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Smart Healthcare: Making Medicine Intelligent

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Abstract: Advancements in technology carry the capacity to transform the landscape of global healthcare. The paradigm of intelligent healthcare draws from cutting-edge information technologies, encompassing Artificial Intelligence (AI) and the extensive reservoir of daily-generated data known as big data. This innovative approach holds the promise of reshaping healthcare, rendering it more effective, tailored, and well-organized. The idea of smart healthcare was derived from the notion of "Smart Planet", which was introduced in the year 2009 by IBM. The Smart Planet employs an intelligent framework that leverages sensors for data collection, followed by IoT transmission and processing through advanced supercomputers and Cloud Computing technologies. Smart healthcare represents a comprehensive, multi-level change rather than just a simple advanced technology. The shift from disease-centred to patient-centred care and focus on preventative care is at the core of this transformation. Smart healthcare involves human participants such as physicians, patients, doctors and non-human participants such as the bodies that perform researches and medicinal trials. This approach incorporates modern biotechnology and encompasses new technologies such as AI, IoT, the Medical Internet of Things (MIoT), edge computing, cloud computing, big data, and the 5G and 6G wireless communication technologies.

Keywords: Smart Healthcare, Artificial Intelligence, Internet of Things, Cloud Computing, Big data.

1. Introduction

The application of artificial intelligence and related technologies to healthcare is gaining momentum. AI encompasses a range of technologies, including Machine Learning (ML)including neural networks (NN) and deep learning (DL), physical robots, natural language processing (NLP), and IoT[1][2].

1.1 Machine learning: NN and DL

- ML involves the imitation of intelligence that isexhibited by the humans by the computer systems with the help of algorithms which improve through experience.
- Neural networks, a complex form of ML, which can be used to predict disease development based on input-output associations.
- Deep learning utilizes multiple levels of variables to predict outcomes, and has already demonstrated superior performance to radiologists in detecting cancer.
- One application of deep learning is in radiology, where algorithms are already outperforming radiologists in detecting clinically relevant features in images, including the detection of cancer[2].

1.2 Physical robots

- Physical robots are already being used and implemented in the industry and their capabilities are becoming more advanced with the improvement of AI technology.
- They are able to perform various tasks such as lifting and welding and are also being used to deliver supplies in healthcare settings.
- Surgical robots are being used to perform surgical procedures in areas such as gynaecology, prostate, and head and neck surgery, including creating incisions and stitching wounds[3].

1.3 Natural language processing (NLP)

- NLP, involves the analysis and understanding of human language, including speech and text. It includes techniques such as speech recognition and text analysis.

- There are two prime NLP approaches: statistical and semantic.
- Statistical NLP works on ML, including deep learning techniques (as mentioned before), which help in improving the capability of identification and recall.
- In healthcare, NLP can be beneficial in creating, classifying, and documenting the clinical information. NLP systems can also analyseand study the clinical notes and reports made by the doctors and physicians and generatesummary as well as transcriptions[4].

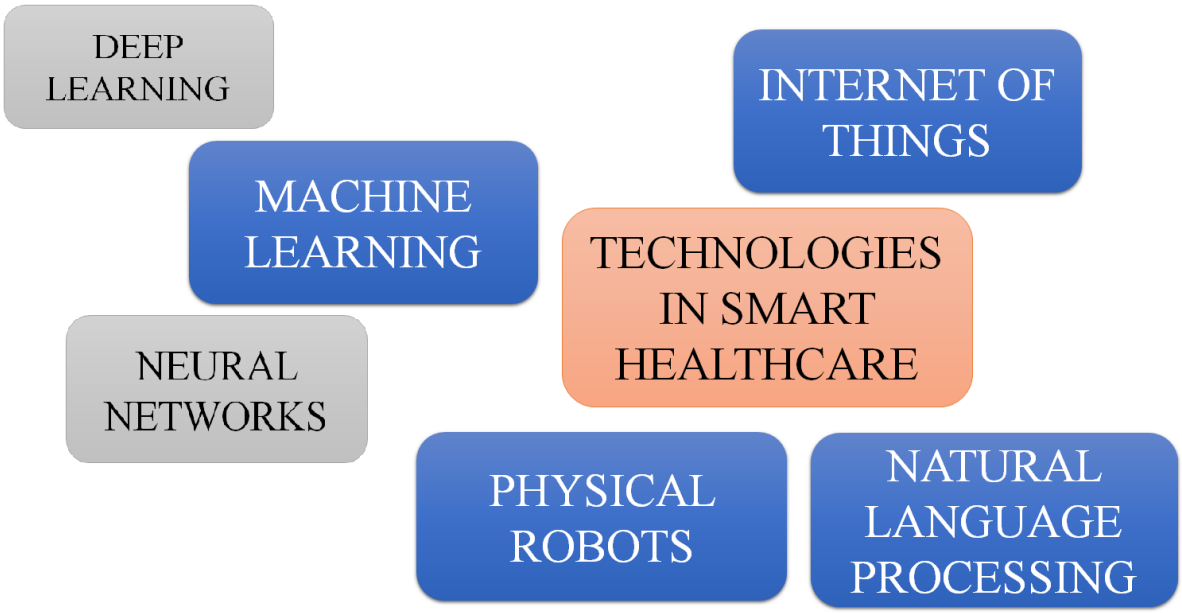

Fig 1: Technologies in smart healthcare

1.4 The Internet of Things (IoT)

IoT represents a fusion of wireless, interconnected intelligent devices proficient in storing and transmitting data across networks without necessitating direct human-to-human or human-to-computer interaction.[5]. In healthcare, the IoT can encompass any portable device capable of gathering data related to the health of the patients. Smart healthcare is a part of AI smart cities [6]. Such entities encompass computing devices, mobile phones, smart wearables, digital therapeutics, implantable surgical instruments, and akin devices proficient in capturing healthcare data and establishing internet connectivity.

Although further exploration is required to assess the feasibility of using IoT to evaluate the digital literacy extent of healthcare providers and patients, it is expected that the IoT will enhance healthcare delivery by streamlining the entire process, including diagnosis, treatment, and patient monitoring, both inside and outside the hospital[7].

2. Smart Healthcare

Smart healthcare is a branch of healthcare that utilizes various technologies such as IoT, AI, machine learning, and other smart technologies to improve the efficiency, effectiveness, and quality of healthcare services. The use of smart healthcare technologies can help in better disease diagnosis, early detection of chronic diseases, remote monitoring of patients, and personalized treatment plans. In addition, smart healthcare can also improve communication between patients and healthcare providers, reduce healthcare costs, and provide better access to healthcare services for patients in remote and underserved areas. However, the implementation of smart healthcare technologies also raises concerns regarding data privacy, security, and ethical issues.

2.1 AI Learning in Healthcare

In the healthcare sector, AI and machine learning have been used extensively over the past decade for data acquisition, beyond just disease and infection monitoring. Real-time data collection is being utilized to manage hospital beds, surgical units, and supply and demand of bays, as well as predicting the most likely day of patient discharge. Expert systems based on "if-then" rules are useful for this real-time data acquisition and are integrated with electronic health records (EHRs). These rule-based systems help with clinical decision making by the machines, which is then interpreted by the lead physician. While AI is proficient in data mining, tracking, and pattern recognition using large amounts of data, human experts and engineers are still required for maintenance. Additionally, many moral and ethical decisions that physicians face cannot be handled by binary systems.

2.2 Challenges

Some of the challenges faced in implementing smart healthcare include[8] [9]:

- Data privacy and security: With the use of advanced technologies such as AI, machine learning, and IoT, a vast amount of patient data is generated and processed. Ensuring the privacy and security of this data is a significant challenge that needs to be addressed.
- Limited access to technology: Despite the growing adoption of smart healthcare, many individuals and healthcare organizations still lack access to the necessary technology and infrastructure required to implement smart healthcare solutions.
- Resistance to change: Implementing smart healthcare requires significant changes to traditional healthcare systems, and there may be resistance to these changes from healthcare providers, patients, and other stakeholders.
- Ethical concerns: The use of AI and other advanced technologies in healthcare raises ethical concerns related to issues such as patient autonomy, informed consent, and the potential for bias in algorithmic decision-making.
- Integration with existing systems: Integrating smart healthcare solutions with existing healthcare systems and processes can be challenging and requires careful planning and execution.

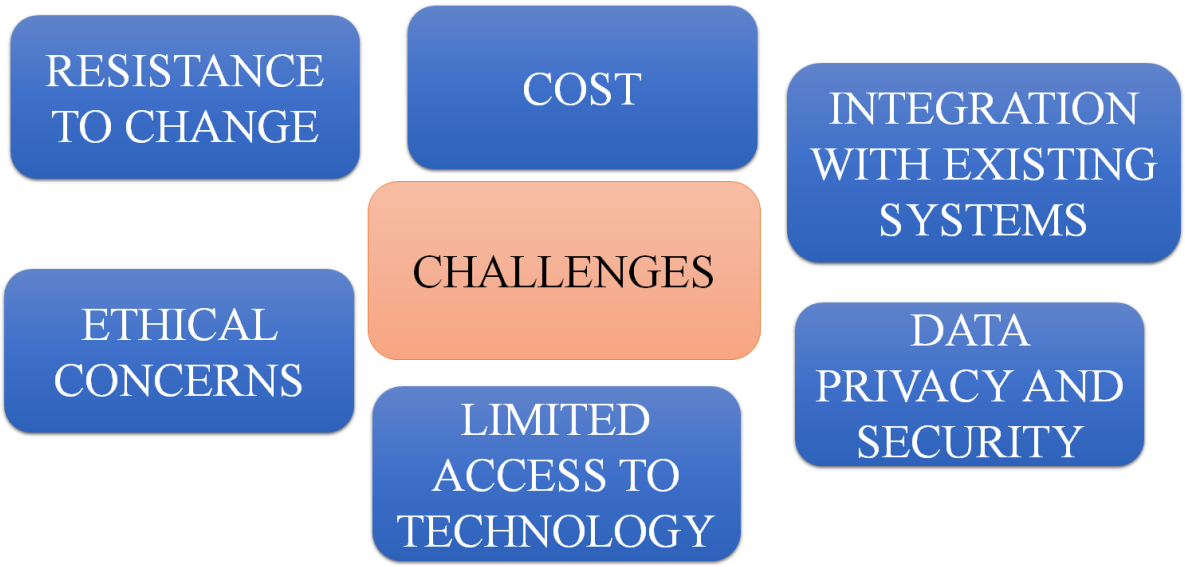

Fig 2: Challenges in smart healthcare

- Cost: Implementing smart healthcare solutions can be expensive, and healthcare organizations may need to justify the cost of these solutions to stakeholders such as patients, insurers, and government agencies.

2.3 Potential solution

Here are some potential solutions for the challenges in smart healthcare:

- Security and privacy: Smart healthcare systems need to ensure the security and privacy of patient data. This can be addressed by implementing strict security protocols and using encryption to protect sensitive data. Additionally, regular audits and monitoring of the system can help identify and address any potential security breaches.
- Interoperability: The lack of interoperability between different healthcare systems and devices can be addressed by developing standardized protocols and interfaces. This would enable different systems to communicate with each other, allowing for seamless integration and data sharing.
- Data overload: To address the issue of data overload, healthcare providers can leverage AI and machine learning algorithms to analyse and interpret large amounts of patient data. This would enable healthcare providers in making highly accurate diagnoses and carter uniquely personalized medication plans for patients.
- Limited access: Limited access to smart healthcare systems can be addressed by developing mobile health apps and other digital tools that enable patients to access healthcare services remotely. Additionally, healthcare providers can leverage telemedicine technologies to provide remote consultations and other healthcare services.
- Ethical concerns: Ethical concerns related to the use of smart healthcare technologies can be addressed by establishing clear guidelines and regulations for their use. Additionally, healthcare providers can work with patients to ensure that their rights and privacy are protected, and that they fully understand the risks and benefits of using smart healthcare technologies.

3. Smart Healthcare For Disease Detection

Smart healthcare has the potential to revolutionize disease detection by leveraging various technologies such as AI, ML, and IoT. Here are some ways smart healthcare can aid in disease detection[10][11]:

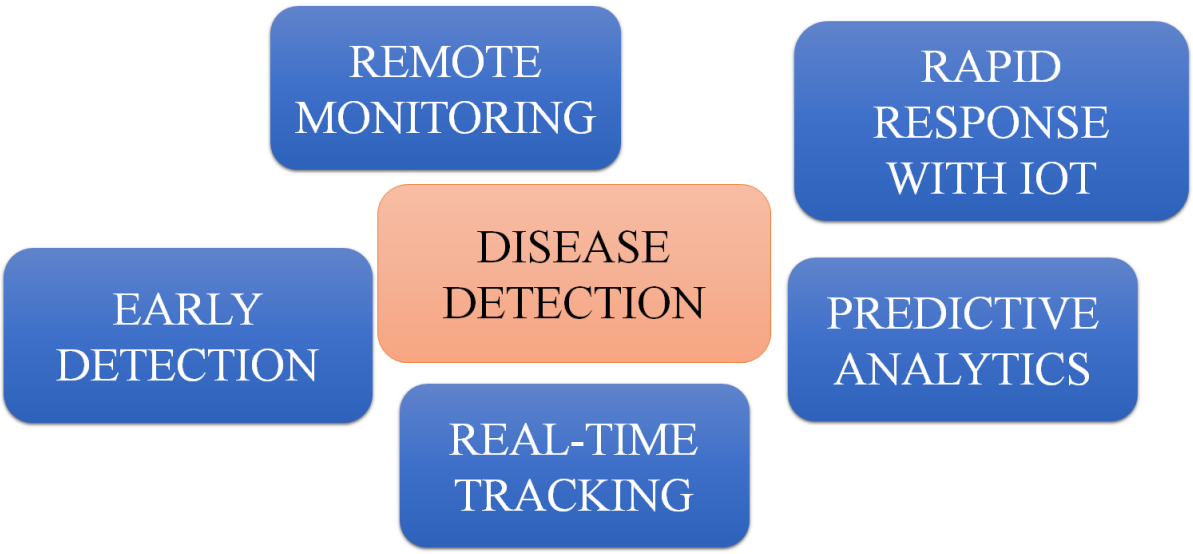

Fig 3: Disease detection using smart healthcare

- Remote monitoring: Smart healthcare devices which are equipped with smart sensors can monitor the vital signs of the patients, such as the heart rate, blood pressure, and oxygen levels, remotely. The data helps in detecting potential health issues before they become severe.
- Early detection with AI: AI algorithms can examine and investigate huge amounts of medical data, including medical history of the patients, their lab results, and various imaging studies, to recognise

patterns that may indicate the early stages of a disease. Which may lead to early diagnosis and treatment.

- Real-time tracking: Wearable devices can track a patient's daily activity and provide real-time data to healthcare providers. This can be used to monitor progress and identify potential health issues.
- Predictive analytics: Predictive analytics can help healthcare providers forecast potential outbreaks of diseases, such as the flu, based on various data sources. This can aid in early detection and prevention.
- Rapid response with IoT: Smart healthcare devices can use IoT technology to connect patients with healthcare providers in real-time. This can enable rapid response to emergency situations and ensure timely treatment.

Overall, smart healthcare has the potential to improve disease detection and prevention by utilizing various technologies to collect and analyse data. This can lead to earlier diagnosis, more effective treatment, and improved patient outcomes.

4. Smart Healthcare For Disease Diagnosis

Smart healthcare can also be utilized for disease diagnosis. With the help of AI-powered systems, medical professionals can analyse patient data and medical images to identify potential diseases and conditions. Machine learning algorithms can be trained to recognize patterns in medical images, such as X-rays, CT scans, and MRI scans, and assist physicians in diagnosing various diseases like cancer, tuberculosis, and others.

Moreover, AI-powered chatbots and virtual health assistants can ask patients relevant questions to gather their medical history, symptoms, and other information, which can assist healthcare providers in making accurate diagnoses. In addition, wearable sensors and other connected devices can collect real-time data about patients' vital signs, allowing healthcare providers to monitor their condition and make timely diagnoses.
Overall, the use of AI in smart healthcare can greatly improve disease diagnosis and lead to more effective treatments, ultimately improving patient outcomes.

4.1 Use cases of smart healthcare for disease diagnosis are:

- Radiology imaging analysis: AI-powered algorithms can analyse radiology images, such as X-rays, CT scans, and MRI scans, to detect abnormalities that may indicate a disease or condition. This technology can help healthcare professionals to make more accurate and efficient diagnoses, particularly in cases where the abnormalities may be difficult to detect by human eye alone.
- Virtual symptom checker: AI-powered virtual assistants can help patients to self-diagnose their symptoms and determine whether they require medical attention. By asking patients a series of questions about their symptoms, the virtual assistant can provide guidance on what steps to take next, such as scheduling an appointment with a healthcare provider or seeking emergency medical attention. This can help to improve access to healthcare, particularly for patients who may not have immediate access to a healthcare professional.
- Skin Cancer Diagnosis: Early detection is crucial for skin cancer for successful treatment, which is the most prevalent form of cancer worldwide. AI-powered skin cancer diagnosis tools can analyse images of skin lesions and moles to determine if they are cancerous. These tools use machine learning algorithms to compare the images to a database of thousands of other images to make a diagnosis with high accuracy.
- Diabetic Retinopathy Diagnosis: Diabetic retinopathy is a complication of diabetes that can lead to blindness if not treated in time. Smart healthcare technologies can help diagnose this condition by analysing images of the retina taken during a routine eye exam. AI algorithms can detect abnormalities in the images, such as bleeding or swelling, and alert healthcare providers to the presence of diabetic retinopathy. This can help patients receive timely treatment and prevent vision loss.

5. Healthcare Systems In Asia

Healthcare systems in Asia are a mix of publicly and privately managed programs. In this section we have discussed the healthcare systems of a few countries

5.1 Singapore

Singapore's healthcare system is financed primarily through taxes, which cover only 25% of the country's total healthcare costs. The remaining expenses are covered by mandatory life insurance schemes and deductions from the Central Provident Fund (CPF) or compulsory savings plan, which are paid by individuals and their employers. The public healthcare insurance system in Singapore is based on three main pillars: Medishield, Medisave, and Medifund.

Medishield is a basic health insurance scheme that covers large expenses for all permanent residents and citizens, including costly outpatient treatments like kidney dialysis. For those who wish to supplement their Medishield Life plans, there are Private Integrated Shield Plans offered by private health insurance companies.

Medisave, on the other hand, is a mandatory savings plan that deducts between 8 to 10.5 percent of an employee's monthly salary, depending on their age group. Singaporeans can use their Medisave accounts to pay for some routine care and for the medical expenses of their immediate family members.

Healthcare of Singapore comprises of about 4.5% of its GDP,in which the government provides about 40% funds and public funds comprise of 30% expenses.

5.2 China

China's healthcare system relies primarily on funding from its social insurance program, which extends fundamental coverage to the majority of its population, including most expatriates, contingent on their residential location. However, some regions exempt foreign residents from contributing to local healthcare systems via taxes, resulting in a lack of public healthcare support. China's medical insurance is segmented into three categories: foundational coverage for urban employees, foundational coverage for other urban inhabitants, and rural cooperative medical insurance for the agricultural community.

In urban settings, employee basic medical insurance is obligatory, with costs distributed between employers and employees. Although contribution rates differ by city, employers typically bear 6% of the salary-related costs, while employees contribute 2%. Self-employed individuals can also avail of this insurance but must shoulder the entire contribution.

For non-enterprise residents, health insurance expenses are shared by individuals and the state. The state extends subsidies for those unemployed or receiving social assistance.

The share of healthcare in the GDP of China lies around 6.6%out of which the government makes a contribution of about 28%, further 28% is contributed by the people and the insurance companies contribute a little above 44%

5.3 India

India has a healthcare system that offers free outpatient and inpatient care at clinics maintained by the government and hospitals organized by individual states. However, these premises often lack staffs and are not equipped sufficiently, which leads many patients to opt for private healthcare out of their own pockets. To tackle this issue, the National Health Protection Scheme (Ayushman Bharat-Pradhan Mantri Jan Arogya Yojana or PM-JAY) was introduced to provide free secondary and tertiary care at private hospitals for individuals living below the poverty line. Funded by taxes, the PM-JAY program aims to provide cashless hospital care for approximately 100 million people.

Additionally, government employees and other formal employees purchase health insurance schemes for themselves and their families.Private health insurance providers are available but they are not very common among the people of India. Unfortunately, less than 40% of Indians are insured, and the quality of public healthcare services is quite low, shortage of doctors and equipment, as well as corruption and accessibility issues, exacerbate the situation.

The share of healthcare in the GDP of India lies just below 4% out of which 25% is funded by the public sector. Private hospital payments account for 75% of the total expenditure, which is considerably higher than other developing countries.

5.4 COVID-19 response

Containment measures used in East Asia's advanced economies were focused on suppressing the spread of the virus. They relied on traditional methods of tracking each case, contact tracing, and quarantine to contain the virus. This approach proved effective in countries like Singapore, Hong Kong, and South Korea. In countries like India, the Philippines, and Vietnamwhich are less economically advancedpublic health education and shared community values played an important role. These values made it easier for people to adopt non-pharmaceutical interventions (NPIs) such as mask-wearing, social distancing, and staying at home. Lockdowns played a critical role in controlling the spread of the virus in India. Additionally, thein-house production of personal protective equipment (PPE) kit, ventilators, and testing kits was ramped up. However, the feeble healthcare system, extreme population density and poverty made it challenging to track and combat the pandemic in India and other developing Asian countries.

6. Conclusion

What will the futuristic digital hospital look like? The Deloitte Centre for Health Solutions predicts that digital hospitals will become a reality in the near future, significantly transforming healthcare. With the use of technology, various aspects of hospital care will become more efficient, but human involvement and empathy will continue to be crucial components of care. This transformation is expected to happen in the next decade.
Indeed, smart healthcare is poised to revolutionize the healthcare industry by leveraging the latest technological advances. As mentioned, smart healthcare is an all-round, multi-level change that goes beyond simple technological advancements. It is a holistic approach to healthcare that seeks to improve patient outcomes and satisfaction while reducing costs and increasing efficiency.

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