADiMan app focuses on two aspects. The first one studies users' dietary constraints and automatically adapts the users' diet through a numerical reasoner. The second part helps the user stick to a healthy diet by generating text messages through Natural Language Generation (NLG) system. The results generated by

numerical reasoners are used for this purpose. The use of the reasoning module makes this app different from other commercial apps. The reasoning module generates a numerical representation of the diet and food consumed. This facilitates proper diet management through an app. Whereas the NLG module contains a document planner, sentence planner, and a realize module for providing customization of the messages. The CheckYourMeal app is used to evaluate the NLG module by considering the description of human-based simulation. Two experiments with two distinct groups of people are conducted, and the correctness of the app on various parameters is checked [1]

Franklin *et al.* categorized the important usability factors. They discussed some of the parameters that would make the interface practical and usable with specific quality parameters such as safety and reliability. The problems in the interfaces are analyzed from the clinical point of view, and the ways are figured out for usability improvement and for meeting the User Experience needs. They also planned to involve certain significant quantitative factors related to these qualitative factors to address the needs of next-generation healthcare systems to improve the usability of the interface [2]. There is less importance given to standardizing methods to collect and integrate Patient-Reported Outcomes (PROs) data in today's internet world. Deliya B *et al.* described a framework for understanding patients' usability and functional requirements collecting PRO data using applications (apps) and healthcare providers using these data at the point of care in ambulatory settings. The STS model asked the guided questions. Semi-structured interviews were conducted with eighteen patients and nine healthcare providers to elicit feedback about facilitators and barriers to the successful use of PRO apps and PRO data in ambulatory settings. The data were analyzed inductively to identify emergent themes. It was observed that younger patients were only interested in using a PRO app if they had an active health issue to track. The nine older patients preferred passive means of data collection to follow a health issue, selected direct contact with their healthcare provider and used office visits to share information. The app provides transparency and privacy. All patients desired optimal usability and emphasized bidirectional communication in an app. All healthcare providers agreed that PRO data would be most useful and relevant if key patient populations were targeted based on the specific measure [3].

In the case of Asthma, the patient's self-awareness and management of the clinical state of Asthma is beneficial. Otilia Kocsis *et al.* proposed a short-term prediction approach for asthma control status named myAirCoach, considering training multiple classification models for each monitored parameter and necessary pre-processing methods to enhance robustness and efficiency. The integrated sensors are used to understand physiological, behavioral, and environmental factors to

CHAPTER 2

Conducting Digital Product Usability Tests with Children who have Atypical Development

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Abstract: When creating digital products, it is essential to validate design decisions through user testing. Ensuring a digital product meets targeted user groups and personas' needs, all sorts of design decisions need to be carefully evaluated and adjusted, including informational architecture, navigation, selections, control patterns, feedback, colors, typography, iconography, and many more. Every testing session is unique and needs to be personalized according to the testing persona. When working with special needs persons, atypical development, or visual impairments, special care and preparation are required. These circumstances of user testing are even more challenging when the targeted audience is children with said disabilities. In preparation for testing, it is essential to understand the type of disability a child has and inform their legal guardian or medical caretaker. Considering all these things, conducting user testing can still prove challenging because of a child's unpredictable behavior. They might seem interested; they might lose focus or generally not be in the mood. With research skills, clear set goals, and preparation, a healthy dose of empathy and human understanding must gather valuable testing session's insights. Insights that will help inform further design decisions.

Keywords: ASD, Atypical development, Atypical users, Autism, Cognitive bias, Developmental disabilities, Digital design, Digital products, Human-computer interaction, Product design, Sensory integration, Specialized design, UI design, Usability testing, User experience, User interface, User research, User testing, UX research, UX/UI.

INTRODUCTION

A digital product is an application, a website, software, or any product in a digital form and requires interaction with users. To create a perfect experience for the desired user, it is necessary to define user requirements. According to Baxter *et al.,* "User requirements refer to the features/attributes a product should have or

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how it should perform from the users' perspective. User-centered design (UCD) is an approach for collecting and analyzing these requirements." [1].

User research enables teams and companies to define who they are making a product and ask their desired user if the product works for them. The purpose of user research is a faster product development process. Speeding up the development process lowers the cost for companies that are funding the operation. As Kuniavsky *et al.* define it – "User research provides a consistent, rapid, controlled, and thorough method of examining the users' perspective." [2]. The users' perspective guides the way the product should be created and defines the result's success.

Product development should not be a linear process. Relying on the design thinking process enables fast problem detection and creates a means to solve the problems in an educated way – based on research results. The design thinking process is an iterative, non-linear process that goes through empathizing, defining, ideating, prototyping, and testing [3]. The main benefit of design thinking is that goals can be adjusted according to previous research findings through the iterative process. This way, everything is moving faster, and products are built in a better way – more fitting for the end-users.

THE VALUE OF USER TESTING

Before conducting a user testing session, much preparation is needed. First and foremost, goals need to be determined. These goals depend on what the current task at hand is. They can either be a business goal or a user-centered goal. Business goals usually define a benefit the research might bring, and these goals, in the majority, have a unique value connected to them. User-centered plans bring value to the users themselves, such as ease of use or an experience that brings satisfaction.

User testing is done in several stages: planning, setting user tasks, recruiting testers, and facilitating the testing [4]. In all these stages, a provisional persona is kept in mind. Provisional personas are generalized perfect users based on assumptions about who might use the product or its target. These hypothetical personas need to be validated so that actual target users can be recruited for user testing [5]. A good determination of the user base can affect successful goal achievement because business and user-centered goals are similar. Considering that user (customer) satisfaction is an essential factor in user (customer) retention, it is necessary to ensure that users encounter minimal service failure [6]. Service failure usually means that users did not successfully finish a task or encountered frustrating situations that created negative emotions attached to the product.

According to [7], to ensure better user experiences in different contexts, it is necessary to analyze user interactions and understand their expectations to provide a positive affective state. The real value of user testing is the ability to funnel research data into manageable information that can be used to influence design decisions. Design elements such as informational architecture, navigation, selections, control patterns, feedback, colors, typography, iconography all need to be carefully considered and selected to serve the users as required.

APPROACHING THE USER BASE

Using provisional personas serves as a guideline in recruitment. Usually, these personas are idealistic and much generalized. Problems arise when the end-users or the target group are not ideal. A perfect example of a non-typical user group is children. Adapting the user testing style is necessary and desired. Children have different needs and require a different approach [8]. Barendregt and Bekker provide a set of guidelines that include best practices for approaching children from ages 5-7. According to these guidelines, children should be educated and eased in the testing as a game. They should also be lightly guided and find support in the researcher [8].

There are not many research papers that focus on testing with children but focusing primarily on children with atypical development. Adding another layer of difficulty to user testing would be testing with children that have atypical development. Children with atypical development have a good grasp of their emotions. They learn that their feelings wane over time and that they should think before they act. Children with atypical development sometimes have problems with regulating emotions, which results in unexpected reactions. These results can be manifested in anger or depression [9].

PREVIOUS EXPERIENCE

The authors have conducted several user testings' which included children that have atypical development. During those researches, they applied techniques that were usual and aligned with their training so far. However, due to the users' specifics, much modification was needed during the research. One research was conducted for a mobile application that teaches sign language to children with atypical development. Preparation for the user testing session was accompanied by a short educational lesson by the expert accompanying the research. The research itself had a few specifics that are out of the scope of this Chapter. However, the main conclusion was that approaching children on their level is vital — appearing as non-threatening, fun to work with and lighthearted provided better cooperation from the children joining in the research.

CHAPTER 3

Assistive Technologies and Artificial Intelligence for Visually Impaired: Investigating Ongoing Issues and Challenges

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Abstract: Nowadays, assistive technologies facilitate visually impaired people a lot. However, they still face many challenges in their daily lives, such as the perception of rich visual information around their adjacent environment. Several assistive technology-based solutions have adopted Artificial Intelligence (AI) which offers instant information of nearby visible things, objects, and persons to visually impaired people. Visually impaired people can also easily access online communication with emerging solutions using AI and perform numerous daily routine tasks. This paper presents a review of AI's role in visually impaired and solving their everyday life problem intelligently. A detailed analysis of assistive technologies and smartphone-based solutions for the visually impaired is presented, highlighting the need for technological enrichments and AI-based interventions for them. Furthermore, some challenges were addressed which faced by the visually impaired during the use of AI-based solutions. Additionally, the usefulness and limitations of the recent assistive solution are presented. Lastly, future research endeavors are introduced, which may help researchers and developers propose some innovative solutions.

Keywords: Adaptive feedback, Artificial Intelligence, Assistive, Auditory, Character recognition, Development, Emerging solution, Environment, Finger-sized, Information, Interventions, Innovation, Interfaces, Learning, Navigation, Smartphone, Technologies, Training, Visual, Visually impaired.

INTRODUCTION

The World Health Organization (WHO) reported approximately 738 million people globally, with about 285 million visually impaired people [1]. Technology innovation can be support visual impairment more proficiently. Assistive technology and Artificial Intelligence can facilitate visually impaired persons.

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Assistive technology is used during the development of products, equipment, systems, and mobile applications to enhance learning, escalate work capabilities, and daily routine task performance in visual impairment. It can alleviate the effects of disabilities that limit the ability to perform activities of daily living and enhance the independence factor. Assistive technology provides simple interactions with technology, enabling visually impaired users to perform complicated tasks efficiently. It is difficult for blind users to interact with the nearby environment without using assistive technology. The early study has shown that independent navigation is a real challenge for the visually impaired [2].

The visually impaired construct a spatial map according to two information channels. One is they can adjust their direction by tracking the sources according to their surroundings or sounds. The other is to sense the information of the surrounding environment according to the sense of touch and adjust the direction through tactile feedback.

On the other hand, AI refers to the simulation of human intelligence in a machine programmed to think like a human and imitate its behavior. As technology continuously improves, the benchmarks that previously defined AI have become obsolete. The goals of AI include learning, reasoning, and perception [3]. For example, the face recognition technology of mobile phones has been widely used and gradually inherent new functions and features.

Typically, people can obtain environmental information through multiple information channels, such as hearing, vision, touch, *etc*. But the visually impaired mainly depend on pictures for information acquisition, which leads to their perception of the surrounding environment significantly reduced. Some earlier studies [4 - 6] have shown that visual impairment brings inconvenience to life, and it is even more challenging to walk independently in a strange and complex environment. Several devices based on AI help the visually impaired walk alone improve walking independence for the visually impaired.

With the rapid development and popularization of information technology, people use digital devices to perform various activities. These digital devices have many automated features, *i.e.*, brightness control, temperature control, and screen display. But there is a lack of such kind of interface which provides support to visually impaired people. Additionally, human beings still have various obstacles. Vision impairment is a prominent aspect, although innovation in digital devices has made a lot of progress [7]. There are still many challenges for human beings to solve vision impairment to interact with digital devices.

Assistive technology and AI play an essential role in introducing new and innovative interaction mechanisms with the digital device to facilitate visual impairment. This paper has reviewed the earlier studies that have used assistive technology and AI to help visually impaired persons.

The remaining sections of the paper mentioned as section 2 provide a detailed overview of the previous studies conducted for visually impaired people. Section 3 summarizes the earlier researchers and summarizes Assistive Technologies and AI interventions for the visually impaired. In section 4, we have a discussion and conclusion of the topic, and finally, section 5 has the future direction for the researchers.

RELATED WORK

Many AI and Assistive Technology researchers are trying to improve the independence of the visually impaired. They are trying to design a more advanced and intelligent AI system and devices. The work related to this area is outlined as follows.

More and more wearable devices [4 - 6] help the visually impaired overcome many difficulties in their daily life. Chang *et al.* [4] proposed that wearable assistive devices based on AI edge computing assist the visually impaired zebra crossing walking. The device consists of a pair of smart glasses, a walking cane, and a waist-mounted box. When the visually impaired cross a zebra-crossing, the device can provide traffic signal information. If there is a deviation during zebra-crossing, the visually impaired will be reminded by voice, and Bluetooth provides the voice guidance service. To lighten the burden of the visually impaired, Kamal *et al.* [5] proposed a kind of glasses that can help the visually impaired get information about the surrounding environment while walking to avoid falling. Their proposed system used RGB data from microcontrollers and smartphones to calculate surface smoothness during the day and in the dark. The system estimated the highest surface smoothness of 96.341% in the daytime and 98.683% at night.

This system helped the visually impaired walk efficiently and find and evade obstacles without holding any sticks or other heavy objects. In terms of navigation and tracking the trajectories of the visually impaired, Shandu *et al.* presented the design of an intelligent walking stick for blind users using Raspberry Pi 3 b+ as a central microcontroller, Ultrasonic sensors, and Global Positioning System (GPS) [6]. Ultrasonic sensors are used to scan the environment of sidewalks and sides at a defined distance using sound waves, while GPS modules are used for real-time direction and navigation. For the safety of the visually impaired, the GPS position coordinates of the visually impaired are sent to the nursing staff through the SMS

CHAPTER 4

Usability Testing of Twitter App with Indian Users

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Abstract: This research paper presents a usability testing of the Twitter app with Indian Twitter users for identifying usability problems, especially for the new users or beginners. This usability test mainly focuses on a normal usage context and subject of observations, which significantly affects the user experience with the Twitter app. Various Twitter functionalities/features have been explored during usability testing, and ten frequently used tasks were selected. The selected users have been ten Indian college students in the age group of 21-23 years but are not using Twitter now or have not used Twitter before. It is directly affected by usability problems related to the app like Twitter. Therefore, several usability problems have been identified during usability testing. These problems include the ambiguous design of icons, faulty design of buttons, hidden options inside the menu, information overload, and inefficiency with functions. Few remedies are also proposed for dealing with identified usability problems with the Twitter app. It is believed that the design updates based on identified usability problems and remedies will improve the user experience of Indian Twitter users, boosting the popularity of the Twitter app among Indian youths.

Keywords: Android Smartphone, Artificial Intelligence, Bookmarking, Content Localization, HCI, Indexical Icons, Indian Users, Interface Simplicity, Laboratory Testing, Lists, Micro Blog, Mobizen App, Section Navigation, Social Media, Time Efficiency, Trends, Twitter App, Usability Problems, Usability Testing, Walkthroughs.

INTRODUCTION

Twitter is a popular microblogging and social networking site that allows users to send messages of up to 280 characters, called tweets, to groups of listeners referred to as followers [1]. Twitter has about 883 million users globally and, out of which 330 million users are monthly active users as per Global Digital. Report 2019 [2] and according to the article of Business Insider [3].

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The users access Twitter through its website interface, through a short message service, or mobile application (App). The registered users with Twitter can tweet or post and retweet or share, but unregistered users can only read the tweets or posts. Usually, Twitter users utilize this platform to express themselves and give opinions to anyone about anything. Each user can choose to follow people and organizations with similar interests to him/her. If a Twitter user follows some other users, he/she can see their tweets in his/her Twitter timeline. Users have found many different uses for Twitter, including communication with friends and family, a way to publicize an event or a memory, and/or as a tool to communicate with the customers for a company.

India has around 34 million Twitter users, and among them, 7.6 million users are monthly active users as per India Digital Report 2019 [4]. These Indian users are curious about Twitter as a social networking site, but it differs from other social networking sites such as Facebook and Instagram. Twitter co-founder and CEO Jack Dorsey want young Indians to tweet their hearts out. Still, the micro-blogging website doesn't appear to be the most popular social media platform for his target group, the 18-to-30-year-olds, and there is some reason like don't know what Twitter or character limit is [5]. The majority of Indian users have never heard of Twitter or only know its name and rarely use Twitter. India has fewer active monthly Twitter users compared to the total Indian Twitter users. Gartner's Asheesh Raina says that Twitter is a 'Literate' tool and is more textual, unlike Facebook, Instagram, and Snapchat. These social networking sites have too much usage, especially with Facebook and WhatsApp. Indian people fail to understand what's the real benefit of Twitter [6]. This research paper is focused on usability testing of Twitter – its UI with the Indian student community. This usability testing is focused on identifying parts of Twitter UI, which is complex and needs improvement in terms of usability in the future.

LITERATURE REVIEW

Several research papers have been identified during the literature study related to usability evaluation of Twitter and usability testing of other Social Networking Sites (SNS) as desktop and mobile applications. These research papers are discussed widely in this section. The first study is a usability testing of Twitter for elderly Arab users using the usability evaluation tool – Morae. This study focuses on usability tests with only elderly people and has used Morae for recording the user's behavior *via* Mobizen software. These users are observed in real-time. The main aim of this study includes analyzing the response of first-time Twitter users and the retention of existing users. This research has provided some suggestions for customizing icon sizes, caption fonts, related hints, and color schemes for elderly users [7]. This study has selected vital tasks such as account creation,

composing a tweet, replying tweet, and deleting a tweet. These tasks are rigorously investigated during the usability testing process conducted during this research work.

A study on usability evaluation of messenger apps of Android phones using cognitive walkthrough has provided several usability issues with these apps. This usability evaluation is carried out with three messenger apps - WhatsApp, Skype, and Go SMS Pro. During this study, vital usability issues include the absence of legends for the message, overuse of uncommon indexical icons, and longer textual instructions for users [8]. These types of problems can be found on various social networking sites including in the Twitter app. There is a plan of investigation for similar kinds of usability issues during the usability testing of Twitter.

The next research paper studied is about the usability testing of Tweet-Caster third-party applications for Twitter on Android and Blackberry. Tweet-Caster is a simplified version of the Twitter platform for those who have difficulty or don't like the official Twitter UI. This study includes some tasks that need to be performed by the participants, like composing a tweet, replying to a friend's tweet, visiting the user's profile, and finding trending topics. The mean time spent on each of these tasks is calculated to estimate efficiency [9]. This research paper has been used as a vital guideline for usability testing for Twitter.

There is an interesting study focusing on heuristic evaluation on Twitter with the participation of 100 users. These users have responded through web-based e-questionnaires that cover every part of Twitter in a heuristic manner. In this study, professional/expert users are considered along with naive users. This study has utilized the combination of five attributes out of Nielsen's attributes of usability, such as Learnability (Ease of Learning), Efficiency of Use, Memorability, Errors (Accuracy), and Subjective Satisfaction. A related questionnaire covers every Twitter module and needs to evaluate for better user satisfaction and completion of goals, which Twitter intends to do [10]. The questionnaire used in this paper has been useful in designing questionnaires for usability testing of Twitter.

Another study deals with usability testing of selected tasks performed with mobile apps. It is focused on a comparison between laboratory and field testing. The test participants are given some tasks to perform with the application. And for the difference between laboratory and field testing, they used equipment like a camera and tripod to study outdoor testing environments and participants' performance [11]. Their research concluded with the result of different types of advantages in laboratory testing. This study improves the understanding of the effect on the work environment in usability testing. In the next paper, usability testing of ten social messaging apps on iOS is conducted. These apps specifically are chosen

CHAPTER 5

Enhancing Gamified Online Learning User Experience (UX): A Systematic Literature Review of Recent Trends

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Abstract: Gamification introduces game elements and game thinking in non-game contexts. Many scholars argue that gamification can potentially be a viable online learning approach to promoting student engagement and learning outcomes in recent years. However, various obstacles impede their practical implementation. As a result, user experience (UX) and user participation may be affected, possibly resulting in high course drop-outs rates. Furthermore, it is unclear which game elements are effective and recognized as the current state-of-the-art gamified online learning research. This study provides a review identifying the game elements introduced in online learning and tested in previous studies from 2017-2020 through a systematic search strategy. By reviewing the literature, we identified the most effective game elements and determined their impact on the learners' user experience. The results show that in 26 of the 34 selected studies, gamified online learning had a significant beneficial effect on user experience, engagement, and completion of courses. Moreover, points, leader boards, levels, badges, and progress bars are the most widely used game elements in the studies. This study's findings may guide the design of more successful gamification interventions for online learning.

Keywords: Adherence, Affordance, Application, Engagement, Education, Game-based, Game elements, Gamification, Gameful design, Innovation, Intervention, Literature review, Motivation, Novelty, Online learning, Platform, Pedagogy, Performance, Technology, User experience.

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INTRODUCTION AND BACKGROUND

In recent decades, the advent of modern technologies such as the high-speed Internet network (5G), cloud computing, the Internet of Things (IoT), and next-generation devices has continued to transform people's lives. This has significantly impacted various domains, such as business, travel, health, and education, and promoted e-learning adoption. The coronavirus (COVID-19) pandemic has created people's need to work and study from home [1]. As a result, we are increasing our over-dependence on information technology in our day-day activities. Education is a crucial area impacted by the pandemic, with about 80 percent of students worldwide affected by COVID-19 [1]. Therefore, classrooms have switched from conventional classrooms to numerous online platforms. Online learning or e-learning relates to utilizing digital technology to provide training and educational resources [2]. Some popular online learning systems include Learning Management Systems (LMS), Moodle, Massive Open Online Courses (MOOC), and Blackboard.

Although online learning institutions have attempted to improve teaching and learning, authors also argue that several online learning systems do not produce the expected results [3, 4]. Essentially, learners' motivation and commitment levels have become a significant hindrance for encouraging online courses' use and completion. Given this, there has been an increase in gamification tools to improve motivation and sustain interest among learners [5]. Gamification is used to modify behaviors in various contexts to achieve behavior outcomes [6]. Education is a critical sector in which gamification is openly explored for its potential to motivate. Hence, it is an essential part of academic performance in an educational setting.

In the specific context of online learning, gamification's impact on user experience (UX) generally relates to motivation and behavioral change [7]. Assuming a user has a poor user experience, they will likely feel discouraged and avoid engaging with the online platform. Although current studies indicate successful gamified interventions, the impact of various game elements on user experience is unclear. Therefore, it is timely to conduct a literature study to establish what we already know thus far and underline multiple future directions. Accordingly, this paper presents a literature review of published works to explain the influential game elements introduced into gamified online learning. The review covers articles published between 2017 and 2020 and their effects on user experience (UX).

The paper is divided into five sections. Section 1 gives a brief overview of gamification and user experience in the education context. Section 2 discusses the

current state of gamification in online education and its effect on user experience. Subsequently, Section 3 outlines the review procedure. Next, the results of the analysis are presented in Section 4. Section 5 concludes the article and highlights potential future avenues for research.

GAMIFICATION

Researchers have defined gamification in a multitude of ways. According to Deterding *et al.* [8], gamification uses the game design feature in a non-gaming sense. At the same time, Hamari [9], from a different viewpoint, described gamification as a process of improving a game-like experience-based service to support a user's value. Werbach [10] also took a distinct view of gamification and described it as a process of making tasks more game-like.

Gamification (gamified) is still very much in its early stages and is evolving, dating back to the early twenty-first century. In recent years, several scholars, such as Deterding and colleagues [8], Johnson *et al.* [11], and Landers *et al.* [12], have explored multiple facets of gamification. These facets include design rules [13, 14], psychological and motivational dimensions [15, 16], health and fitness [17 - 19], media [20, 21] and education [22, 23]. As shown in Fig. (**1**), the gamification structured has three layers: mechanics, dynamics, and components [10]. According to the authors [10], mechanics include various behavior and control mechanisms to support interactivity. Dynamics specifies the runtime behavior of the dynamics for inputs and outputs of players over time. Components refer to the specific instantiations of mechanics and dynamics.

HOW GAMIFICATION WORKS

Koepp and colleagues [24] concluded that playing games produce higher dopamine levels in the human brain. The authors also argue that this is correlated with greater motivation, learning, reinforcing current behavior, and focus [24]. They also observed that dopamine generally relates to conditions involving incentives. Typically, rewards or incentives can be either extrinsic or intrinsic and are used to motivate individuals [25]. Extrinsic or tangible rewards include money, goods, discounts, or promotions. Intrinsic or intangible incentives include positive feelings, appreciation, accomplishment, or social interactions [25]. More importantly, extrinsic motivators can produce extrinsic-motivated individuals, encourage non-autotelic behavior, and possibly short-term behavior outcomes [25]. In contrast, intrinsic motivators may lead to hedonic and autotelic behaviors and might be long-term. Hedonic behavior relates to a sense of pleasure, while autotelic involves experiencing a self-contained activity without seeking any potential benefit [26]. In turn, autotelic behaviors engage people entirely (experience a state of flow) and considered the most enjoyable, satisfying, and

CHAPTER 6

Applications of HCI in Health Care for Diagnosis of Rheumatoid Arthritis

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Abstract: The human-computer interaction (HCI) is a discipline concerned with the design, evaluation, and implementation of interactive computing systems for human use and the study of major phenomena in the health care system. There is a growing demand for healthcare, and this necessitates the development of healthcare technology. Digital technologies are now playing a major role in delivering healthcare and individuals' health and well-being management experiences. The use of digital technology like digital x-ray and computer interface-based applications makes many tasks easy for doctors and humans. These computer interface system saves time with most accurate results as compared to humans. For health care systems, a computer-developed application is used to save time. It was also used to disseminate doctors' efficiency for critical tasks, which made it easy by computer interface such as diagnosis of a critical disease like rheumatoid arthritis. This research is based on computer applications and their doctors' usage to correct Rhemutoidarthrits in an early stage. This research aims to use the software and identify if it is currently being used to enhance or upgrade the level of diagnosis system for doctors using deep learning methods. The Research analysis of the software is performed by collecting digital x-ray image data. The results of the research share the network-wise details of software for the diagnosis of Rheumatoid arthritis.

Keywords: Abnormal, Automatic Detection, Computer System, Convolutional network, Convolution, Deep Learning, Digital x-ray, Features, Full Connected, Gabor Filter, HCI Design, Human-Computer, Image Preprocessing, Normal, Neural Network, Prediction, Pooling, Rectified, Rheumatoid arthritis, Segmentation.

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INTRODUCTION

The implementation of intelligent technologies such as the Internet of Things (IoT) and cloud computing present prospects for advancements in the production of healthcare devices [1]. Along with other sectors, advancements in technology have changed healthcare through electronic health records (EHRs), digital images, wireless sensors, and access to internet information.

Increasing numbers of people own mobile devices from which they access the Internet. Rheumatology and other clinical specialties need to adapt to this changing environment, taking up opportunities that emerge from better digital data and information. As rheumatoid arthritis (R.A.) remains a cornerstone of rheumatology practice, we review these advances in technology and their-opportunities with an R.A. focus.

However, like all new technologies, their introduction adds a learning burden and cognitive load for both patients and healthcare providers (HCPs). Human-computer interaction (HCI) design aims to find solutions to such critical and chronic disease problems. HCI in mobile health (mHealth) devices is a crucial process in the interpretation of health data and dissemination of health services, as it shapes the connection between these devices and both the patients and HCPs

BACKGROUND

The various imaging technologies were studied to evaluate the severity of the disease. But a limitation exists in all the current technologies. The assessment of multiple joints with magnetic resonance imaging (MRI) is time-consuming and too expensive for routine use [2, 3].

For decades, X-ray images have been used to help detect R.A. and monitor bone damage progression [4 - 9]. In early R.A., however, X-rays may appear normal although the disease is active – making the films useful as a baseline but not much help in getting a timely diagnosis and treatment.

Enter modern imaging techniques, including ultrasound and magnetic resonance imaging (MRI), which can reveal early, non-bony signs of R.A. that are invisible on X-ray.

“Both MRI and ultrasound are more sensitive at detecting bone erosion than X-ray. Also, they reveal inflammation, which we could not see directly before and had to rely on blood tests and to use our fingers to feel the joints,” says rheumatologist Philip Conaghan, professor of musculoskeletal medicine at the University of Leeds.

That capability has become increasingly important in developing ways to slow the R.A. disease process before severe bone and joint damage occurs, using disease-modifying antirheumatic drugs (DMARDs), including biologics.

Both ultrasound and MRI can detect inflammation of the lining of the joints and tendon abnormalities. Also, MRI detects increased fluid (edema) areas in the bone marrow that is a predictor for bony erosions. While musculoskeletal MRI is quite expensive and requires an experienced radiologist to read, rheumatologists often have access to power Doppler ultrasound in their offices – used most frequently to guide joint aspirations and injections. Many rheumatologists can add ultrasound to their physical exam. Still, quantifiable measures of what distinguishes R.A. from routine ultrasound (or how many joints need to be examined) have been lacking. Fig. (**1**) shows the different existing methods for detecting the R.A.

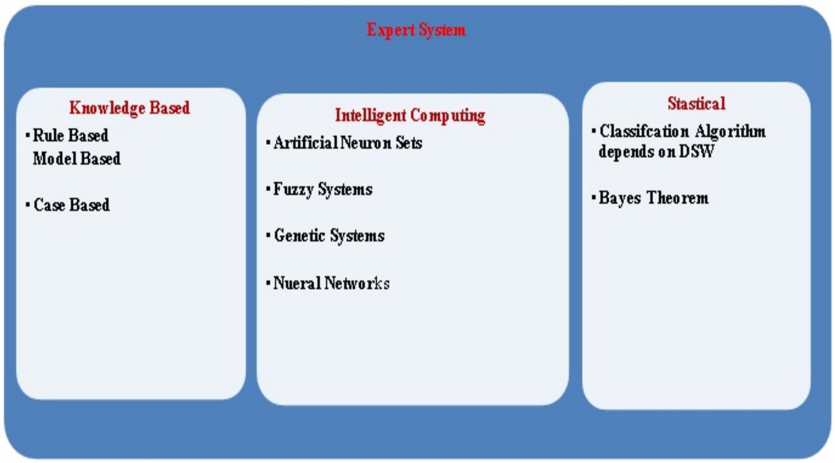

Fig. (1). Existing Different Methods for detecting Rheumatoid Arthritis.

In research presented at the American College of Rheumatology (ACR) annual meeting in November 2012, researchers from Brazil looked at how ultrasound measurements are taken in small, medium, and large joints that could help physicians diagnose R.A. For most joints, they were able to quantify a level of change that distinguished R.A. patients from controls. However, useful ultrasound is not a solo diagnostic test for rheumatoid arthritis.

Patients are typically referred to a rheumatologist by their primary care physician if R.A. is suspected. Rheumatologists use several symptoms and blood tests to determine if R.A. is present. Rheumatologists routinely order radiographs (X-Rays) to help with the diagnosis and record disease progression. Radiographs of the hands and feet have been used consistently for the past half-century to

CHAPTER 7

Optimization Techniques in ANN for Assessing Meteorological Droughts in Dhaka and Chittagong, Bangladesh

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Abstract: Bangladesh significantly depends on seasonal and annual rainfall for agriculture. Yet, there are flash or regional floods and droughts affecting human-lives, properties, and crops that urge low-cost but accurate warning systems in meeting sustainable developments. The paper aims to predict rainfall in Bangladesh by incorporating the Artificial Neural Network with optimizations based on climatology. The study-site is focused on metropolitans: Dhaka (capital) and Chittagong (port) cities and compared with historical evolutions. The experiments include data mining and a statistical approach for trend analyses before modeling. The observation data, *i.e*., 24-hr accumulated rainfall (mm), is obtained from Bangladesh Meteorological Department (1989 to 2014) and Ogimet (1999 to 2018). September is a neutral and transitional month from monsoon to winter to evaluate drought scenarios. Additionally, in Matlab R2018b, Nonlinear Autoregressive with external input (NARX) is tested with several optimization techniques: Levenberg-Marquardt (LM), Bayesian Regularization (BR), and Scaled-Conjugate Gradient. ANN models show that Chittagong has more rainfall than Dhaka supporting climatological statistics. Specifically, forecasts for Dhaka are 25%, 21%, and 22%, and Chittagong 31%, 30%, and 8%, respectively, using LM, BR, and SCG. The iterations for Chittagong 12, 201, and 10 and Dhaka are 5, 12, and 47, respectively, by LM, BR, and SCG. The results suggest rainfall probabilities in September about 20 to 30% of annual events. The study, particularly for Chittagong in ANN, refers to computational resources and time that are significant to test sensitivities before building a meteorological disaster management tool.

Keywords: Agriculture, Artificial intelligence, Bangladesh, Bayesian Regularization, Computation, Conjugate gradient, Climatology, Development, Economy, Levenberg-Marquardt, Meteorological Droughts, Metropolitans, NARX, Neural Network, Optimization, Prediction, Rainfall, Sustainability.

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INTRODUCTION

The 21st century aims to provide comfortable and advanced lifestyles *via* eco-friendly infrastructure and green technology. These developments are leading to the growth of the smart city, smart environment, and disaster management. The role of green infrastructures is also to meet sustainable development goals (SDGs). Various researches illustrate the application of the internet of things (IoT) in developing greener cities, safer environments, and better observations.

For instance, an optimized algorithm using long short-term memory (LSTM) was applied to detect changes in Land-use and Land-cover (LULC) for better environmental management [1]. This modeling system will reduce environmental degradation and secure animal habitats. In other words, IoT application enhances green technology for progressing smart environments. Another current research developed an algorithm to monitor, track, and analyze human behavior (among elderly people) for providing safe healthcare [2]. This study shows that smart city improves lifestyles while continuing the development of applications in information technology. For meeting SDGs, a smart environment is also necessary for better disaster management.

Meteorological disasters, both floods and droughts, have significant impacts on human lives and the environment. Besides economic losses, humans and environmental diversity also suffer from these disastrous effects. Both SDGs and smart city-environment, smart disaster management is growing around the globe. Besides, the government of Bangladesh (GoB) focuses on various actions to enhance smart countries' economic growth and lifestyles. As GoB also declares a slogan “Digital Bangladesh” and SDGs, this initiative shows how Bangladesh aims to enter smart management systems. Eventually, disaster management can boost up using smart technology to save property damages and human losses. In this chapter, the development of a smart meteorological disaster management system is given in the context of Bangladesh.

Rainfall is important for evaluating irrigational costs in an agro-based economy and water infrastructure development and management. Bangladesh, a developing country, significantly depends on rain-fed rivers and groundwater storage for practicing agriculture. However, the country experiences regional and flash floods that frequently affect human-lives, property-damages, and agricultural-products. Furthermore, Bangladesh is a lowland and deltaic country. *Trans*-boundary Mountains with India, Myanmar, and Bhutan complicate the geographical location. Specifically, three major rivers, such as the Ganges, Brahmaputra, and

Meghna, connect to more than 450 channels, rivers, tributaries, streams, and canals around the country flowing to the Bay of Bengal (BoB) and Indian Ocean (IO).

Bangladesh Bureau of Statistics (BBS) states that yearly average rainfall is received 191 and 125 (mm) in 2015 and 2016, respectively comparing from 1981 to 2016 climate data. The variations in season are also found about 210 with 80% relative humidity (RH) in post-monsoon, whereas pre-monsoon, monsoon, winter are 453, 1733, and 44, respectively [3]. This rainfall amount shows how Bangladesh faces floods in the rainy season and droughts in the dry season. Annual rainfall significantly varies in Southeast about 275 and 184 (Chittagong and Teknaf), Southwest about 144 and 185 (Khulna and Sundarbans), Central about 160 and 114 (Dhaka), North about 177 and 180 (Bogra and Rajshahi), Northeast about 269 and 358 (Sylhet and Srimongol) regions in 2015 and 2016 respectively [3]. Station observations signify local situations and their diversity, equally important to note for agricultural and industrial water demands.

In addition to geographical locations, the capital and port city expand to accommodate huge populations for job markets, education, and health- care. The urbanizations and land-use changes eventually have impacts on water storage [4]. For instance, concrete roads and infrastructures poorly support rainfalls to infiltrate recharging the groundwater. This causes metropolitans to experience flash and regional floods along with insufficient warning systems. Since water does not recharge well during monsoon (quick drainages), the groundwater table significantly reduces as over-extraction supports urban lifestyles [4]. Moreover, Bangladesh has sparse observations (only 34 stations), which makes it challenging to forecasting. However, artificial intelligence (AI), mostly machine learning (ML) techniques, can study meteorological variables to efficiently address these challenges.

Investigations of historical evolutions are significant for metropolitans to find any correlation to rainfall climatology and meteorological disasters. Several studies found that backpropagation neural networks (BPNN) are popular in forecasting weather variables like temperature and rainfall. For example [5], found 98% forecasting accuracy for 2001 to 2013 data. A study in [6] showed 99.79% (train) and 94.28% (test) for 1901 to 2000, *i.e.,* 2/3 and 1/3 data used, respectively [7]. concluded the root mean square error (RMSE) of 8.14 and 8.28 respectively for the train: 2005-2009 and for the test: 2010-2014 datasets. Finally [8], performed sensitivity tests for various BPNN and found model E outperformed by yielding a 96.72% efficiency index with 0.71 RMSE. These AI and ML offer a platform for testing Bangladesh rainfall cases.

CHAPTER 8

The Role of EUPs in custom GUIs for Future Integration of HCI-enhancing Devices

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Abstract: Although architecture software companies incorporate high-level programming to process the complexity of data, only some End-User Programmers (EUP) manage to customize their GUI to design and integrate smart devices for future smart homes and smart cities. HCI is a source of inspiration to incorporate a large part of the design process into creative flows. In this context, we identify patterns to analyze, interpret, and optimize the work of EUP architects who seek to customize the GUI of their digital design tools. We obtained a set of 16 patterns that reconfigure the interaction of their processes. We programmed the integration of data science in architecture, machine learning, visual and textual programming, Cloud Computing with AWS, and Augmented Reality with Unity. The result is an ecosystem of three platforms that compensate for the shortcomings of computerized design in data-driven design processes, optimizing execution time in an emergency, with perspectives towards Smart and Interconnected Environments. Considering that the GUI is the most important product of HCI research, our analysis and interpretation of the results and their discussion highlight the need to explore personalized GUI solutions promoted by the designers to enrich them, capitalizing on their processes in codes for the reuse and co-design of new interactions.

Keywords: Artificial Intelligence, Architectural Design, Augmented Reality, AWS, AWS Comprehend, AWS Rekognition, Cloud Computing, Computational Design, Design Process, EUP, GUI, HCI, Industry 4.0, IoT, Latin America, Neural Network, Open Data, Unity, Pattern, Visual Programming.

INTRODUCTION

Barricelli *et al.* [1] argue that computational techniques that empower end-users of technologies were born from Human-Computer Interaction (HCI). In the 1990s, Nardi [2] (in the context of End User Computing) explained that people such as chemists, librarians, teachers, architects, and accountants, seriously

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wanted to use computers level because they often failed to get the applications they wanted. However, they were not interested in becoming professional programmers or "contract programmers or in-house programmers to write the few programs they will need" [2]. In architecture, Gantt and Nardi [3] named them Gardeners. In the same context, Burry [4] justified this practice due to the lack of specific tools to solve some design problems, forcing architects to create their macros in the software of their choice. At the end of the first decade of the 21st century, the evolution of Computation Theories and Technologies in Architectural Design [5] allowed architects to develop their tools [6] above other professionals such as industrial designers [7].

As demonstrated [8], End-User Programming (EUP) introduced a new scenario in the HCI because it brought users closer to personalizing, expanding, and/or combining resources for other contexts of needs and usage, to the point that the EUP along with Graphical User Interfaces (GUI) became convergent technologies.

Research in the context of Smart Home of connected objects and Smart Cities initiatives is driven towards hyper-connected urban environments, promoting that intelligent systems adapt to the work and daily needs of users who interact with defined parameters and in a context-specific to achieve a goal [9]. In this context, interactions are captured and processed in databases [10], or human behavior is analyzed during the interaction of those actions [11]. Di Nardo *et al*. [12] stated that the data of these interactions originated from the Internet of Things (IoT) and Cyber-Physical Systems (CPS) in the context of the Fourth Industrial Revolution: Big Data and analytics, Robot-assisted production, self-driving logistics vehicles, augmented reality, and additive manufacturing. EUPs in the Fourth Industrial revolution context [12], [13] revealed solutions to different modes of interaction because they allowed adapting tools and workplaces to the needs and user preferences [14].

Scupelli [15] proposed that commercially available IoT systems could empower non-programmers to sense user activity, control smart things, test their configuration, and make it easier for end-users to customize their work environment. Sailer [16] showed how researchers from the Space Syntax group discovered that the configuration of a space system significantly explains the movement flows but shows limitations when the interaction and co-presence of participants are highly controlled. Therefore, the movement flows prevent following the configuration proposed by the users. Brich *et al*. [17] stated that scheduling notations and rule-based process-oriented configuration could be used by end-users for effective scheduling, rather than just focusing on the configuration. For this reason, EUP designers proposed solutions such as activity

connectivity, which implies a set of parameters (integration, choice, control value, and entropy) that would allow the configuration of the living quarters for the elderly [18]. Designers can thus know all the variables to optimize their design over time, improving users' quality of life, unlike only those who configure their environment, without knowing the variables that govern the design.

The System Mapping Study (2000-2017) [1] showed that the solutions proposed by the EUPs focused on making programming an easy activity for non-programming expert users, but at the same time, "to design novel techniques that foster end users' participation in system modification and shaping over time without requiring a high cognitive effort." Reisinger *et al.* [19] argued that the use of End-User Programming addressed different solutions from simple to complex in the context of smart homes. From an opposite context, we consider Harrison [20], quoted by Barricelli *et al*. [1], who doubts the value of the EUP in the correction, maintenance, and security that can be configured in the products. In our experience, this statement is critical when the end-user has not been part of the product creation process. On the contrary, designers who were part of the process have more opportunities to enhance their work as EUP. Therefore, in this research, we focus on programming for the End-User of the process (such as designers and architects) and not on programming for the product's End-User. The inclusion of EUP and customization from the design process becomes an important basis for integrating them into devices that improve and promote the sustainability of HCI towards Smart and interconnected environments. The model proposed for the End-User of the design process integrates different professionals who co-design (and program) the solution simultaneously. This process is constantly reviewed, with a code that promotes participatory design using a common visual programming language. Raymond [21] evidenced that in a digital context and the socialization of information, "the greater the number of reviewers, the easier the errors in a problem will be found," allowing advancing and integrating sub-processes to enhance the model. This could answer Kronman and Zingerle [22] in the context of the internet of other people's things: How are citizens involved in co-design collaborations with private corporations and the public sector to build better cities? A starting point, which is the subject of this research, is to return to the process code. Action between the 1960s and 1980s was limited by programming languages that did not manage to separate themselves from academic research and make sustained incursions into the practice. Our model is emerging as a space for integration and continuous improvement, allowing the HCI to strengthen its life cycle from the workgroup that produces it to enrich the product's user experience.

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