Human Computer Interaction (In English)

Prof. Rajiv Ratn Shah

Department of Computer Science and Engineering
Institute IIT Madras

HCI and AI in Conversational Systems

Hello, everyone. Welcome back to the class of human-computer interaction. This week, we will be talking about HCI and AI-based conversational systems. So in the previous week, we discussed about harms, deepfake, privacy, and security issues in systems related with human-computer interaction. We also had a demo with ChatGPT on privacy and security-related questions. So this week, we'll be talking about what is a communication system? What is AI-based communication system? What do we mean by socially responsible multimodal intelligent systems? And we'll be having some demos towards the end of this lecture.

So what is human conversational systems? So a communication is the process by which information is exchanged between individuals through a common system of symbols, signs, or behavior. Communication is central to human interaction, which facilitates relationships, collaboration, and the transmission of culture. In the seminal work by Shannon and Weaver, they define what is communication they given a mathematical theory of communication they define that the word communication will be used here in a very broad sense that include all the procedure by which one mind may affect another this of course involves not only written or oral speech that we have but it could be anything else such as music, any pictorial art, the theater, the ballet, and in fact, human behavior or gesture or anything. In the Shannon theory of communication, they have divided the combination into three tiers.

In the first one, level one, it is more a technical problem where they are talking about how accurately can the symbols of communication be transmitted. It's about how we can send a message correctly, completely to the some receivers. Level B talks about how precisely do the transmitted symbols convey the desired meaning. Similarly, in the last level, how effectively does the received meaning affect conduct in a desired way? What is the effect of message received by receiver which a sender has sent and if you see that there is a information source and a sender sent the message over some channel and as you can see there is maybe some noise in between and this receive signal has been received by some receiver and the message has been interpreted and ideally it should have some effect which the center wanted to convey through the message so the three levels build on top of each other so to solve level c we need level a and b to be solved first at least to

some large extent so in a way you can convey this in level a it's more about for example sender sends a message over the WhatsApp to the receiver. So ideally it should be sent more encrypted way and it should be exactly what I have written for my some receiver.

Level B is precisely about how precisely do the transmitted symbols convey the desired meaning. So if the receiver is able to understand the message in a way in order to read or understand the message, it has to be decoded first. It has to be decrypted first. So that is more level B problem. And in level C, we wanted the receiver to probably do some action based on our reply.

In level C, we wanted the receiver to do some actions in reply to my message. For example, I wanted, the receiver to send me her resume for the internship purpose. If it happens then it means that the effect of my message has been done effectively. So as mentioned level A is more a technical problem and with the advancement of the internet and the technology this has solved quite efficiently. Second Level B, where it is more a semantic problem and that has also been solved very efficiently, especially after the advancement in LLMs that we have.

The level three is about how effective the message was. What was the effect happened after the message has been received by the receiver? So level C, the effectiveness problem. So this problem can be further divided into, you can say the four levels. So the first one is simulate human behavior for a certain content. So can we understand that for a given content, how many people are going to, for example, like this particular message or post and so on.

Similarly, generate content to elicit a given behavior. How should I write my message? How should I make my post in such a way that at least, for example, 1,000 people are going to like it or share it? Similarly, use behavior to extract signals about the content. So can we use behavior such as the way we write, the way we speak, the way we react to something? Can it help us in understanding the content in a better way? Finally, explain the human behavior. Why? Can we do some reasoning? Can we provide some justification? Why some user has done something after receiving the message? For example, if I made a post on Instagram and if there are some user who liked it or probably retweeted it, why this is so? So in our recent work, which has been published in ICLR 2024, a premier AI conference, we have proposed a large content and behavior models to understand, simulate, and optimize content and behavior. So where we proposed a kind of LLM, which is optimized for behavior.

So in this example, you can see that there is a kind of communicator or sender who sends a message over some channel and a receiver has received it and it should have some

corresponding effects. So for example, like views, screenplays and so on. So in this case, there is a video advertisement by Nike where we can see that there is some video content there is some title there is some message corresponding to it and similarly we have some description there are some objects like in this case a football player grass and there is some speech and that speech you can convert to the text here even after hours of practice and blah blah blah so that is something is given as part of the content and the audience will be in this case it could be general youtube audience or it may be some subscriber to your nike channels and this is the corresponding behavior happened this is the corresponding effect happened after receiving the messages by these people so as we discussed So these are the following components of any human conversational based systems. So there is a sender, there is a message, the message has should be encoded and probably send out some channel that is a medium. And after a receiver received the message, it has to be decoded first and finally some effect will happen that is the feedback happen here is there.

So in order to build something through AI, we should able to facilitate the human conversation it should also have same components like this. And the model of communication will be, it could be linear where a more uni way where a sender sends a message to receiver and that's it. It could be interactive model where sender receives the some message and receiver probably send back or some message or feedback going forward. It could be a more transactional model where a more complex process where both parties send and receive message simultaneously. And there may be some noise in between.

So any interference that distort the message that is in physical noise. So for example, if you're recording a voice and sending, there may be some environmental noise in the background, which also will be recorded as part of the message. So it could be language barrier and misunderstanding and so on. So in order to build something similar to AI, our system should also mimic these elements. It should have these features.

and there are several kind of communication can happen it could be verbal communication which involves the use of words or language it could be spoken or written it could be non-verbal communication which more you can say the gesture human body language facial expression and other form of non-verbal cues it could also be paralinguistic communication which refers to the aspect of speech like tone pitch rhythm that accompany verbal communication because it's not just about what you say it is also about how you speak how you write and written communication is communication written communication which is happened through some written symbols and text so The role of context is very important in communication because it depends on the cultural context. So where you need to follow cultural norms and the values and it influence how

messages are sent and received and corresponding effect happens. It also depends on the social context where the relationship between the communicators and their roles are important. And it is also quite dependent on the situational context where the environment or the setting where the communication occurs, which can again impact the message. So one such situation could be probably you are conversing with your professor, your boss, or maybe you're communicating with your friend.

So the kind of word choices, the tone that you have is also quite dependent on the situational context. So again, so there are quite, lot of barriers which can cause hindrance in effective communication it is physical barriers where noise distance and environmental destruction can happen it could also be physiological barriers such as prejudice stress your emotional state and so on it could be semantic barrier as well misunderstanding due to the language difference or unclear wordings It may be we are communicating with someone who doesn't speak the language I can understand. It could also be the cultural differences where the differences in values or norms between the different cultures are there. In order to do the effective communication, we need to have active listening. So which is about focusing on speaker, understanding and responding appropriately.

It should also have clarity and conciseness, keeping the message clear and to the point because unnecessary saying too many things not to the point will confuse the recipient. We should also provide the feedback, so offering constructive feedback to ensure that message is understood. Otherwise, it is very difficult for the sender to understand that whether the message has done respective effect or not, whether you understood the message or not. We should definitely have the empathy, which is understanding the emotional context of the message. It should also have the adaptability, so adjusting your communication based on the context and the audience.

So based on the barriers we have discussed, based on the effective communication techniques we have discussed, again, so these are very important learning for us if you want to build some kind of AI-based conversation system, which should definitely keep these effective techniques in their solutions. role of technology and so the advent of digital communication technology like email social email social media video calls has changed how human communicate and it has impact on interpersonal communication so technology has increased the speed of communication but can also introduce challenges like misinterpretation or reduced personal connections often we see that for example if you're having conversation with whatsapp with some friend so probably we send the message in between whether we complete it and the receiver may have misunderstand the given message because maybe it is incomplete so far. You're still writing, completing your text, and that may create unnecessary confusion, unnecessary misunderstanding between the sender and the receiver. So the conclusion is the human communication

system involves multiple components, factors that influence how messages are sent, received, and perceived. And the importance of effective communication is mastery of communication techniques, and it is crucial in personal, professional, and social interaction.

And there are many future trends, which we have also highlighted. The role of AI and machine learning in improving communication, such as chatbot, voice assistant, and so on, that we use in our daily life. So that's where let's next talk about AI-based communication system. So what is AI-based conversational system? So AI-based conversational system is a system like chatbot or virtual assistant that uses NLP to interact with user through spoken or written language. In context of SCI, the focus is on creating seamless, intuitive, and efficient communication between human and the machines.

So in a way, if you see the difference between the human conversation system to the AI based conversion system. So here at least one party is now being replaced by the some kind of machines. So now instead of two humans are conversing each other, so probably one of them has been replaced by some kind of machines, some kind of chat bot as indicated here. So some kind of virtual agent which is going to take the role of either sender or receiver. So the key feature is natural language understanding, machine learning and adaptive learning, and user-centric design for intuitive interaction.

So some real world example that we can see here, for example, chat bot. Some real world example that we can see here, for example, chat GPT is you just open the interface and it will ask you, how can I help with? So it already given a couple of indicators. Do you want to create an image, summarize text, analyze data, or probably help me with writing and so on. So for example, I ask, can you make a itinerary for a week in January for Kerala? So as you can see that ChatGPT has generated, a seven-day itinerary for my trip. For example, for day one, you arrive in Kochi.

In day two, you do this, that, that, and so on. That is something is there. And that is indeed a revolutionary thing happened in the recent years. And that is the reason Bill Gates has said about chat GPT, the most revolutionary tech in the last 40 years. Similarly, the Fei-Fei Li, one of the pioneer in human-centered AI, said that it revitalizes the way we interact with machine and make human-like conversation with AI, which is indeed was not the case before.

So if you talk more about ChatGPT, so it is a text-based conversational model capable of answering questions, drafting text and generative creative content. So now it is possible to generate a poem, generate a story, generate an essay, make a fictional movie, novel,

blah, blah, blah, and so on, just based on your inputs. So it is context aware and capable of maintaining coherence across multi-turn conversations. So it is built on transformer architecture GPT with the state of state-of-the-art natural language processing. So a fine-tuned on diverse dataset for a wide range of applications.

So these application ranges across education, customer support, content creation, ideation, and many others. but at the same time it suffers through different challenges. So it occasionally generates incorrect or nonsensical responses. That's why if you see the ChatGPT interface just below the response, it says that the answer generated by ChatGPT may be incorrect and so on. And that requires active management to ensure the ethical uses.

Another Very popular system that you are aware of, Alexa. It is basically voice activated assistant for smart home control, shopping and entertainment. So often you see that just sitting in your living room, you simply say, Alexa, please play this song for me. Alexa, what is the date today? Alexa, how is the weather today? And so on.

Alexa, please make a call. So you can also think of something doing this. So it utilizes natural language understanding for interpreting users commands. So it skills ecosystems allow third party developer to extend the functionality by using the provided SDK by Amazon. So technologies, basically cloud-based processing with ASR, automatic speech recognition, and text-to-speech, TTS, are the key concept behind this. So for example, if you say something, or if you give some command to Alexa, so your speech has been converted to some kind of text, and based on that text, it tried to answer the response to you, and Eventually, this response again converted to the speech, that is the text-to-speech, and you hear the response said by the Alexa.

So application is home automation, e-commerce, weather updates, reminders, and so on. At the same time, it suffers from the challenges like privacy concerns and occasional misinterpretation of commands. Often those who are using Alexa or Google Assistant or similar system in the Indian setting in the Indian home, probably these systems may not able to understand your pronunciation quite well and probably misunderstood your command and probably try to place something different which you have not asked for. Similarly, similar to Alexa, we have Google Assistant by Google. So again, it is voice and text interaction with contextual capabilities.

So deep integration with the Google ecosystem like Calendar, Maps, and Gmail. Support multi-turn conversation and follow-up conversation. So it is powered by Google's AI. for contextual understanding and uses advanced ASR, TTS, and machine learning for personalization. And again, application is similar to the Alexa, where hands-free device

control, real-time translation, navigation, reminders, and so on.

And again, challenges limited in-depth conversational capabilities compared to the generative AI like ChatGPT is not there. So as we discussed, it has application in different areas. So for example, in finance. So AI driven system helps with the customer support, fraud detection, financial advice, and the conversational about streamlining bank process like checking balance, or probably fund transfer inquiry, or probably investment advice and so on. So example is, for example, for Bank of America's Erica, a financial assistant that help user with the bill payment, budgeting, or financial insight.

Similarly, we have. So one of the renowned scientists who is working in AI, Professor Andrew Ng, said that AI will impact all the industries, but the impact in finance will be profound. So a tip for the new researchers. So this is the something area that you should explore, which works in the intersection of ASCI, AI, LLMs and so on. So it has application in the healthcare where AI system provide virtual consultation, provide symptom analysis and patient triage. So conversational agent can support mental health, remind patients of medication and assist with chronic disease management.

So again, so there are a couple of examples are there, such as Bobot, a conversational bot for mental health support, offering cognitive behavior therapy, CBT, and so on. So the integration of AI into healthcare will transform it reactive to proactive to preventive, said by Eric Topol. Similarly, in case of application in education, so we have Duolingo Chatbot, we have edutech platform like Quizzle and many others are there, which is transforming the education. As founder of Khan Academy said, AI has potential to make education more personalized. And why it needs to be personalized? Because different students have different capabilities, different strengths, different limitations.

So it has to be personalized based on their needs. And it should be accessible to all. and their application in software engineering. So given that often we deal with probably thousands lines of code or probably even hundred thousands lines of codes and so on. So AI system help with the bug tracking, code suggestions, developer support and so on. So recently there is a news by Google that shows that nearly 25% of the written code is through generative AI.

And that is the case with many other companies. So they can facilitate answering technical questions, recommend code snippet, facilitate code reviews, code understanding, and so on. So some key examples that we may already aware of, GitHub Copilot. It is AI powered code completion and suggestion tool for developers. Similarly, we have Stack Workflow Bot, a conversational agent that helps developer find solution to their coding issues. So automation doesn't replace developers, it makes them more

productive and which is happening these days.

And regarding the application in assessment, again, we have AI powered chatbot that can conduct interviews, provide training, simulation, evaluate performance and so on. And these communication system facilitate adaptive learning assessment and offer instant feedback on a profile. So for example, we have a system like Chiron Cogni, which is helping in recruitment and learning. So AI can assess competencies with precision and help close skill gaps. And similarly, you can see their application information retrieval.

So Google search, NLP based search suggestion that you use, which uses AI to provide more relevant search results and so on, which is there. And the benefit it provides, so it enhances user experience, more natural and engaging interaction, because now you can express your requirement in more natural language and free speech and so on, instead of some restricted constraint like press 1 to do this, press 2 to do this, write A to probably select this query, write B to select this query and so on. It is available 24 cross 7 because these AI chatbots provide constant support without any downtime. Personalization, so they have tailored responses and suggestions based on the user behavior, understanding, situation, and so on.

Efficiency, so faster resolution of queries on the task. So real-world example that you can see, so GenDesk AI chatbot provides automated customer support, allowing business to offer instant assistance. So often there is a discussion, these AI for good or bad? Are they going to replace human's job everywhere? So that's where Satya Nadella rightly said, AI won't replace humans, but it can augment our abilities to provide better user experience. And I do agree with that. So challenges in building such kind of AI-based conversation system, there is bias in AI and which will be propagated to the conversational agent we will build based on AI. So ensuring the data used for training doesn't lead to bias output, that is something we have to be careful.

Privacy and security, again, one of the very important topic that we discussed in the previous lecture. So managing sensitive user data securely is again a very important So understanding the context is also very important because it helps us in understanding the complex user queries and the nuances. User trust is one of the utmost thing we should have. So building and maintaining trust when using AI driven system. So some real world example, as you can see that Microsoft State Chatbot, a conversational agent that had to be shut down due to the bias learned from user interactions.

AI must be unbiased as possible, reflecting the diverse user base it serves, said by Fefele, pioneer SAI researcher. So the emerging trends which are involved in conversational AI is emotion detection. So your conversational AI capable of understanding user emotion

for better interaction so that you as a user feels that you are not talking with a machine, but some kind of with human who also probably respond to you based on the emotion that you have. Voice-driven UI, so increasing Preferences for voice-based interactions over text. So that is the reason we are using significantly Alexa, Google Assistant, Siri, and so on.

Multimodal interfaces, combining voice, text, and visual cues for richer interactions. Often, one modality may not be enough to convey everything. We need to have explainable AI, making AI's decision-making process more transparent to the user, and which is contributed towards the trust that we talked about so one real example that you can see so google duplex and ai capable of making phone calls and having human-like conversation for reservations so the future of ai and hci will be less about what it can do and it's more about how it does it said by don normal so let's next talk about socially responsible multimodal intelligent agents, because these conversational systems that we talked about, they are nothing but some kind of agent, which are working as a human, which are mimicking and acting like a human to perform some task for you. But at the same time, we have to understand that it has to be socially responsible. And what do you mean by socially responsible? Let's go ahead and discuss in the upcoming slides.

So these slides has been derived from Professor Ramesh Jain's keynote talk. And he is professor at University of California, Irvine. So what is intelligent agents? So AI system being the best and the worst out of the human imagination. So intelligent agent will transform our life related to health and quality of life, education, employment, home assistance and many other ways. And the fear from intelligent agent that we have these days, it will take over and make human extinct or slave and human superiority will be gone.

if we talk about intelligent agents and this is the open AI imagination of our AI future so in level 1 so it is a chatbot where AI with some conversational language in level 2 it is more reason and human level problem solving so we are somewhere in the level 1 and 2 at this moment so level 3 is about where agent or system that can take actions by themselves In level four, innovators, AI can aid in invention. Level five, where organizations, AI that can do work of an organization itself. So you can think about how scary it might be when it goes to the level of three, four, and five. So that's why it is very, very important to make these agents socially responsible. Agent, as defined in 1996, computer systems that are situated in some environment and capable of autonomous actions in this environment to meet their design objectives.

So how can we move beyond the vague notion of agent and develop some precise framework that understands these intelligent systems? So these levels of intelligent

agents gives a direction where we can go from today to in the future. So as we can see that we have moved significantly in the last 20-25 years in the area of multimedia as you can see that it has moved from compact disc to LMS phones to video telepresence, TV to streaming on demand, email to multimodal messaging for everybody emergence of GPS heart rate steps and so on so that's where you can see that so now we are talking about multimodal agents and This is the article by Prof. Ramesh Jain, you can see that. So multimodal agents from reason to reality. So if we talk about the foundational metrics for evaluating effectiveness of the healthcare conversation powered by generative AI, We have to go beyond the existing matrices that we have accuracy such as ground data to data multimodal.

So we have to go about trustworthiness. We have to go about empathy. So in this article by Professor Ramesh Jain and their colleagues, you can see that how these matrices are important specifically in the context of healthcare. As we discussed, so these are stages of AI and what if we are somewhere in level 3 and what will happen if you go beyond in level 4 and 5? So in case of conversational agent, you can see that. So you have the users and there is some question answering happening between the conversational health agent that we have. So there may be some personalized conversation. Again, that could be multimodal, multi-language, empathetic and companionship.

So there is a health agent which can understand user query, think and plan, process current knowledge, access personalized data, perform multimodal analysis, and prepare final answer. And it will also have the information to health, so that personalized health data, recent health publications, health data analytics tools, and so on. And in this way, it can help a user.

So there's a paper again by Prof. Amesh Jain and his team. So conventional health agents upon slice LLM-powered agent framework, that is something you can go through for greater details and further research directions. this is something they have built they build an open platform called opencha so where we can see that so where we have the users where there is couple of apis which can be quite useful in building a healthcare based chatbot so as you can see here so the conversational health ai agent that we have so for level and two we are able to probably do these things but if you go beyond especially in level three and more you'll see you are able to have these additional capabilities which can help in your healthcare based systems so for more details about opencha you can go through these documents and the details and it is already being used by many collaborators for developing applications and it is also being used in many hackathons by the participants. So let's talk about MIA, multi-modal intelligent agents. So using multi-modal intelligent agents in socially responsible applications is very important things to do. So how to design socially responsible MIA? That is something we are going

to discuss.

So to develop socially responsible applications, So again, related to the healthcare, education, environmental sustainability, human rights and social justice and so on. And designing social responsible MIAs to drive positive social change in the society, uphold ethical principles, act responsibly across diverse social and cultural contexts. And as we know that social media is full of minas. So it amplifies the negative effects it drives political and ideological polarization so multimodal content spread disinformation we have discussed deepfakes fuels hatred and division so hate speech and the toxic discourse spread rapidly on social media polarizing communities and escalate violence so existent existential risk with this so i could surpass human intelligence Especially if you discuss the different levels of intelligent agents, if you go to the stage of 4 or 5, AI could surpass human intelligence.

Autonomous decision making could spiral out of control. For example, it started making decisions which probably endangers humans and so on. So unchecked AI system could make unpredictable decisions with catastrophic consequences. So AI agent could turn against humanity itself. So it is very very important to have ethical and social deliverance. So ensuring alignment with human values, promoting fair opportunities, ethical use of personal data, promoting fair opportunities, and so on.

So that's why if you're building any kind of conversational system, AI-based conversational system, we should be thinking about how we can make it more ethical and social. So that's where, can we design a socially responsible MIS? So, in order to do that, we have to understand different aspects where MIA and human beings are there. So, for example, for perception, so MIAs process multiple data sources such as text, speech, and images, and human perceive through different senses they have saved by the experience. So here, similarly, we have to see how they are doing the learning, how they are doing the decision-making, how their emotional intelligence consequences, social responsibility, and so on. So if we can keep these points in mind, we can try to make your multimodal intelligent agent behave similar to human beings, make them more socially responsible and ethical.

So in order to make your MIA socially responsible, it can be programmed to act responsibly based on the data, like human beings who innate the abilities to make moral and ethical judgments. So the social responsibility is fostered in human through learning and socialization. So can we apply similar approaches to cultivate social responsibilities in intelligent agents? So we should go through the basic law of robots. So the first law is a robot may not injure a human being through inaction and allow a human being to come to harm.

That is the utmost thing. At no cost, the human being should be harmed. So second law is a robot must obey the order given by human beings. It should not do something which has not been instructed except where such order would conflict with the first law itself. Third law, a robot must protect its own existing as long as such protection does not conflict with the first and second law. So eventually the essence is at no cost a robot should harm a human being.

It should listen to the human being, its bosses. So adhering to these principles can also help us to building your multimodal intelligent agents socially responsible. So we have to address to these guidance guiding principles. So MIA should be trained to follow guiding principle as a core part of their functionalities, ensuring alignment with the ethical standards and societal goals. It should cease functioning when non-compliant. If MIA deviates from guiding principle, which has been discussed above, it should immediately cease its functionality until it is debugged and guaranteed to comply with these principles.

Secondary principles are, in addition to the core principle, which cannot be compromised at any cost, secondary principle will be established to encourage desirable behaviors, enhancing the MIA's role in positive societal impacts. So the first guiding principle here, human welfare and autonomy first. So MIA system must prioritize human well-being, dignity, and autonomy in all interaction, ensuring that users' rights, freedoms, and emotional needs that are respected while promoting the integrity of information. So second guiding principle is fairness, equity and inclusivity. So MIA must ensure that all individuals and groups are treated fairly and equitably, actively working to eliminate bias, discrimination and harm while promoting inclusive participation in social and cultural dialogues.

So the third guiding principle is credibility, accuracy, and truthfulness. So MIA must assess, label, and promote the credibility of the information. It curates or presents, ensuring that only verified, truthful, and accurate content is shared, especially in high-stake environment like news, healthcare, education, and so on. So the last guiding principle is transparency and accountability. So MIA system must be transparent in their decision-making process and explain to user ensuring the accountability for their actions and the decisions. So following these guiding principles again in a way help us in building socially responsible MIAs.

the secondary principles around this firstly is privacy security and the control so in this principle ai must be adoptable and capable of evolving its ethical guidelines as a societal values laws and ethical standards changes over the time in the secondary principle so

empathy and human-centered design so ai must be designed to understand and respond to human emotions and social cues fostering empathy, human connection in its interactions. So the future of socially responsible MIAs are, so the development of MIAs is at critical turning point at this moment. So the potential to create ethical, compassionate and impactful agent is immense. We have the opportunity to guide and design the future of AI that serves humanity responsibly.

So let's create a future where AI work for everyone. Together we can develop socially responsible MIAs that work in harmony with human values and contribute to the greater good of society and human being. So the future of AI is in our hand. And it's time to build intelligent agent that benefits society in meaningful ways, as Professor Ramesh Jain rightly said. So let's work towards AI for empowerment and democratization. So next, we are going to have demos from our student Mania and Aditya regarding our project Wave, as we discussed.

We have started the project in the beginning of this course, and we have shown its progress in different classes. And finally, end of this course, we are going to show you what they have achieved. You have also have to probably complete a task designing a brochure in Adobe Express. So you can refer to the project task using this URL.

You can also use Adobe Express reading resources to understand about how to use Adobe Express. You can also provide your feedbacks and suggestions to everybody through this suggestion form. So this is the further details regarding the project task that you can do for learning. So to summarize, human communications. So it relies on natural context-rich interaction using verbal or non-verbal cues. It is highly adaptable, empathetic, and contextual aware, but constrained by physical presence and individual cognitive limits.

at the same time AI-based conversation system. So these systems such as Alexa, Google Assistant, ChatGPT, they leverage AI technologies to simulate human-like interactions. They are scalable, efficient, capable of processing vast amount of data in real time, but often lack genuine empathy and deep contextual understanding. So the core technologies which are involved here, ASR, which primarily convert your speech to the text, natural language processing, text-to-speech which convert the speech to a text, machine learning models like transformers and so on. And the applications as we discussed, virtual assistants like Alexa, Google Assistant for everyday tasks, advanced conversational AI such as ChatGPT for creating content, education, and customer support.

So challenges as we discussed related to ethical concern, privacy, and misuse. So often they may have limitation in understanding the complex human emotion and nuances in

the conversations. So going forward in the future, so bridging the gap between human-like empathy and AI efficiency, integrating emotional intelligence and advancing ethical AI development, That is something we have to work towards that. So development of socially responsible MI is utmost thing we have to work now to make this place safer for everyone. So for further readings, you can go through these resources, which are quite useful with this.

 I thank you so much for attending this course. I'm sure that you're going to apply the learnings you had in this course in the different problem that you're going to work. So let's make this society a better for everyone using the concept learned in this course, human-computer interaction. With this, I thank you so much and wish you all the best.