Continuous Arm Gesture Recognition based on Natural Features and Generalized Methods of Image Processing

Prof. Deepak Uplaonkar (Guide), Swapnil Mishra, Payal Gaikwad, Sanjay Singh, Pratik Magar

Abstract - Hand gesture interaction has been the trending technology for human-computer interaction (HCI). Frequently a number of research works are carried out in this area to expedite and contrive interaction with computers. In this project, we are attempting to create a real-time human-computer interaction system (HCI) using different hand gestures methods : hand movement and hand signs. We propose a single camera hand gesture estimation algorithm for hand gesture tracking in 2D space from a distance and are mapped to the screen coordinates. OpenCV library can be used to perform the needed task. Various methods of Image Processing can be applied for the same and the operations that can be carried out are Capturing frames, Background Subtraction using MOG filter, Noise Reduction using Gaussian Blur, converting the captured image to binary image, find contours through Convex Hull method which is used for removing convexity defects. The image is then segmented and it's features are extracted. Different sets of gestures are assigned with different key-press events which are then performed when the captured gesture matches a similar gesture from the dataset.

Index Terms – Artificial Intelligence (AI), Human-Computer Interaction (HCI), Image Processing

I. INTRODUCTION

The HCI product is produced and used by the humans which are the users of the product. For understanding humans as an information-processing system, how they communicate, characteristics of the human/user as a processor of information-Memory, attention, problem-solving, learning, motivation, motor skills, conceptual models and diversity. Language, interaction and communication-Aspects of language-Syntax, pragmatics, semantics, conversational interaction and specialized languages. to workplace and the environment around them, also provide a platform to user to formulate and interact with the components and provide and effective learning.Computers are good at counting and measuring, precise storage and recall, rapid and consistent responses, data processing or calculation, formulations, repetitive actions, and performance over time, "Simple and sharply defined things". The interaction is a two- way process between a user and a computer.

HCI surfaced in the 1980s with the advent of personal computing, just as machines such as the Apple Macintosh, IBM PC 5150 and Commodore 64 started turning up in homes and offices in society-changing numbers. For the first time, sophisticated electronic systems were available to general consumers for uses such as word processors, games units and accounting aids. Consequently, as computers were no longer room-sized, expensive tools exclusively built for experts in specialized environments, the need to create human-computer interaction that was also easy and efficient for less experienced users became increasingly vital. From its origins, HCI would expand to incorporate multiple disciplines, such as computer science, cognitive science and human-factors engineering.

HCI soon became the subject of intense academic investigation. Those who studied and worked in HCI saw it as a crucial instrument to popularize the idea that the interaction between a computer and the user should resemble a human-to-human, open-ended dialogue. Initially, HCI researchers focused on improving the usability of desktop computers (i.e., practitioners concentrated on how easy computers are to learn and use). However, with the rise of technologies such as the Internet and the smartphone, computer use would increasingly move away from the desktop to embrace the mobile world.

HCI differs from human factors and ergonomics as HCI focuses more on users working specifically with computers, rather than other kinds of machines or designed artifacts. There is also a focus in HCI on how to implement the computer software and hardware mechanisms to support human–computer interaction. Thus, human factors is a broader term; HCI could be

described as the human factors of computers although some experts try to differentiate these areas. HCI also differs from human factors in that there is less of a focus on repetitive work-oriented tasks and procedures, and much less emphasis on physical stress and the physical form or industrial design of the user interface, such as keyboards and mouse devices.

Human–computer interaction studies the ways in which humans make-or do not make-use of computational artifacts, systems and infrastructures. Much of the research in the field seeks to improve human–computer interaction by improving the usability of computer interfaces. How usability is to be precisely understood, how it relates to other social and cultural values and when it is, and when it may not be a desirable property of computer interfaces is increasingly debated.

Much of the research in the field of human–computer interaction takes an interest in:

1. Methods for designing new computer interfaces, thereby optimizing a design for a

2. Methods for designing new computer interfaces, thereby optimizing a design for a desired property such as learnability, findability, efficiency of use.

3. Methods for evaluating and comparing interfaces with respect to their usability and other desirable properties.

4. Methods for studying human computer use and its sociocultural implications more broadly.

5. Methods for determining whether or not the user is human or computer.

6. Models and theories of human computer use as well as conceptual frameworks for the design of computer interfaces, such as cognitivist user models, Activity Theory or ethnomethodological accounts of human computer use.

7. Perspectives that critically reflect upon the values that underlie computational design, computer use and HCI research practice.

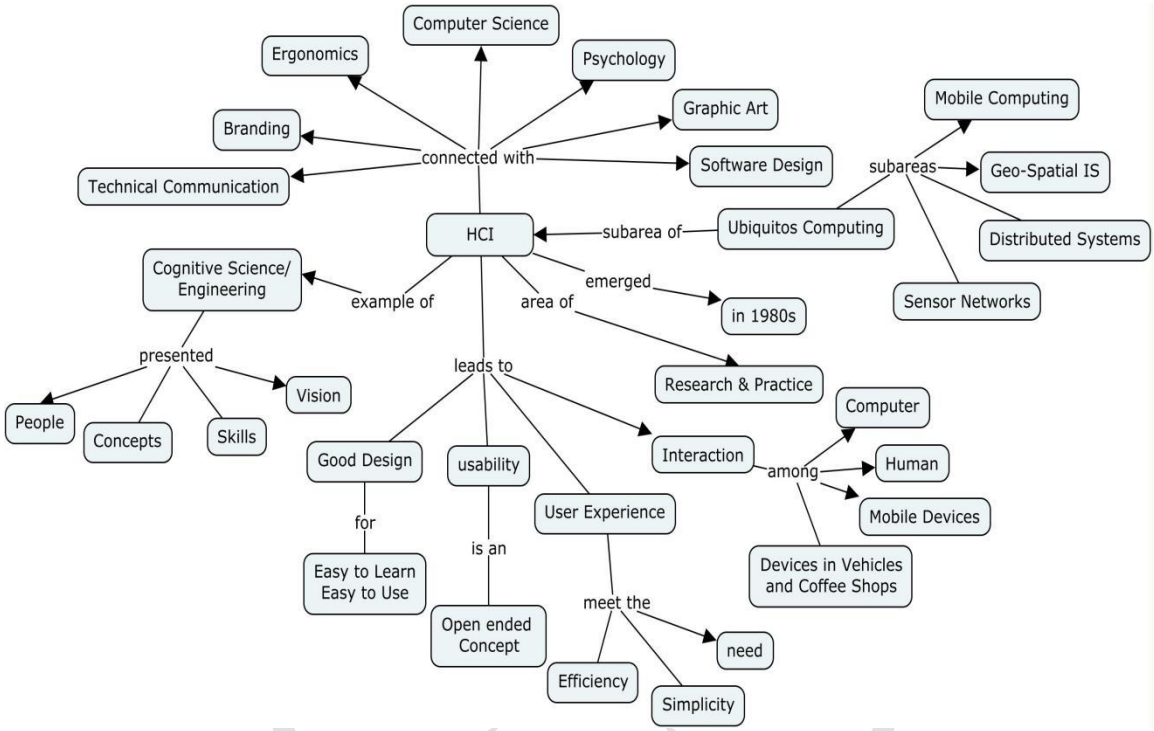

Fig. 1. Fields in HCI

II. HCI DESIGN PROCESS

HCI design is considered as a problem solving process that has components like planned usage, target area, resources, cost, and viability. It decides on the requirement of product similarities to balance trade-offs.

The following points are the four basic activities of interaction design −

- Identifying requirements
- Building alternative designs
- Developing interactive versions of the designs
- Evaluating designs

Various methodologies have materialized since the inception that outline the techniques for human–computer interaction. Following are few design methodologies −

1. Activity Theory − This is an HCI method that describes the framework where the human-computer interactions take place. Activity theory provides reasoning, analytical tools and interaction designs.

2. User-Centered Design − It provides users the center-stage in designing where they get the opportunity to work with designers and technical practitioners.

3. Principles of User Interface Design − Tolerance, simplicity, visibility, affordance, consistency, structure and feedback are the seven principles used in interface designing.

4. Value Sensitive Design − This method is used for developing technology and includes three types of studies − conceptual, empirical and technical.

- Conceptual investigations works towards understanding the values of the investors who use technology.
- Empirical investigations are qualitative or quantitative design research studies that shows the designer's understanding of the users' values.
- Technical investigations contain the use of technologies and designs in the conceptual and empirical investigations.

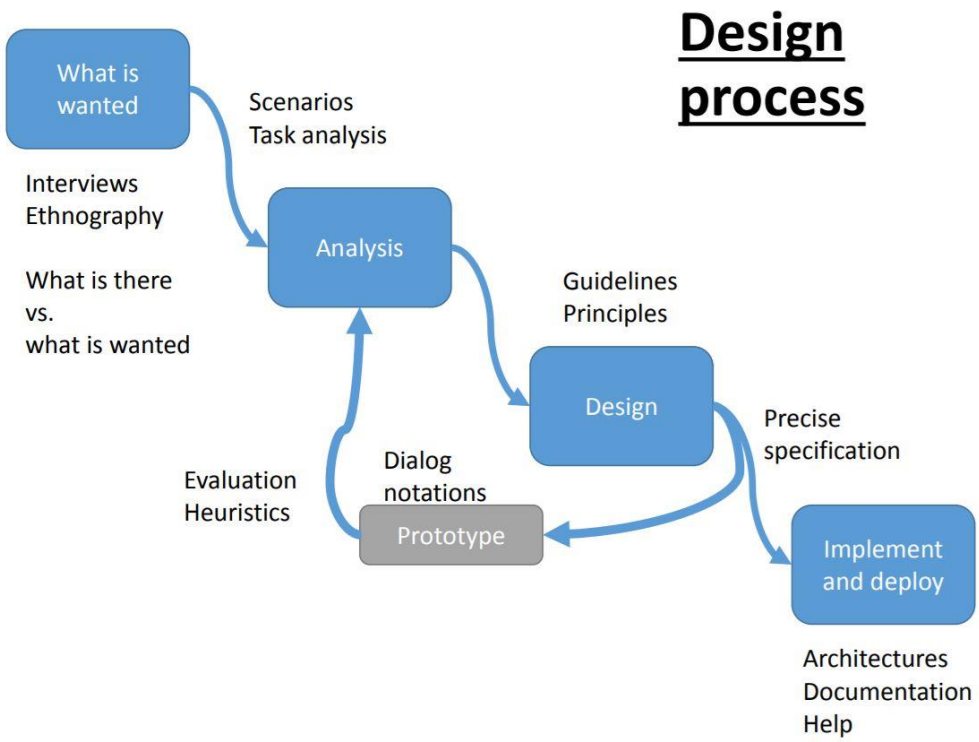

Fig. 2. Design Process of Human Computer Interaction (HCI) System

Ebert's described four human computer interactions design approaches that may be applied to the user interface designs to develop user friendly, methodical, and instinctive users experience for the users.

One or more approaches can be used in a single user interface design. The four approaches to design a user interface are-

1. Anthropomorphic Approach

This approach involves designing human interface such as to produce human like characteristics.

2. Cognitive Approach

This approaches used to develop a user interface that supports the end user and considers the abilities of human brain and sensory recognition.

3. Empirical Approach

This approach is used for examining and comparing the usability of multi-conceptual designs.

4. Predictive Modelling Approach

GOMS method is used for examining and takes into consideration, user's experience in terms of time taken by a user to efficiently and effectively complete a goal. GOMS stands as G stands for goals, O for operators, M for methods and S for section rules. The definite measurements of human's performance are used to calculate the time taken by it to accomplish a particular goal.

III. FACTORS OF CHANGE

Traditionally, computer use was modeled as a human–computer dyad in which the two were connected by a narrow explicit communication channel, such as text-based terminals. Much work has been done to make the interaction between a computing system and a human more reflective of the multidimensional nature of everyday communication. Because of potential issues, human–computer interaction shifted focus beyond the interface to respond to observations as articulated by D. Engelbart: "If ease of use was the only valid criterion, people would stick to tricycles and never try bicycles."

The means by which humans interact with computers continues to evolve rapidly. Human–computer interaction is affected by developments in computing. These forces include:

- Decreasing hardware costs leading to larger memory and faster systems
- Miniaturization of hardware leading to portability
- Reduction in power requirements leading to portability
- New display technologies leading to the packaging of computational devices in new forms
- Specialized hardware leading to new functions
- Increased development of network communication and distributed computing
- Increasingly widespread use of computers, especially by people who are outside of the computing profession
- Increasing innovation in input techniques (e.g., voice, gesture, pen), combined with lowering cost, leading to rapid computerization by people formerly left out of the computer revolution.
- Wider social concerns leading to improved access to computers by currently disadvantaged groups.

As of 2010 the future for HCI is expected to include the following characteristics:

- Ubiquitous computing and communication. Computers are expected to communicate through high speed local networks, nationally over wide-area networks, and portably via infrared, ultrasonic, cellular, and other technologies. Data and computational services will be portably accessible from many if not most locations to which a user travels.
- High-functionality systems. Systems can have large numbers of functions associated with them. There are so many systems that most users, technical or non-technical, do not have time to learn them in the traditional way (e.g., through thick manuals).
- Mass availability of computer graphics. Computer graphics capabilities such as image processing, graphics transformations, rendering, and interactive animation are becoming widespread as inexpensive chips become available for inclusion in general workstations and mobile devices.
- Mixed media. Commercial systems can handle images, voice, sounds, video, text, formatted data. These are exchangeable over communication links among users. The separate fields of consumer electronics (e.g., stereo sets,

- VCRs, televisions) and computers are merging partly. Computer and print fields are expected to cross-assimilate.
- High-bandwidth interaction. The rate at which humans and machines interact is expected to increase substantially due to the changes in speed, computer graphics, new media, and new input/output devices. This can lead to some qualitatively different interfaces, such as virtual reality or computational video.
- Large and thin displays. New display technologies are maturing, enabling very large displays and displays that are thin, lightweight, and low in power use. This is having large effects on portability and will likely enable developing paper-like, pen-based computer interaction systems very different in feel from present desktop workstations.
- Information utilities. Public information utilities (such as home banking and shopping) and specialized industry services (e.g., weather for pilots) are expected to proliferate. The rate of proliferation can accelerate with the introduction of high-bandwidth interaction and the improvement in quality of interfaces.
-

IV. LITERATURE REVIEW

A review of important factors of the interaction between human and computers will help to explore applications of human-computer interaction (HCI) within the hospitality workplace. First, the definition of HCI must be clarified since there is no consensus on the exact definition of HCI applications within the service industry. Then, why and how people interact with computers in order to accomplish their personal goals and work must be described. For example, what are the interaction factors and constraints on the users' side? Service industry researchers have identified that the customers' perception of service quality is a critical element that determined the nature of the service encounter between customers and the human or computer service provider. The quality of service may be highly undermined by purchasing a poorly designed HCI. If the computer action is not in tune with the service command, problems will occur resulting in frustrated customers and angered employees (McBride & Eleltagi, 2004).Thus, the applicability of HCI design within the hospitality workplace and considerations for successful implementation

will be rejected.

1. Ker-Jiun Wang et. al: "Human-Centered, Ergonomic Wearable Device with Computer Vision Augmented Intelligence for VR Multimodal Human-Smart Home Object Interaction" 2019:

In this paper, we will showcase the use of an ergonomic and lightweight wearable device that can identify human's eye/facial gestures with physiological signal measurements.

2. Fang Rong Hsu et. al: "A Study of User Interface with Wearable Devices Based on Computer Vision" 2019:

Smart wearable devices are widely used in the field of healthcare. This article presents three approaches to human–computer interaction (HCI) via computer vision and hand gestures. They are timeline-user interface, virtual keyboard user interface, and handwritten digit user interface, respectively. These user interfaces are achieved by including the image process and machine learning, such as Convolutional Neuron Networks and AdaBoost. To evaluate the approaches, a prototype of the android device with a built-in color camera was employed. The result of the handwritten digit model was significant for high accuracy of 92.9%. In our view, the results emphasize the validity of our models.

3. Jing Xiao, et. al: "An Electrooculogram-Based Interaction Method and Its Music-on-Demand Application in a Virtual Reality Environment" 2019 :

This paper proposes a new nonmanual human-computer interface (HCI) based on a single-channel electrooculogram (EOG) signal and enables real-time interactions with the VR environment. The graphical user interface of the EOG-based HCI in VR includes several buttons flashing in a random order. The user needs to blink in synchrony with the corresponding button's flashes to issue a command, while the algorithm detects the eye blinks from the EOG signal and determines the users' target button. Furthermore, with the EOG-based HCI, we developed a music-on-demand system in the VR environment.

In this paper, three combined non-invasive psychophysiological measures were used to verify which of them represents the emotion's dimensions. Besides that, an approach to studying the tendency of user's emotion is presented, assisting HCI researchers in HCI experiments. An experiment was conducted using quantitative and qualitative data analysis, and the results show important correlations that were used in the proposed approach.

5. *Dharmaraj Ojha et. al: "Histogram based Human Computer Interaction for Gesture Recognition" 2019 :*

This paper introduces a technique for human computer interaction using open CV and python. We have first detect, pre-processing and recognize the hand fingers and the count. Then with the help of recognized fingers count, it is act as a mouse to perform the different operations and this hand mouse interface known as a "virtual monitor". The hand mouse is controlled by the virtual monitor provides a virtual space. The accuracy of the proposed algorithm is 80%. This envisioned concept controlling a system by hand has been implemented successfully with effective efforts.

6. *Liannan Lin et. al: "Intelligent Human-Computer Interaction: A Perspective on Software Engineering" 2019:*

The design of traditional human-computer interaction courses is facing new challenges due to the breakthrough of the third generation of AI technology. New human-computer interaction scenarios, such as smart home and driverless cars, keep on emerging. More natural and efficient intelligent interaction methods are widely used in these scenarios, generating brand-new user experience. Combined with an example on the interactive design of intelligent products and the previous experience on teaching. In this article, an innovative design of human-computer interaction courses is introduced from the perspective on innovative content, cultivation of talents, and practice of software engineering.

7. *Jae-Woo Choi et. al: "Short-Range Radar Based Real-Time Hand Gesture Recognition Using LSTM Encoder" 2019:*

This paper proposes a hand gesture recognition system for a real-time application of HCI using 60 GHz frequency-modulated continuous wave (FMCW) radar, Soli, developed by Google.

The overall system includes signal processing part that generates range-Doppler map (RDM) sequences without clutter and machine learning part including a long short-term memory (LSTM) encoder to learn the temporal characteristics of the RDM sequences. A set of data is collected from 10 participants for the experiment. The proposed hand gesture recognition system successfully distinguishes 10 gestures with a high classification accuracy of 99.10%. It also recognizes the gestures of a new participant with an accuracy of 98.48%.

8. *Gang-Joon Yoon et. al: "Three-Dimensional Density Estimation of Flame Captured From Multiple Cameras" 2019:*

This paper presents a 3D density flame reconstruction method, captured from the sparse multi-view images, as a constrained optimization problem between the flame and its projected images. For effective estimation of the flame with a complicated structure in an arbitrary viewpoint, we extract the 3D candidate region of the flame and, then, estimate the density field using the compressive sensing.

9. *Yanbo Tao et. al: "Human-Computer Interaction Using Fingertip Based on Kinect" 2018:*

Controlling the computer through the hand and eye is a new type human-computer interaction, which overcomes the problem of insufficient flexibility in controlling the traditional computer through the mouse and keyboard. This kind of human-computer interaction is more natural and is an inevitable trend of human-computer interaction in the future. The Kinect based hand-eye positioning system is capable of quickly locating the hand-eye position through depth images and color images, and has a strong real-time performance.

10. *Sherin Mohammed Sali Shajideen et. al: "Hand Gestures - Virtual Mouse for Human Computer Interaction" 2018:*

This research work focuses on the improvement of human computer interaction systems using hand gesture with 3-D space by using two camera in position. The hand pointing gesture is estimated and mapped to the screen coordinate system. Also we use other hand gestures to complete the action of virtual mouse. We use hand pointing to point to the screen and other gestures for other operations such as selection of a folder/an object.

11. *Sherin Mohammed Sali Shajideen et. al: "Human-Computer Interaction System Using 2D and 3D Hand Gestures"*

2018:

In this paper, we propose a real-time human-computer interaction system (HCI) using two different hand gestures - hand pointing and clenched fist gesture. We propose a single camera hand gesture estimation algorithm for hand gesture tracking in 2D space from a distance and are mapped to the screen coordinates. Moreover, we also propose orthogonal cameras to estimate hand gestures in 3D space from a distance and is mapped to the screen coordinates.

12. *Gu Jialu, S. Ramkumar et. al: "Offline Analysis for Designing Electrooculogram Based Human Computer Interface Control for Paralyzed Patients" 2018:*

This paper shows an average classification accuracy of 90.72% for convolution features and 91.28% for Plancherel features. Off-line single trail analysis was also performed to analyze the recognition accuracy of the proposed HCI system. The off-line analysis displayed that Plancherel features using LRNN were high compared to convolution features using LRNN.

13. *Shravani Belgamwar et. al: "An Arduino Based Gesture Control System for Human-Computer Interface" 2018:*

This paper presents a literature survey conducted which provides an insight into the different methods that can be adopted and implemented to achieve hand gesture recognition. It also helps in understanding the advantages and disadvantages associated with the various techniques.

14. *Adrian Hoppe et. al: "Multi-user Collaboration on Complex Data in Virtual and Augmented Reality" 2018:*

We propose a technique that gives the remote supporter the ability to see a high fidelity point cloud of a real world object in Virtual Reality (VR). The VR user can indicate points of interest via a laser pointer. The local worker sees these indications on top of the real object with an Augmented Reality (AR) headset. A preliminary user study shows that the proposed method is faster and less error-prone regarding the comprehension of the object and the communication between the users.In addition to that, the system has a higher usability.

of cursor movement (ALCM)-that locks a cursor at the center of a target at the instant the cursor enters the target. The method is intended to suppress irritating subtle cursor movements that occur when an eye-gaze input system transforms involuntary eye movement (e.g., drift) into cursor coordinates. The effectiveness of the proposed ALCM was verified using pointing performance (speed and accuracy) in two types of HCI tasks. In a drag task, we compared mouse input versus eye-gaze input with use of a backspace (BS) key or voice input.

16. *Sourav S. Bhowmick et. al: "VISUAL:* Simulation of Visual Subgraph Query Formulation to Enable Automated Performance Benchmarking" 2017 :

Our experimental study demonstrates the effectiveness of VISUAL in accurately simulating visual subgraph queries.

17. *Lennart E. Nacke et. al: "Games User Research and Gamification in Human-Computer Interaction" 2017:*

Video games have become the focus of attention in the field of human-computer interaction (HCI), a focus that looks beyond the study of video games as mere testbeds for interaction studies, or investigations of a game's user interface. For example, some games have moved to free-to-play business models, where a small number of players pay for premium game content. In these games, user behavior is predicted through the collection of telemetry data, which is also used on mobile phones to provide information about a user's location. This data is then analyzed with machine learning techniques to create personalized experiences.

18. *Jinxian Qi et. al: "Intelligent Human-Computer Interaction Based on Surface EMG Gesture Recognition" 2017:*

In this paper, linear discriminant analysis (LDA) and extreme learning machine (ELM) are implemented in hand gesture recognition system, which is able to reduce the redundant information in sEMG signals and improve recognition efficiency and accuracy. The characteristic map slope (CMS) is extracted by using the feature re-extraction method because CMS can strengthen the relationship of features cross time domain and enhance the feasibility of cross-time identification. This study is focusing on optimizing the time differences in sEMG pattern recognition, the experimental results are beneficial to reducing the time differences in gesture recognition based on sEMG.

19. Elisabeth Adelia Widjojo et. al: "Virtual Reality-Based Human-Data Interaction" 2017:

In this position paper, we share our views on how VR-based HDI can support exploration of multidimensional large data sets with the aim at providing direction for open research areas that may serve the design of a VR-based HDI system in this emerging field of research.

20. Soumya Priyadarsini Panda et. al: "Automated speech recognition system in advancement of human-computer interaction" 2017:

This paper provides an overview of the automated speech recognition system along with a wide set of possible applications of the technology in advancement of human-computer interactive systems.

21. Nuri Murat Arar et. al: "A Regression-Based User Calibration Framework for Real-Time Gaze Estimation" 2016 :

We propose a novel weighted least squares regression-based user calibration method together with a real-time cross-ratio based gaze estimation framework. The proposed system enables to obtain high estimation accuracy with minimum user effort, which leads to user-friendly HCI applications.

22. Kwang-Ryeol Lee et. al: "Real-Time "Eye-Writing" Recognition Using Electrooculogram" 2016:

In this study, we developed a real-time electrooculogram (EOG)-based eye-writing recognition system, with which users can write predefined symbolic patterns with their volitional eye movements.

23. Daniela Dauria et. al: "Human-Computer Interaction in Healthcare: How to Support Patients during Their Wrist Rehabilitation" 2016:

The increasing use of IT/Informatics within the healthcare context is more and more helpful for both medical doctors and patients in all the surgical specialities. In this paper, we propose a low-cost system exploiting a haptic interface aided by a glove sensorized on the wrist orientation for supporting patients during their wrist rehabilitation allowing the identification of the wrist

24. Regina Jucks et. al: ""I Need to Be Explicit: You're Wrong": Impact of Face Threats on Social Evaluations in Online Instructional Communication" 2016:

This study analyzed the evaluation of face-threatening acts with a 1×3 design. An online forum thread confronted a layperson with an expert who either (a) addressed the layperson's misconceptions directly and frankly, (b) mitigated face threats through explicit hints about the need to be direct or (c) communicated politely and indirectly.

V. APPLICATIONS OF HCI

HCI has applications in many different domains of technology. Different booming technologies like Artificial Intelligence (AI), Natural Language Processing (NLP), Machine Learning (ML) and Cognitive Science make use of Human Computer Interaction in order to carry out different operations and enhance the existing technology. Not only in fields of technology, HCI has also been brought into use in many other fields like Medical, Military, Construction, etc.

Following are the different applications in which HCI has been used:

A. *Virtual Reality (VR)*

- Virtual Reality has been a trending technology since past few years. It is an artificial environment created with software and is presented to user in a way that the user accepts it as a real environment. Virtual Reality on a computer can be primarily experienced through two of the five senses: sight and sound. A 3-D image is the simplest form of virtual reality is that can be explored interactively at a personal computer. It can be done usually by manipulating keys or the mouse so that the content of the image moves in some direction or simply zooms in or out. There are even more sophisticated efforts such as haptics devices that let you feel the display images, wrap-around display screens and actual rooms augmented with wearable computers .

B. Mutli-touch Technology

- It is essentially a type of technology that allows a device to recognize and process multiple touches simultaneously. Most of the touchscreen devices like tablets or mobiles are only capable of recognizing a single touch. So it will only register the spot touched by your first finger and not your second, if you try to place your fingers on two different spots on the device at the same time. This technology is designed to terminate this problem by supporting the use of multiple, simultaneous touches.The multi-touch technology typically works in

conjunction with an ASIC sensor that is located on the device's surface. This sensor identifies the point or points of touch, relays this information to the on-board computer system of the device. There are also multi-touch gestures, which support the use of predefined motions to interact with the respective device. There are a variety of laptops, smartphones and tablet computers with multi-touch gestures.

C. 3D Printing

- 3D printing (additive manufacturing) is a process of making three dimensional solid objects from a digital file on computer. Some additive processes lead to the creation of a 3D printed object. In an additive process, an object is created by laying down successive layers of material until the object is created. Each of these layers is a thinly sliced horizontal cross-section of the object. 3D printing is the opposite of subtractive manufacturing. 3D printing helps you to create complex shapes using less material than other traditional manufacturing methods.

D. Smartwatch

- Smartwatches have been a booming trend in the market. A smartwatch is a wearable computing device that resembles a wristwatch. Many smartwatches are Bluetooth-capable and not just tell time, but also perform different functions. The watch becomes a wireless Bluetooth adaptor capable to extend the capabilities of the user's smartphone to the watch. The wearer can use the watch initiate and answer phone calls from their mobile phone, read email and text messages, get a weather report, listen to music, dictate email or text messages or ask a digital assistant a question.

E. Image Processing

- Image processing includes the manipulation of images using digital computers. Its use has been increasing exponentially in the last decades. It has many applications ranging from medicine to entertainment, geological processing and remote sensing. Multimedia systems that are one of the pillars of the modern information society too rely heavily on digital image processing. It is one of the rapidly growing technologies today, with its applications in various aspects of a business. Image Processing forms core research area within engineering and computer science. Image sharpening and restoration, Medical field, Remote Sensing, Transmission and encoding Machine/Root vision, Color processing, Video processing, Microscopic Imaging, Pattern recognition, etc are some of the major fields in which digital image processing is widely used.

F. Gaming

- Computer and Video Games are one of the most popular and the most important products of the software industry. They are one of the greatest contributors to the success and rapid improvement of technologies. However, Game Development processes still have to face some problems. The lack of guidelines and theoretical foundations are the major causes why most of the Game Designers need to bring their own experiences and intuitions into the Game Design. So, it is essential to increase the involvement of the Human Computer Interaction (HCI) in the processes of designing games.

G. *Augmented Reality*

- Augmented Reality (AR) is the result of using technology to superimpose information sounds, images and text on the world we see. Augmented Reality can be defined as a system that fulfills three basic features: a combination of real and virtual worlds, real-time interaction and accurate 3D registration of virtual and real objects. The overlaid sensory information can be either constructive or destructive. The experience is seamlessly interwoven with the physical world such that it is perceived as an immersive aspect of the real environment. In this way, augmented reality alters one's ongoing perception of a real-world environment, whereas virtual reality completely replaces the user's real-world environment with a simulated one.

VI. CONCLUSION

In the above mentioned information, we discussed about Human Computer Interaction in details. We also had a look over the HCI Design Process, it's approaches and it's various applications in different fields and domains including Image Processing. Thus, we can design a robust gesture recognition system which is based on different methods of image processing that can perform various key-press events in order to carry out different operations. Being an important technology, HCI shows us how it can be enhanced in different fields where the human requires to take help of the computer and interact with it in order to carry out the given task using image processing means.

VII. REFERENCES

1. S.Zhou, F. Fei, G. Zhang, J. D. Mai, Y. Liu, J. Y. Liou, and W. J. Li, "2d human gesture tracking and recognition by the fusion of MEMS inertial and vision sensors," IEEE Sensors J., vol. 14, no. 4, pp. 1160–1170, 2014.

2. C. Breazeal, "Social interactions in hri: the robot view," IEEE Trans. Syst., Man, Cybern. C, vol. 34, no. 2, pp. 181–186, 2004.

3. A. Akl, C. Feng, and S. Valaee, "A novel accelerometer-based gesture recognition system," IEEE Trans. Signal Process., vol. 59, no. 12, pp. 6197–6205, 2011.T. Nakamura and Y. Morishita, "Acceptability evaluation in prototype of menu search system by feelings (in Japanese)," *IEICE technical report. Data engineering*, vol. 112, no. 75, pp. 73–77, 2012.

4. T. Fan, C. Ma, Z. Gu, Q. Lv, J. Chen, D. Ye, J. Huangfu, Y. Sun, C. Li, and L. Ran, "Wireless hand gesture recognition based on continuous wave doppler radar sensors,"IEEETMICROWTHEORY,vol.64,no.11, pp. 4012–4020, 2016.

5. Z. Zhang, Z. Tian, and M. Zhou, "Latern: Dynamic continuous hand gesture recognition using FMCW radar sensor," IEEE Sensors J, vol. 18, no. 8, pp. 3278–3289, 2018.

6. Kunihiko. F, and Sei. M, "Neocognitron: A self-organizing neural network model for a mechanism of visual pattern recognition," IEEE Transactions on Systems, Man, and Cybernetics, vol. SMC-13, no. 5, pp. 826–834, Sept. 1983.

7. Lecun. Y. L, Bottou. L, Bengio. Y, and Haffner. P, "Gradient-based learning applied to document recognition," Proceedings of the IEEE, vol.86, no. 11, pp. 2278–2324, Dec. 1998.

8. Krizhevsky. A, Sutskever. I, and Hinton, G, "ImageNet Classification with Deep Convolutional Neural Networks," presented at the NIPS, Lake Tahoe, Nevada, Dec. 03–06, 2012.

9. Zeiler. M. D, and Fergus. R, Visualizing and understanding convolutional networks. Berlin, Germany: Springer, 2014, pp. 818–833.
Karen. S, and Andrew. Z, "Very Deep Convolutional Networks for Large- Scale Image Recognition," presented at the ICLR, San Diego, CA, USA, May. 07–09, 2015.

10. Szegedy. C, Liu. W, Jia. Y, Sermanet. P, Reed. S, Anguelov. D, Erhan. D, Vanhoucke.V, and Rabinovich.A, "Going deeper with convolutions," presented at the CVPR, Boston, MA, USA, Jun. 07–12, 2015.

11. K. He, X. Zhang, S. Ren and J. Sun, "Deep Residual Learning for Image Recognition," in CVPR, Las Vegas, NV, United States, 2016, pp. 770–778.

12. T. Fan, C. Ma, Z. Gu, Q. Lv, J. Chen, D. Ye, J. Huangfu, Y. Sun, C. Li, and L. Ran, "Wireless hand gesture recognition based on continuous wave doppler radar sensors,"IEEETMICROWTHEORY,vol.64,no.11, pp. 4012–4020, 2016.

13. Z. Zhang, Z. Tian, and M. Zhou, "Latern: Dynamic continuous hand gesture recognition using FMCW radar sensor," IEEE Sensors J, vol. 18, no. 8, pp. 3278–3289, 2018.

14. A. Just and S. Marcel, "A comparative study of two state-of-the-art sequence processing techniques for hand gesture recognition," COMPUT VIS IMAGE UND, vol. 113, no. 4, pp. 532–543, 2009.

16. J. Alon, V. Athitsos, Q. Yuan, and S.

Sclaroff, "A unified framework for gesture recognition and spatio-temporal gesture segmentation," IEEE T PATTERN ANAL, vol. 31, no. 9, pp. 1685–1699, 2009.

16. J. Alon, V. Athitsos, Q. Yuan, and S. Sclaroff, "A unified framework for gesture recognition and spatio-temporal gesture segmentation," IEEE T PATTERN ANAL, vol. 31, no. 9, pp. 1685–1699, 2009.

17. S. Poularakis and I. Katsavounidis, "Low-complexity hand gesture recognition system for continuous streams of digits and letters," IEEE T CYBERNETICS, vol. 46, no. 9, pp. 2094–2108, 2016.

18. S. Iengo, S. Rossi, M. Staffa, and A. Finzi, "Continuous gesture recognition for flexible human-robot interaction," in Robotics and Automation (ICRA), 2014 IEEE International Conference on. IEEE, 2014, pp. 4863–4868.

19. O. D. Lara and M. A. Labrador, "A survey on human activity recognition

using wearable sensors," IEEE COMMUN SURV TUT, vol. 15, no. 3,

pp. 1192–1209, 2013.

20. H.-K. Lee and J. H. Kim, "An hmm-based threshold model approach for

gesture recognition," IEEE Trans. Pattern Anal. Mach. Intell., vol. 21,

no. 10, pp. 961–973, 1999.

21. H.-I. Suk, B.-K. Sin, and S.-W. Lee, "Hand gesture recognition based on

dynamic bayesian network framework," PATTERN RECOGN, vol. 43,

no. 9, pp. 3059–3072, 2010.

22. M. Elmezain, A. Al-Hamadi, and B. Michaelis, "Hand trajectory-based

gesture spotting and recognition using hmm," in Proceedings of the 16th

IEEE international conference on Image processing. Cairo, Egypt:

IEEE Press, 2009, pp. 3541–3544.

23. S. Mitra and T. Acharya, "Gesture recognition: A survey," IEEE Trans.

Syst., Man, Cybern. C, vol. 37, no. 3, pp. 311–324, 2007.

J., vol. 16, no. 5, pp. 1333–1341, Oct. 2015.

25. K. Liu, C. Chen, R. Jafari, and N. Kehtarnavaz, "Fusion of inertial and

depth sensor data for robust hand gesture recognition," IEEE Sensors J.,

vol. 14, no. 6, pp. 1898–1903, 2014.

26. M. H. Ko, G. West, S. Venkatesh, and M. Kumar, "Using dynamic time

warping for online temporal fusion in multisensor systems," INFORM

FUSION, vol. 9, no. 3, pp. 370–388, 2008.

27. B. Hartmann and N. Link, "Gesture recognition with inertial sensors

and optimized dtw prototypes," in IEEE International Conference on

Systems, Man and Cybernetics, 2010, pp. 2102–2109.