Artificial Intelligence and Human-Computer Interaction

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ABSTRACT

Computers are becoming ubiquitous and are playing significant roles in our lives. Domestic digital devices for leisure and entertainment are becoming increasingly important. To be usable, every computing device must allow for some form of interaction with its user. The human-computer interaction is the point of communication between the human user and the computer. AI has been gradually being incorporated into human-computer interaction (HCI). As AI systems become more and more ubiquitous, it is imperative to understand those systems from a human perspective. This paper provides an introduction to the "marriage" between HCI and AI.

KEYWORDS: artificial intelligence, human-computer interaction

INTRODUCTION

The earliest user interface to a computer was the punched card devised by Joseph Marie Jacquard in 1804 [1]. Computers have been interacting with humans as restaurant servers, customer service representatives, health care providers, and sexual partners. In 2011, 15-million people watched on TV as an IBM computer, named Watson, beat human contestants [2].

Although people have interacted with computers from the beginning, it took a while for human–computer interaction (HCI) to be recognized as a field. HCI is concerned with understanding how people interact with machines in general and with computing systems in particular. It is the study of how people design computer systems and how computers affect individuals and society. It focuses on the interfaces between human users and computing devices [3]. HCI was formerly known as the man-machine studies or man-machine interaction. It is an ever expanding multidisciplinary field which sits at the intersection between social sciences (on the human side) and computer science (on the computer side).

Artificial intelligence (AI) is the use of computer science to develop machine that can be trained to learn, reason, communicate, and make human-like decisions. It is a technology that is rapidly being adopted in many industries to improve performance, precision, time efficiency, and cost reduction. Although AI is a branch of computer science, there is hardly any field which is unaffected by this technology. Common areas of applications include agriculture, business, law enforcement, oil and gas, banking and finance, education, transportation, healthcare, automobiles, entertainment, manufacturing, speech and text recognition, facial analysis, and telecommunications [4]. Today, the fields of AI and HCI are converging.

As shown in Figure 1, the relationship between AI and HCI falls somewhere into the spectrum between human-computer interaction and intelligent systems

[5]. Although some view AI and HCI as having opposing views of how humans and computers should interact, we believe in unifying AI and HCI. The underlying divide is not between AI and HCI, but between rationalistic and design approach [6]. The two fields explore the nexus of computing and intelligent behavior. Although several factors work to keep the fields of AI and HCI apart, the AI and HCI communities need to make AI ready for human interaction. AI and HCI can mutually benefit from a closer collaboration.

This chapter provides a brief introduction to application of artificial intelligence on human-computer interaction. It begins by providing a general overview on both artificial intelligence and human-computer interaction. Then, it presents the various applications of combining the two fields. It discusses the benefits and challenges of AI and HCI. The last section concludes with comments.

OVERVIEW ON ARTIFICIAL INTELLIGENCE

The term "artificial intelligence" (AI) was coined in 1956 by John McCarthy during a conference held on this subject. AI is the branch of computer science that deals with designing intelligent computer systems that mimic human intelligence. The ability of machines to process natural language, to learn, to plan makes it possible for new tasks to be performed by intelligent systems. The main purpose of AI is to mimic the cognitive function of human beings and perform activities that would typically be performed by a human being. AI is stand-alone independent electronic entity that functions much like human expert. Today, AI is integrated into our daily lives in several forms, such as personal assistants, automated mass transportation, aviation, computer gaming, facial recognition at passport control, voice recognition on virtual assistants, driverless cars, companion robots, etc. [7].

An important feature of AI technology is that is can be added to existing technologies. AI has benefited many areas such chemistry and medicine, where routine diagnoses can iitiated by AI-aided computers. It embraces a wide range of disciplines such as computer science, engineering, machine learning, chemistry, biology, physics, astronomy, neuroscience, and social sciences.

AI is not a single technology but a range of computational models and algorithms. The major disciplines in AI include expert systems, fuzzy logic, and artificial neural networks (ANNs), machine learning, deep learning, natural language processing, computer vision, and robotics. The various computer-based tools or technologies that have been used to achieve AI's goals are the following [8,9]:

➢ **Expert Systems:** An expert system (ES) (or knowledge-based system) enables computers to make decisions by interpreting data and selecting between alternatives just as a human expert would do. It uses a technique known as rule-based inference in which rules are used to process data.

➢ **Neural Networks:** These computer programs identify objects or recognize patterns after having been trained. Artificial neural networks (ANNs) are parallel distributed systems consisting of processing units (neurons) that calculate some mathematical functions. The ANN model represents nonlinear relationships which are directly learned from the data being modeled. Neural networks are being explored for healthcare applications in imaging and diagnoses, risk analysis, lifestyle management and monitoring, health information management, and virtual health assistance.

➢ **Natural Language Processors:** Computer programs that translate or interpret language as it is spoken by normal people. Natural language processors (NLP) techniques extract information from unstructured data. NLP targets at extracting useful information from the narrative text to assist decision making. NLP includes applications such as speech recognition, text analysis, translation and other goals related to language. There are two basic approaches to NLP: statistical and semantic. Healthcare is the biggest user of the NLP tools. NLP has been used in the clinical setting for capturing, representing, and utilizing clinical information [10].

➢ **Robots:** Computer-based programmable machines that have physical manipulators and sensors. For example, medical robots can help with surgical operations, rehabilitation, social interaction, assisted living, etc. Robotic-guidance is becoming common in spine surgery [11].

➢ **Fuzzy Logic:** Reasoning based on imprecise or incomplete information in terms of a range of values rather than point estimates. Fuzzy logic deals with uncertainty in knowledge that simulates human reasoning in incomplete or fuzzy data. The fuzzy model is robust to parameter changes and tolerant to impression.

➢ **Machine Learning:** Algorithms to make predictions and interpret data and "learn", without static program instructions. ML is a statistical technique for fitting models to data and training models with data. Machine learning (ML) extracts features from input data by constructing analytical data algorithms and examines the features to

create predictive models. The most common ML algorithms are supervised learning, unsupervised learning, reinforcement learning, and deep learning. Machine learning is widely used in human-computer interaction [12].

➢ **Deep Learning:** A subset of machine learning built on a deep hierarchy of layers, with each layer solving different pieces of a complex problem. It aims at increasing the capacity of supervised and unsupervised learning algorithms for solving complex real-world problems by adding multiple processing layers. An illustration of deep learning with two hidden layers is in Figure 2 [13]. Figure 3 shows how AI encompasses machine learning and deep learning [14].

➢ **Data Mining:** This deals with the discovery of hidden patterns and new knowledge from large databases. Data mining exhibits a variety of algorithmic tools such as statistics, regression models, neural networks, fuzzy sets, and evolutionary models.

Each AI tool has its own advantages. Using a combination of these models, rather than a single model, is recommended. AI technologies are drastically influencing the retail industry and customer experience. An emerging area of interest in AI is to make AI agents cooperate with each other.

FUNDAMENTALS OF HUMAN-COMPUTER INTERACTION

As shown in Figure 4 [15], human–computer interaction (HCI) draws on psychology, social and cultural anthropology, human geography, ergonomics, artificial intelligence, and potentially any discipline that deals with human behaviors. While computer science is the hard science of HCI, psychology is its soft science [16]. The term "human-computer interaction" was popularized by Stuart K. Card, Allen Newell, and Thomas P. Moran in their 1983 book, *The Psychology of Human-Computer Interaction.* The main goal of HCI is to produce usable and safe computer systems. Usability (or usefulness) is often defined in terms of efficiency, effectiveness and satisfaction. The success of any product is determined by the satisfaction of the humans who use the product. The data that affect usability of a system include age, experience, and capabilities.

As its name suggests, human–computer interaction (HCI) consists of three parts:

➢ **The Human:** This refers to an individual user or a group of users. The underlying objective of HCI is that people using a computer system should

come first. The design of HCI should be user-centered or user-friendly. This requires careful analysis of user characteristics and the goals that users want to achieve. Humans have emotion and emotion can influence important their behaviors including technology use and customer loyalty. While natural language input by the human appears desirable in human-computer communication, this assumes that the human can express his knowledge and that the computer can interpret the language.

➢ **The Computer:** This refers to any computing technology ranging from desktop computers, to large scale computer systems. Before we used to deal with stand-alone computers, but today computers are embedded in several devices. Devices such as mobile phones or VCRs may also be regarded as computers. The rapid development of computers has made effective HCI essential.

➢ **The Interaction:** Humans interact with computers in several ways using different interfaces such as keyboards, mice, tablets, voice, and hand gestures. For example, desktop applications use handheld computers graphical user interfaces (GUI), while speech recognition systems use voice user interfaces (VUI). In a world where the user interface has been mostly visual, focus has been on the GUI. The interaction may occur at the physical, social, and psychological context. Many other paradigms for human-computer interaction exist. Perhaps one of the best-known paradigms is the World Wide Web with the browser and HTML

We must understand these parts in order to understand HCI. Applications of HCI include information kiosks, computer terminals, interactive Web sites, computer games, mobile devices, robots, computer games, NLP, eye-tracker, hand gesture, fatigue monitoring, improving electronic medical records (EMR), natural language interfaces, human speech recognition, and surgery [17].

APPLICATIONS OF AI IN HCI

The AI-related technologies are silently redefining the way we make our intentions known to computers. The fields of AI and HCI are mutually influencing as never before. The synergies of AI and HCI, especially interactive machine learning, could become very relevant in several areas such as medical and business applications. Some common applications of AI in human-computer interaction include computer vision, speech recognition, natural language processing [18]:

➢ **Natural Language Processing (NLP):** This s is the technology that enables computers to

understand human speech as it is spoken. NLP is drastically changing the way we interact with more complex systems. Natural communication among humans consists primarily of a combination of speech, hand gestures, facial expressions, eye motions, and body language. Gestures are not equivalent to speech, but they complement each other. Conversational AI systems like Alexa are constantly growing smarter and better at language and conversation, all made possible through advances in machine learning. By combining data from speech and non-verbal signals computers may learn appropriate patterns of interactions for cooperation between humans and computers [19].

➢ **Multimodal Interaction:** This is part of everyday human discourse. We speak, move, and gesture in an effective flow of communication. To improve reliability and usability, researchers are now designing multimodal interfaces that automatically learn and adapt to important and environmental parameters [20]. Artificial Intelligence (AI) is powering speech-based and gesture-based systems, helping to fundamentally change HCI from simple, unimodal channels to complex, multimodal channels.

➢ **Computer Vision:** With the progress in deep learning and neural networks, we have made great inroads in the field of computer vision. AI and computer vision have made eye tracking more efficient and affordable.

➢ **Computer Emotion:** The recent developments in human-computer interaction have emphasized user-centered rather than computer-centered approach. This led to design of intelligent and affective interfaces. Important discoveries in neuroscience and psychology have contributed to an interest in the scientific study of emotion. Without the ability to process such affect or emotion information, computers cannot be expected to communicate with humans in a natural way. The ability of machines to recognize, interpret and respond according to human emotions is known as adaptive or affective computing. It is computing that relates to emotion or other affective phenomena. It involves the study and development of systems and devices that can recognize and express human affects or emotions. It uses both hardware and software technology to detect the affective state of a person [21].

➢ **Computer Games:** Computer games are becoming popular and the encounter between games and culture has become inevitable.

Applying HCI skills would enable game developers to design applications that are tailored to the player's cultural background, allowing developers to transcend cultural barriers [22]. Combining the human-computer interaction and the artificial intelligence areas can promote accessibility in games. This will lead them making them more democratic and useful for society.

BENEFITS
Human-computer interfaces have benefits both in terms of performance and in terms of the human's role in the system. The computer will do whatever it is commanded to do. It has no ego or emotion and never feels overworked or underworked [23]. HCI makes a big difference in terms of efficiency, convenience, even for life and death. The world is full of badly designed products and some products look good but may not work well. The skills developed with HCI help us to understand why some products are good and others are bad. There are some disabled people who cannot control parts of their bodies and real time human –computer interaction systems can help them [24].

The AI revolution is coming at a rapid speed, promising better performance than human professionals. AI does not need to sleep, rest, food, or need air to breathe. It can predict human interactions with computers and identify patterns far quicker than humans. It is not just replacing jobs (the takeover of human jobs by automation), it is creating new jobs as well. We must decide whether to ride on the wave of AI or resist the inevitable change. The combination of AI and HCI can improve education and make homes smarter.

CHALLENGES
AI and HCI have both potential benefits and risks. The biggest challenge product designers have is escaping the mindset of their own technical understanding and gaining a perspective of what it is like to be a user. HCI is a rapidly evolving discipline. Other challenges involved in HCI design include performing real evaluations, tailoring software, and recognizing design conflicts [25]. Several factors impede precision in HCI devices due to a lack of standard for the quality of data obtained by such devices. Courses offered on HCI must be carefully put together so that they do not quickly become out of date.

The potential negative effects of AI on society cannot be ignored. Merely introducing human guidance into AI applications is not enough to prevent its unintended consequences. Human involvement in AI system design and development is critical to ensure

that AI-based systems work as intended. Some AI applications were very expensive and failed due to a lack of use value. It would be a security threat if AI could not be fully controlled by humans. Although AI is advancing rapidly, ethics and security are not [26].

CONCLUSION

Much of the research effort in HCI seeks to improve human-computer interaction by improving the usability of human-computer interfaces. It is a young field with considerable success. Researchers have begun to be more concerned about the need for a stronger "marriage" between HCI and AI.

As AI systems become more and more ubiquitous, it is imperative to understand those systems from a human perspective. This will help the designers figure out how to build collaborative relationships between humans and computers to enhance human creativity. The future HCI will definitely shape around AI. A new field of "Human Artificial Intelligence Interaction" will emerge from this. For this reason, HCI has gradually become part of the curricula in several institutions [27]. The HCI courses should incorporate AI technology. Allowing AI to revolutionize education will mean that it will take less time for students to learn new skills after graduation. What the future holds is anyone's guess.

More information about HCI can be found in several books in [28-40] and several others available on Amazon.com. One should also consult the following journals exclusively devoted to AI and HCI:

➢ Human Computer Interaction
➢ Computers in Human Behavior
➢ ACM Transactions on Computer-Human Interaction
➢ Artificial Intelligence
➢ Applied Artificial Intelligence

REFERENCES

[1] B. A. Nardi and J. Kallinilkos, "Human–computer interaction," in W. Donsbach (ed.), *The International Encyclopedia of Communication.* John Wiley & Sons, 2009.

[2] M. N. Posard, "Status processes in human-computer interactions: Does gender matter?" *Computers in Human Behavior,* vol. 37, 2014, pp. 189–195.

[3] M. N. O. Sadiku, C. M. M. Kotteti, and S. M. Musa,"Human-computer interaction: A primer," *International Journal of Trends in Research and Development*, vol. 5, no. 3, May-June 2018, pp. 169-171.

[4] M. N. O. Sadiku, "Artificial intelligence", *IEEE Potentials*, May 1989, pp. 35- 39.

[5] "List of papers and talks." https://people.ok.ubc.ca/bowenhui/pubs.html

[6] T. Winograd, "Shifting viewpoints: Artificial intelligence and human-computer interaction," *Artificial Intelligence,* vol. 170, 2006, pp. 1256-1258.

[7] Y. Mintz and R. Brodie, "Introduction to artificial intelligence in medicine," *Minimally Invasive Therapy & Allied Technologies*, vol. 28, no. 2, 2019, pp. 73-81.

[8] R. O. Mason, "Ethical issues in artificial intelligence," *Encyclopedia of Information Systems*, vol 2, 2003, pp. 239-258.

[9] A. N. Rames et al., "Artificial intelligence in medicine," *Annals of the Royal College of Surgeons of England*, vol. 86, 2004, pp. 334–338.

[10] M. N. O. Sadiku, Y. Zhou, and S. M. Musa, "Natural language processing in healthcare," International Journal of Advanced Research in Computer Science and Software Engineering, vol. 8, no. 5, May 2018, pp. 39-42.

[11] "No longer science fiction, AI and robotics are transforming healthcare," https://www.pwc.com/gx/en/industries/healthca re/publications/ai-robotics-new-health/transforming-healthcare.html

[12] V. S. Moustakis and J. Herrmann, "Where do machine learning and human-computer interaction meet?," *Applied Artificial Intelligence,* vol. 11, no. 7-8, 1997, pp. 595-609.

[13] F. Jiang et al., "Artificial intelligence in healthcare: Past, present and future," *Stroke and Vascular Neurology*, 2017.

[14] C. Shorten, "Machine learning vs. deep learning," September 2018, https://towardsdatascience.com/machine-learning-vs-deep-learning-62137a1c9842

[15] B. K. Chadktaborty et al., "a review of constraints on vision-based gesture recognition for human-computer interaction," *IET Computer Vision,* vol. 12, no. , November 2017.

[16] A. Newell and S. K. Card, "The prospects for psychological science in human-computer interaction," *Human Computer Interaction*, vol. 1, 1985, pp. 209-242.

[17] T. F. Waddell, B. Zhang, and S. S. Sundar, "Human–Computer Interaction," in C. R.

Berger and M. E. Roloff (eds.), *The International Encyclopedia of Interpersonal Communication*. John Wiley & Sons, 2016.

[18] B. Dickson, "How artificial intelligence is revolutionizing human-computer interaction," May 2017 in Artificial Intelligence, https://thenextweb.com/artificial-intelligence/2017/05/10/artificial-intelligence-revolutionizing-human-computer-interaction/

[19] M. N. O. Sadiku, Y. Zhou, and S. M. Musa, "Natural language processing," *International Journal of Advances in Scientific Research and Engineering*, vol. 4, no. 5, May 2018, pp. 68-70.

[20] Z. Obrenovic and D. Starcevic, "Modeling multimodal human-computer interaction," *Computer,* Sept. 2004, pp. 65-72.

[21] M. N. O. Sadiku, A. E. Shadare, and S. M. Musa," Affective computing," *International Journal of Trend in Research and Development,* vol. 5, no. 6, Nov. -Dec. 2018, pp. 144-145.

[22] J. Chakraborty et al., "The human–computer interaction of cross-cultural gaming Strategy," *Journal of Educational Technology Systems,* vol. 43, no. 4, 2015, pp. 371–388.

[23] W. B. Rouse, "Human-computer interaction in multitask situations," *IEEE Transactions on Systems, Man, and Cybernetics,* Vol. 9L1 SMC-7, no. 5, May 1977, pp. 384392.

[24] D. Aksu and M. A. Aydın, "Human computer interaction by eye blinking on real time," *Proceedings of the 9th International Conference on Computational Intelligence and Communication Networks,* 2017, pp. 135-138.

[25] G. Fisher, "Human-computer interaction software: Lessons learned, challenges ahead," *IEEE Software*, vol. 6, no. 1, 1989, pp. 44-52.

[26] A. Miller, "The intrinsically linked future for human and artificial intelligence interaction," *Journal of Big Data*, vol 6, 2019.

[27] J. Urquiza-Fuentes and M. Paredes-Velasco, "Investigating the effect of realistic projects on students' motivation, the case of human-computer interaction course," *Computers in Human Behavior*, vol. 72, 2017, pp. 692-700.

[28] A. Dix et al., *Human-Computer Interaction.* Essex, UK: Pearson Education Limited, 3rd Edition, 2004.

[29] A. Zahirovic et al. (eds.), *The Encyclopedia of Human Computer Interaction*: The Interaction Design Foundation, 2nd edition, 2013.

[30] S. Smith-Atakan, *Human-Computer Interaction*. Thomson, 2006.

[31] A. Sears and J. A. Jacko, *The Human-Computer Interaction Handbook: Fundamentals, Evolving Technologies and Emerging Applications.* Boca Raton, FL: CRC Press, 2nd ed., 2007.

[32] Y. Rogers, H, Sharp, and J. Preece, *Interaction Design: Beyond Human-Computer Inrteraction*. Chichester, UK: John Wiley & Sons, 2011.

[33] D. A. Norman, and S. W. Draper (eds.), *New Perspectives on Human-computer Interaction*. Boca Raton, FL: CRC Press, 1986.

[34] S. K. Card, T. P. Moran, and A. Newell, *The Psychology of Human-Computer Interaction.* Boca Raton, FL: CRC Press, 2008.

[35] B. A. Nardi, *Activity Theory and Human-Computer Interaction.* Cambridge, MA: MIT Press, 1996.

[36] J. M. Carroll, *Human-Computer Interaction in the New Millennium.* New York, NY: ACM Press/Addison Wesley Publishing Co., 2001.

[37] S. Love, *Understanding Mobile Human–Computer Interaction.* Elsevier Butterworth-Heinemann, 2005.

[38] J. Jacko (ed.), *Human-Computer Interaction Handbook*. Boca Raton, FL: CPC Press, 3rd ed., 2012.

[39] G. J. Kim, *Human-Computer Interaction: Fundamentals and Practice.* Boca Raton, FL: CRC Press, 2015.

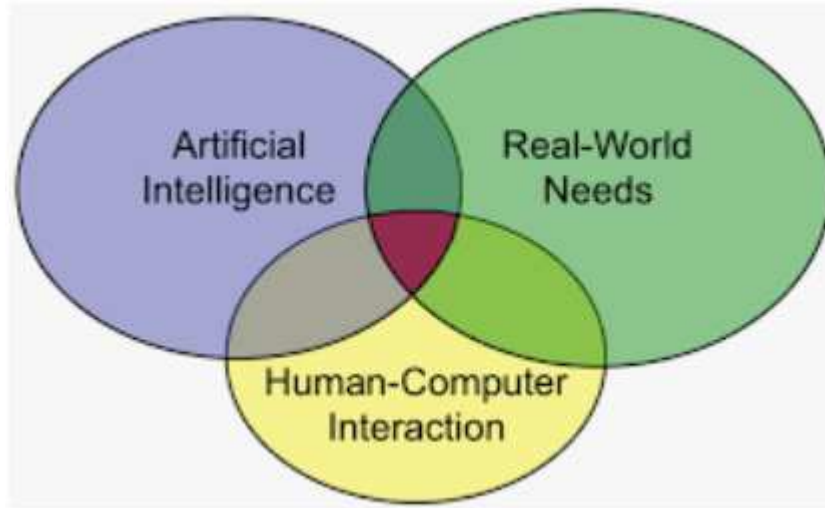[40] A. Sarmento (ed.), *Issues of Human Computer Interaction.* IRM Press, 2005.

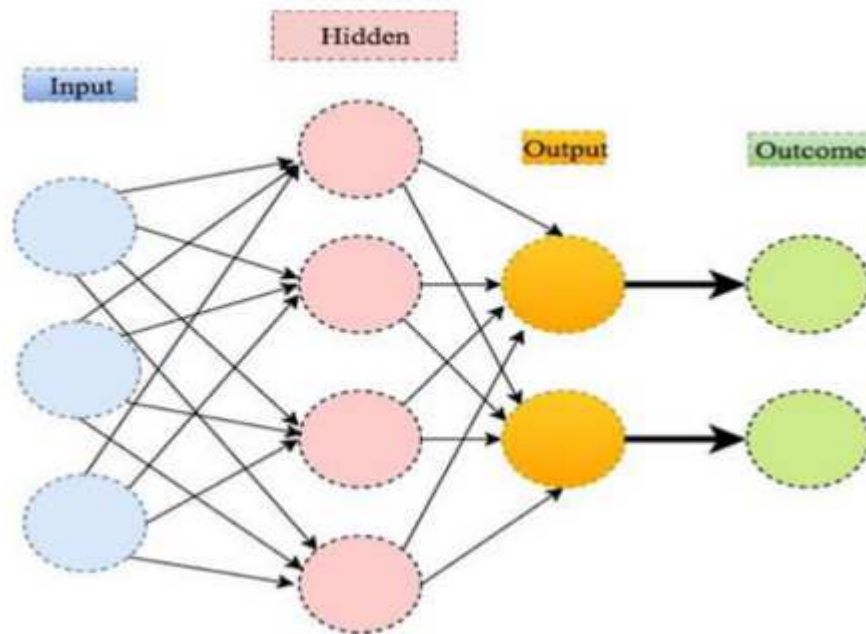**Figure 1 The relationship between AI and human-computer interaction [5].**

Figure 2 An illustration of deep learning with two hidden layers [13].
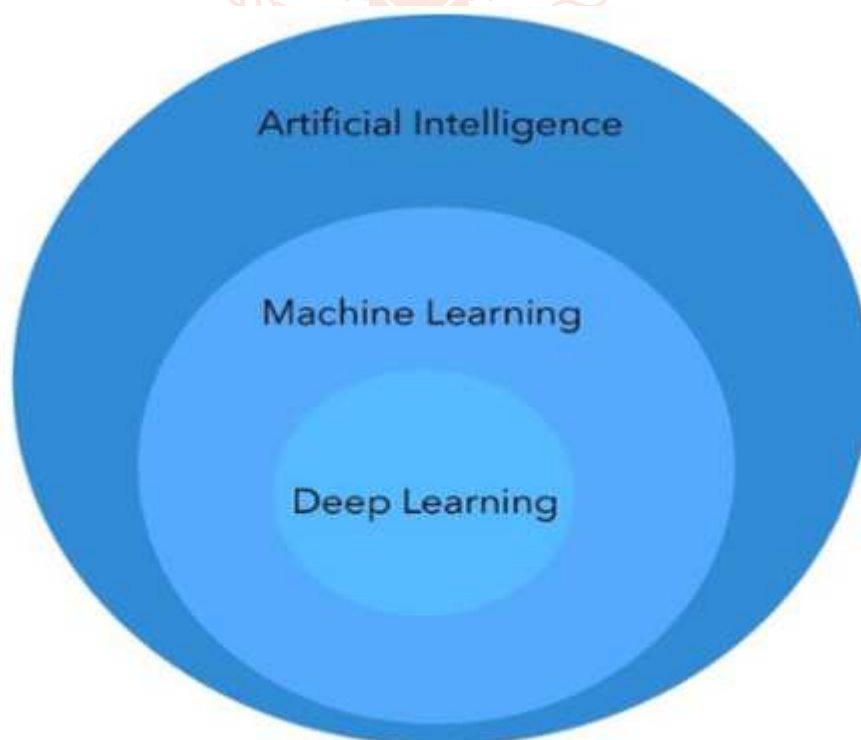

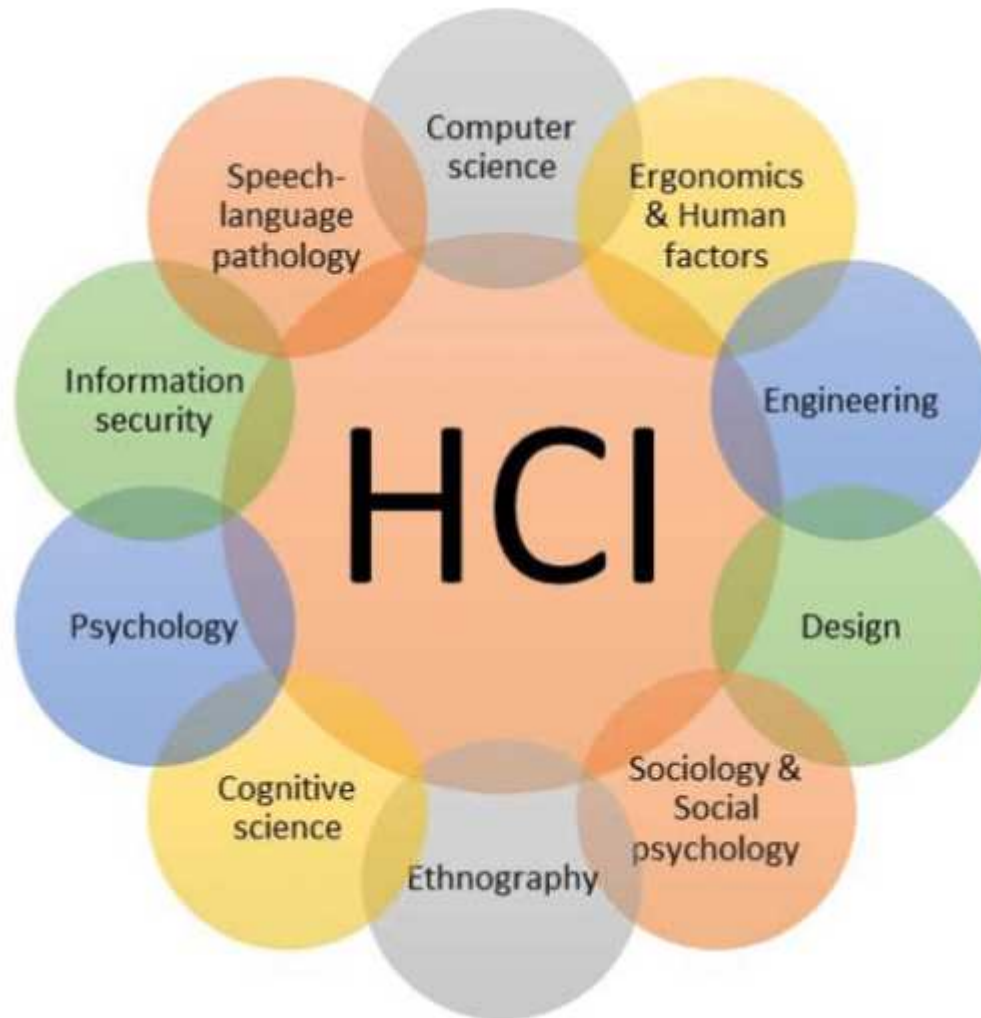**Figure 3 Artificial intelligence encompasses machine learning and deep learning [14].**

Figure 4 Human-computer interaction and related research fields [15].