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Applications of Artificial Intelligence and Voice Assistant in Healthcare

Elaheh Ahanin, Abu Bakar Sade, Huam Hon Tat
Putra Business School, Universiti Putra Malaysia, Selangor, Malaysia

Abstract
The modern smart technology such as Artificial Intelligence (AI) is merging with humans' physical lives and is going to change the way we live, work, and interact. AI in the healthcare sector is gaining attention from researchers, health professionals, and life sciences companies. The new technology advancement has brought various opportunities in electronic health (e-health) that allows healthcare to be accessible regardless of distance using information and communication technologies (ICTs) such as use of blood pressure telemonitoring service and voice assistants. Voice Assistant (VA) as an emerging technology in healthcare helps to reduce expenses, build loyalty, drive revenue, and it is especially beneficial amidst COVID-19 outbreak as healthcare will need to move towards more touch-free technologies post-pandemic. In this paper, we summarize the latest developments of applications of AI and VA in healthcare, and some basic knowledge regarding the techniques, the current state of this technology in healthcare, and possible developments in future, which potentially can transform many aspects of patient care.
Keywords: Artificial Intelligence, Voice Assistant, Electronic Health Record Systems, Machine Learning, Healthcare.

Introduction

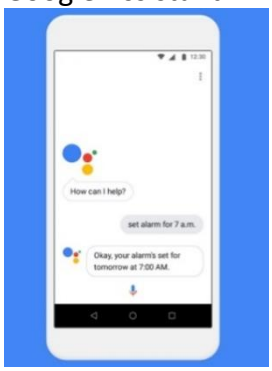
Introduction of new technologies, and improvement of data technologies such as storage size, computational power, and data transfer speeds are the key factors driving the growth of Artificial Intelligence (AI) in many fields. Voice assistant are AI-based technologies, which are designed to think and act like a human. Apple's Siri, Amazon Alexa, and Google Assistant (Figure 1) are examples of Voice-activated systems, which help consumers to manage their daily tasks for instance searching online, listening to news, controlling other connected smart devices (e.g., light, AC), answering a phone call, paying utility bills, and setting reminders. In recent years, such technologies have seen strong growth (The Star Online, 2020). The report by Marketsandmarkets in 2020 stated the Voice Assistant Application Market is estimated to increase from USD 2.8 billion in 2021 to USD 11.2 billion in 2026, with a Compound Annual Growth Rate (CAGR) of 32.4 percent throughout the forecast period.

The voice assistant application market owes its widespread adoption to the advancements in voice-based AI technologies, growth in the number of voice-enabled devices, and increasing focus on customer engagement.

Several applications in electronic health (e-health) have been created with the rapid development of new technologies, which enables healthcare to be provided for patients from home via Information and Communication Technologies (ICTs)(Lo Presti et al., 2019).

Apple's Siri

Google Assistant



Amazon Alexa

Figure 1: Sample of Voice Assistants

Over the past decades the focus was on the innovation provided by medical products. The present decade is focused on providing medical platforms, real-time, outcome-based care such as smart watch. With the explosion of available medical data, the next decade is moving towards medical solutions by using AI, robotics, and virtual and augmented reality, with the purpose of delivering intelligent solutions (Mehta et al., 2019). Various types of AI-based applications are already being employed by healthcare providers, and life science companies. These applications include disease diagnosis and treatment recommendations, medical document classification, and question answering based on consumer's commands,

Voice assistants are becoming important in healthcare as they can help patients get answers to critical questions about various diseases, help patients to learn about symptoms, and also assist in setting up doctor appointments, etc. More importantly this technology help patients to interact with smartphones without using their hands, which is a great help in Covid-19 outbreak and healthcare will need to move towards more touch-free technologies post-pandemic (The Star Online, 2020).

The significant increase in the number of individuals in need of healthcare services (e.g., growth of golden agers) combined with ongoing developments in healthcare technology is predicted to put upward pressure on health and long-term care spending (Fanta & Pretorius, 2018). VAs are available on smart phones and smart devices, which are used by youngsters as well as older adults due to their utility (Vollmer Dahlke & Ory, 2017). These smart devices are specifically designed to cater to the needs of all age groups, different ethnic groups, and work profiles worldwide (Dogra & Kaushal, 2021; Koon et al., 2020).

The aim of this review is to understand the availability of recent advancements in AI-based technologies, provide awareness about the potential of AI in healthcare services, and inspire the researchers in the related field.

AI-based Technologies in Healthcare

Voice assistants use AI technology to communicate with the users in natural language (Terzopoulos & Satratzemi, 2019). AI-based technologies (Figure 2) such as Machine Learning, Deep Learning, and Natural language processing are of high importance to healthcare, which are defined and described below.

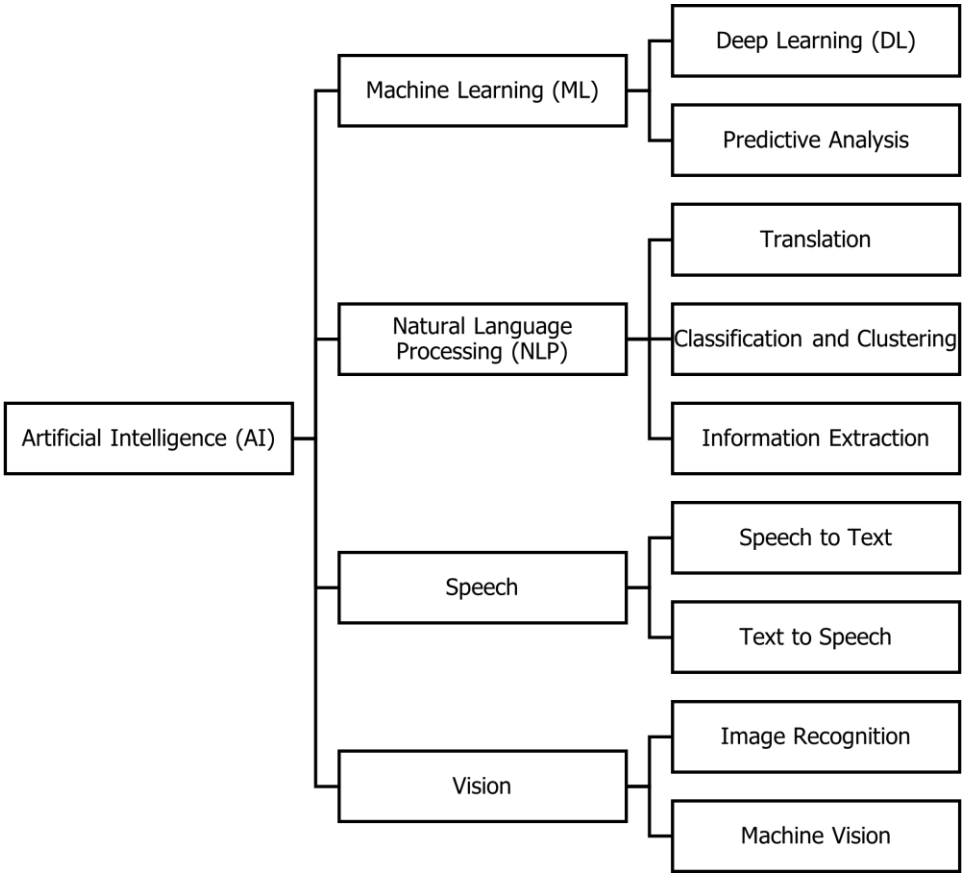


Figure 2: AI technology

i. Machine Learning (ML) and Deep Learning (DL)

Exploring approaches to help machines develop their own sort of common sense has always been an interest of scientists. Such machines not only have high predictive accuracy based on the previous data, but also are intelligent and have the ability to learn. Artificial intelligence (AI), Machine Learning (ML), and Deep Leaning (DL) refer to intelligence demonstrated by machines. Conventional machine learning uses the theory of statistics and employs algorithms to learn from a large dataset, train the system, and make informed decisions based on what it has learned. Deep learning is a subset of machine learning that uses advance machine learning approaches. Deep learning structures algorithms in layers to create an artificial neural network (ANN) for the purpose of learning and making intelligent decisions without any human intervention (Alpaydin, 2008).

ML plays a key role in many health innovations. It assists researchers with drug development, drug discovery, drug testing, and drug repurposing. Drug discovery (Reda et al., 2020) aims at uncovering putative drug candidates or gene targets, or causal factors, of a given disease or a given chemical compound. Drug testing (Aziz et al., 2021) helps to evaluate the effectiveness of drug properties and develop in silico prediction models to save time and money on later testing stages, and subsequent in vitro and in vivo experiments. Drug repurposing uses various methods such as identify correlations between drug molecules and gene or protein targets in literature to find a new therapeutic indications (Tari & Patel, 2014). DL has recently been applied to spot malignant tumors or to predict drug effectiveness based on large amounts of healthcare data, and various attributes (Chang et al., 2018).

Personalized medicine or "precision medicine" is another well-known application in healthcare. It uses enormous amount of data, such as medical imaging data or existing medical documentation to predict and analyze diagnostic decisions for each individual patient (Toh & Brody, 2021).

There are many applications such as PathAI[1], Tempus[2], Microsoft's Project InnerEye, IBM's Watson AI technology, and Pfizer[3] that uses ML to predict illness and deliver personalized treatments for patients. These applications use computer vision and machine learning with the aim of providing quicker and more accurate diagnoses.

ii. Natural Language Processing

Natural language processing (NLP) enables computers to understand text and voice data similar to human. NLP employs several technologies including machine learning, and deep learning models, to understand the semantic and sentiment of user's data (Alpaydin, 2008). NLP derives computer programs in text translation, text summarization, and speech recognition, and is widely used in the form of voice-operated GPS systems, digital assistants, speech-to-text dictation software, and customer service chatbots. The dominant applications of NLP in healthcare involve classification of clinical documentation, conversational chatbots, automated question answering, and disease diagnosis, which are described in the following section.

a. Document Classification

NLP systems can classify and analyze unstructured medical information into their respected categories (such as Diabetes, Cancer, Depression, Pediatrics, etc.), which simplifies access to content and reduces the time for retrieving information. NLP algorithms has shown promising results in clinical text classification such as classification of online medical articles (Al-Doulat et al., 2019), and smoking status classification and proximal femur (hip) fracture classification from the clinical notes and radiology reports (Wang et al., 2019).

b. Chatbots

A Chatbot helps consumers by simulating human-like conversations via text messages or voice commands. Chatbot uses NLP technology and supports speech to text and text to speech conversion so that the user can also communicate using voice. Speech and NLP technology is used to process text, transcribe consumers interactions, and respond to consumers' inquiries and questions automatically.

In healthcare chatbots can offer useful medical information based on user needs. Such AI-based systems, eliminate the cost and time in seeking medical help, particularly in rural areas, which consultation with qualified professionals is not easily available (Hsu & Yu, 2022). Moreover, mental health chatbot has shown to be an effective and engaging way to deliver mental health support and decreases depression and anxiety symptoms in students (Fitzpatrick et al., 2017; Wyllie et al., 2022).

[1] pathai.com
[2] tempus.com
[3] pfizer.com

c. Question Answering

Question classification and question answering helps to extract information find answers efficiently. It employs NLP algorithms to retrieve documents relevant to a question posed by humans in a natural language, and then processes such documents to automatically generate a paragraph-length answer.

For instance, automated question classification can be applied on cancer-related questions that have been enquired on the web. Question classification could also be used to assist clinical support staff in answering questions by suggesting a likely set of answer templates or be used to provide metadata for questions on the web, so that questions posted in social media could be linked to similar questions or to sources on the web that might provide answers. McRoy et al (2016) proposed a classifier to answer community-based questions. The scheme of the classification includes a set of questions such as clinical, non-clinical, and patient-specific questions.

d. Diagnosis

The development of advanced AI-based technologies and the recent research in the field of NLP leads to flourishing new businesses with innovative concepts in healthcare. Today, applications can perform disease diagnosis based on user's symptoms through medical reports or over one-on-one conversation (Badlani et al., 2021). Such applications can transcribe patients' interaction, and effectively extract the wealth of information into a format which can be utilized effectively by physicians and healthcare professionals.

IBM's Watson is one of the well-known data analytics processors that employs machine learning and NLP to generate answers to questions. It has been used in precision medicine to help medical staff and provides treatment methods based on huge number of past clinical trials. IBM's Watson is the first medical AI and introduces their first application on cancer diagnosis and treatment in 2013, which received attention of healthcare providers. However, in recent years, Watson has been criticized for its lack of accuracy (Ross & Swetlitz, 2018). Complexity of patient files, and lack of available clinical data based on locality failed the system to provide good recommendations. Despite Watson's unsuccessful attempt, big companies such as Google, and Microsoft are still attracted to develop AI solutions in health care.

Voice Assistant Applications

Some of the well-known VA applications includes Apple's Siri in 2011, Google Now in 2012, Microsoft Cortana in 2013, Amazon Alexa in 2014, and Google Assistant in 2016. Based on statistical research by Olmstead (2017), 46% of U.S. adults are using voice assistants at home. Due to simplicity of this technology, millions of devices use them in households nowadays.

Smart speakers are stand-alone devices that can be connected to smartphones. These portable devices are useful at home or work, and perform actions based on the given commands (Figure 3).

Voice assistants can also be used on smartphones. Smartphones offer built-in VAs such as Samsung Bixby, Google Assistant, and Apple's Siri. Apple has Siri built into on all Apple devices. Recently, apple introduced HomePod mini, a compact smart speaker which has native Apple Music and Apple HomeKit integration. Google designed Google Assistant to give users conversational and two-way interactions and made it available across all android smartphones. Google Assistant also works in Google Home smart speaker that allow users to control the smart devices. Amazon successfully launched Alexa led by Echo devices that

provides a lot of functionality and has an associated app for Android and iOS phones. The companies are attempting to make VAs ubiquitous and market them across various third-party devices to appeal to different user preferences and contexts (Rubin, 2018).

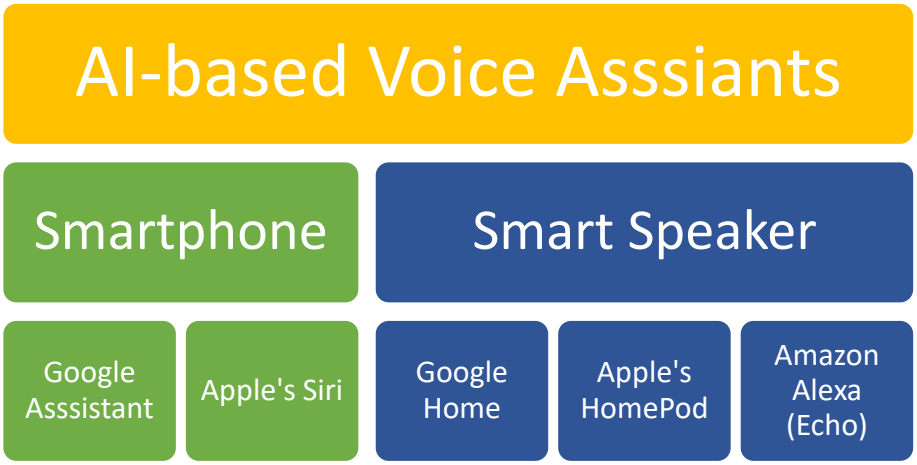


Figure 3: Types of AI-based Voice Assistants

The working mechanism of VA is simple. Voice assistant is usually unobtrusive and constantly monitor its surroundings for trigger words such "Ok Google" or "Hey Siri". Once the trigger word is said loud enough for the bot to hear, it will begin listening to the user's query. Unlike humans, machines require structure, detail, and process to break down complex nuances of the human language such as context, user intent, slang, accents, etc. Therefore, voice assistants rely on natural language processing (NLP) software to step in and resolve any barriers to understanding. After processing the user's query using voice recognition and NLP, voice assistant retrieves information related to the question by accessing knowledge base where information is stored. Finally, the output is the answer to the user's request using text-to-speech technology.

i. Voice Assistant in Healthcare

The role of AI in healthcare is complex and its capabilities are continuously extending (Cheung et al., 2020). Voice assistant systems in healthcare help to:

- get answers to critical questions about various diseases,
- learn about symptoms
- call nurse
- setting up doctor appointments
- monitor and analyze health issues, etc.

Therefore, VA in healthcare improves patient experience in the following use cases:

1) Intelligent Healthcare Voice Assistant: Alexa and Google Home are intelligent voice assistants that let patients get immediate responses to questions about symptoms of various illnesses, potential drug side effects, available treatments, drug availability, and therapeutic advice.
2) Real-time Medication Reminders: Patients often forget their medicine, which may cause a problem because missing a dose may make the medicine less effective. According to the report, 66% of Americans take prescription drugs, however about 50% those consumers do not take their medication as prescribed. Currently, medication non-adherence accounts

for 125,000 avoidable deaths, hospitalizations, and failures in treatment (Health Policy Institute, 2021). Using VAs such as Alexa on smartphones helps patients, particularly elderlies, to create timely reminders for taking their dose on time and prevent missing anu doses.

3) Virtual Care: VAs in healthcare systems recommends doctors or specialists and allow consumers to arrange an appointment with their desired doctor by speaking with voice assistants.
4) E-monitoring: Tech companies, and wellness application development companies are integrating voice-activated tool, which allows consumers to track and monitor their medical conditions via a voice command. For example, users can see trends in blood sugar or monitor their eating habits in applications with VAs.

Enterprise Bot's HealthAI[4] is one of the organizations that provides voice assistant technology in healthcare to automate routine tasks. Another application is Dr. AI (Mohr, 2019) launched by HealthTap which uses Amazon Alexa to help patients diagnose their illness through a conversation. Users are able to ask Dr. A.I. to diagnose their symptoms, pose health questions or complaints, and get suggestions for treatment and/or recommendations of nearby doctors. Dr. AI checks that against their health profile in HealthTap and can ask follow-up questions to gather more data. It then provides potential diagnoses and guidance on what to do next. Roche Diabetes Care[5] provides voice assistant focusing on pharmaceuticals and diagnostics. This application works with Alexa or Google Assistant with the purpose of improving people's lives.

The Future of AI in Healthcare

Despite the development of various AI-based applications in several sectors, the use of AI in healthcare is still in its early stage. According to the research, the combination of computer vision and machine learning to analyze medical imaging and other types of data such as text or speech, has shown to be effective in decision making, capturing clinical notes, providing automatic answers to the healthcare related questions, and document classification. Although there are challenges in delivering precision medicine and providing personalized medicine, given the rapid advances in AI, we expect AI to enhance and provide more accurate results. The efficiency and accuracy of AI-based healthcare services would enable clinicians to cope with the growing demand on healthcare.

We believe companies will push AI-based healthcare systems toward predictive analysis to predict and determine whether an individual is at risk of any diseases based on the individual's place of living, diet, emotion or mental conditions, or daily activities. Therefore, care providers can suggest preventative measures before the disease get worse. It not only reduces the costs but also improves individuals' health and quality of life.

Moreover, the fast advances in voice-based technology coupled with the coronavirus precautions encourages individuals to move toward using touch-free technology and voice assistants in daily life. The adoption of such technologies has already been accelerated due to the pandemic; however, the widespread use of VAs depends on several factors such as consumer engagement, public awareness, and governments policies toward using AI-based technologies.

[4] enterprisebot.ai

[5] healthline.com

Corresponding Author
Elaheh Ahanin
Putra Business School, Universiti Putra Malaysia, Selangor, Malaysia.
Email: ahanin.elaheh@gmail.com

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