From AI to Robotics to Precision Medicine

Revolutionising the Healthcare Sector

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24 March 2050. Ramakrishna enters into the reception of a super speciality hospital at 9 am. He cannot find any receptionist. A machine similar to an ATM welcomes him, takes his personal details and sends him to a room where another machine examines him. It recommends an immediate colorectal surgery. Once again, in the operation theatre, a machine briefs him about the surgical procedure. By 12.00 noon the surgery is complete and he is back home announcing to his astonished wife that he has had a colorectal surgery.

This may look like fiction today, but considering the incredible developments happening in the field of biomedical technology during the last decade, this could be a reality within another decade. The role of doctors could recede to the backstage, as an interlocutor between machine and patient.

The concept of the family doctor or the village doctor is slowly vanishing. With the changing social set up in the digital world and the mindboggling growth in science and technology, the human touch is being fast replaced by machines.

Today, diseases are diagnosed by Artificial Intelligence (AI) enabled instruments that provide the complete health chart of a person. No need to labour hard at deciphering the handwritten prescription of doctors, which only a chemist can understand. From the simple blood test to complex MRI and CT scan everything is incorporated with AI. Technology has grown to such a level that even surgery and nursing care is given by robots.

The role of doctors and nurses has become more challenging in this changing environment. There was a time when hospitals advertised the profiles of their doctors, but today one can find advertisements of hospitals talking about their expert robot surgeons.

From disease diagnoses to treatment, everywhere in the health care you can see tremendous changes. Genomics technology has revolutionised the way drugs are delivered. Personal or precision medicine is gaining popularity in the society. Advances in genomics, robotics, artificial intelligence, deep learning and big data will in the near future make many tasks performed by physicians and nurses obsolete.

Artificial Intelligence (AI) and Robotics

AI is getting increasingly sophisticated at doing what humans do, but more efficiently, more quickly and at a lower cost. The potential for both AI and robotics in healthcare is vast.

Today, technology applications and apps encourage healthier behaviour in individuals and help with the proactive management of a healthy lifestyle. It puts consumers in control of health and well-being. Additionally, AI increases the ability for healthcare professionals to better understand the day-to-day patterns and needs of the people they care for, and with that understanding they are able to provide better feedback, guidance and support for staying healthy.

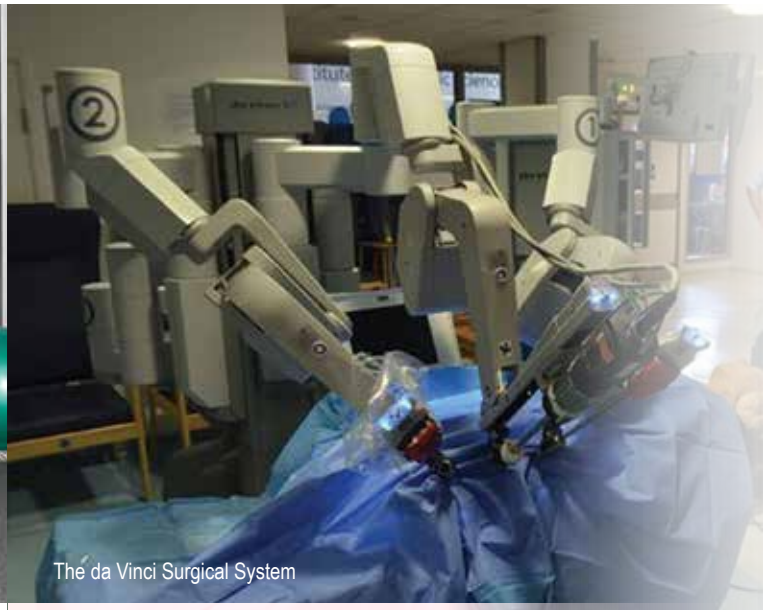
Robots are taking on more challenging tasks in today's medical applications with their improved capabilities like robotic-assisted surgical procedures, robotic medicine dispensing, and rehabilitation and movement therapy where robots assist the patient and reducing costs for medical staff and ultimately patients.

A young boy talks with Pepper at a Belgium hospital

Will robotic doctors replace human doctors?

"Erato" at Hygeia Hospital in Athens, Greece

Ekso Bionics' EksoGT™, a wearable exoskeleton



The da Vinci Surgical System

Robots as Receptionist

The humanoid assistant Pepper, who has a screen on his chest and around his head, is the first robot in the world to be used to greet people in a medical setting. Pepper can take up reception duties at hospitals. Standing 140 centimetres (4 ft 7 in) tall and equipped with wheels under his white frame, Pepper can recognise the human voice in some 20 languages and detect if he is talking to a man, woman or child.

Another robot Erato which is able to communicate interactively has been installed in a hospital in Greece. It can provide services and guide visitors and patients throughout their stay at the hospital, while visitors are able to submit their views and comments to the robot to help with quality improvement. Erato is equipped with a camera, microphones, sensors and a motorized remote-controlled platform with a balancing system that allows it to move with absolute safety around the hospital.

Robots for Rehabilitation

Ekso Bionics won the US Food and Drug Administration (FDA) clearance to offer its Ekso GT powered exoskeleton for rehabilitation of patients who suffer from partial paralysis caused by a stroke and for those with spinal cord injuries between levels T4 and L5 and T3 to C7. The device can provide varying amounts of assistance to one or both legs depending on the patient's needs and what the rehab specialist recommends.

Robots for Surgery

The Food and Drug Administration approved the da Vinci Surgical System from Intuitive Surgical in Sunnyvale, California in 2000. Since that time, the da Vinci has been adopted by many hospitals in the United States and Europe to treat a range of conditions. The system's console gives the surgeon a high-definition, magnified 3-D view of the surgical site. It is gaining popularity in India also.

The CyberKnife system

Robots can also be used to deliver high doses of radiation with sub-millimetre accuracy anywhere in the body. The AccurayCyberKnife Robotic Radiosurgery System is one such system developed in 1990 by a professor of neurosurgery and radiation oncology at Stanford University. Approved by the FDA in 2001, the CyberKnife system can treat tumours anywhere in the body and has been used on 40,000 patients worldwide.

Robots in Pharmacy System

Pharmacy inventory management in most hospitals is largely a manual process. Medications sit on shelves, and as the pharmacy receives orders for patients or to refill automated dispensing cabinets or satellite locations, technicians pick medications, put them into bags, and pharmacists are required to check everything leaving the pharmacy.

The new Omnicell XR2 Automated Central Pharmacy System is a self-contained robotic warehouse that stores and dispenses medications, automating the repetitive logistical tasks of inventory storage and management without requiring human involvement.

Robots in Patient Care

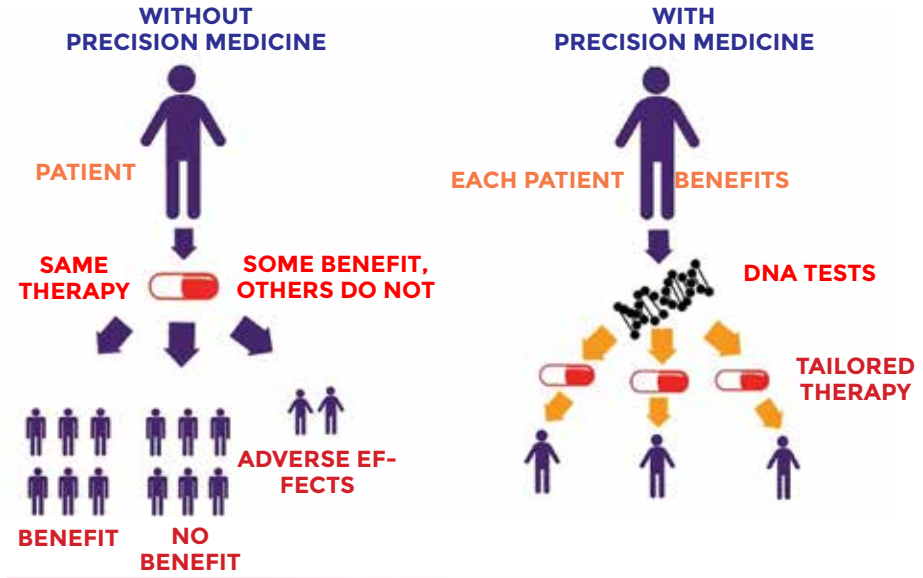
There are robots that help patients in and out of bed, remind them to take medication, measure their mood and provide regular updates to human caregivers. These include the Bestic® Arm that assists patients with meals, Toyota's Healthcare Assistants that help patients regain the ability to walk, and Tugs®, a mobile robot made by Aethon, buzzing around several US hospitals, using elevators to move floor-to-floor as they haul drugs, linens and lab results.

In patients suffering from dementia, Alzheimer's and depression robots can provide a soothing effect. Caregivers of people with dementia carry a really heavy burden. A South Korean-made robot called Silbot3 has shown promise in this area. A Japanese baby seal robot called Paro can help calm people with dementia and keep them company. Another robot named MARIO is capable of providing companionship and support to a person with dementia. It can connect and/or remain connected to their family and friends, and stay engaged in activities and events that interest them.

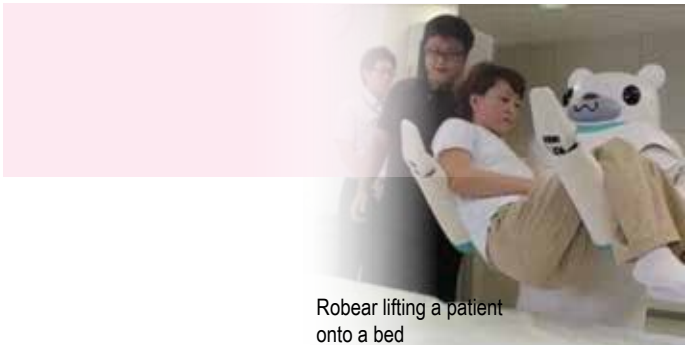
Robots in Telemedicine

Robotic telemedicine has made patients assess their doctors sitting in remote places thereby allowing them diagnosis and treatment. Medical professionals on site can plug peripherals into the units to directly extend the remote doctor's capabilities beyond just audio-visual. For example, a nurse could plug a stethoscope into the robot and then place one end of the stethoscope on a patient's chest, so that the neurologist at the workstation could hear the breath or heart sounds directly as if they were at the bedside. Although the equipment can be expensive, upwards of $25,000 a unit, telemedicine is a cost-effective mode of care when compared to traditional methodologies, and the outcomes are often improved.

In 2013, researchers at the Georgia Institute of Technology developed a way to give robots the sense of touch using artificial skin, which can dramatically improve the lives of people with severe disabilities. The ability of a robot to sense pressure is an important advancement in the ability of robots to deliver care to humans. Currently, artificial skin is being tested on a robotic arm using a series of sensors to transmit information to a computer that determines how much pressure the robot should exert when in contact with humans.



Aethon TUG autonomous mobile robot automates delivery and material movement in hospitals



Robear lifting a patient onto a bed

BesticStenHemmingsson 1 feeding the patient

Precision Medicine

Along with AI another emerging area in healthcare is Precision Medicine, commonly known as personalised medicine. It is defined as medical care for each patient's unique condition.

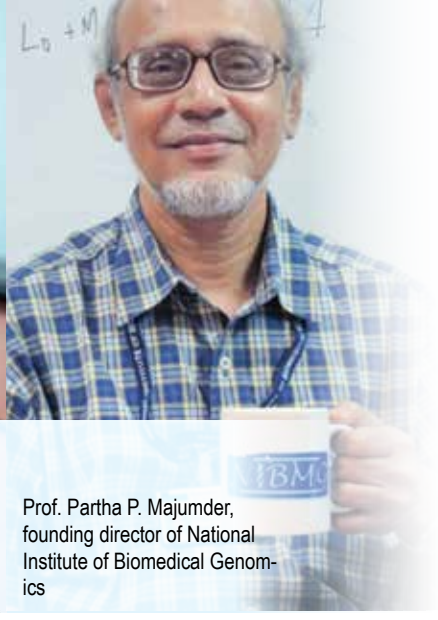
Even though scientific breakthroughs and new miracle treatments are announced on a seemingly daily basis, doctors know that even the most effective drugs in their arsenal won't work for large sections of the population. For example, the drugs commonly prescribed to treat disorders like depression, asthma and diabetes are ineffective for around 30-40 per cent of people they are prescribed to. This 'one size fits all' system of drug discovery – though it helped uncover the most important medicines of the 20th Century – is now increasingly seen as ineffective, outdated and dangerous. It means medicines are developed to work on 'the average person', when in fact all of us – even our diseases and our responses to drugs – are unique. Not only are many drugs ineffective for large subsections of the population, but they can also cause severe adverse reactions in others.

In the 21st century, personalised medicine is all about DNA sequences. This has emerged after the human genome project. The human genome project has revealed that humans are 99.9% identical. The genetic variation due to Single Nucleotide Polymorphism (SNP) is the most common between different human beings. The phenotypic differences arise due to SNP and it contributes 0.1% of the differences. There are 3 billion nitrogen bases and 30,000 genes in human chromosomes. Fifty per cent of the human genome has repetitive sequence and 1.42 million SNPs are distributed throughout human genome, an estimated 1 SNP per 1000 base pair (bp). The complete mapping of these genetic polymorphisms that influence drug response forms the basis of personalised medicine and these differences could be helpful in the understanding of Adverse Drug Reactions (ADRs).

Precision medicine relies on advanced DNA testing process known as Next-generation Sequencing (NGS) like Illumina, Oxford nanopore, etc. which can provide the sequence of a human being within a few hours. The portable Sequencing machine *MinION* developed by Oxford nanopore in 2014 was widely used for the diagnosis of Ebola virus outbreak in Africa**.** Since the first human genome was sequenced in 2001, after more than a decade and at a cost of around US$3 billion, the sequencing technology has become much faster and cheaper. Many genomes can now be sequenced in a single day for around $1,000 each. As a result, genome sequencing is entering medical practice, particularly to diagnose rare disorders, where conventional techniques have failed.

Advances in precision medicine have already led to powerful new discoveries and several new treatments that are tailored to specific characteristics, such as a person's genetic makeup, or the genetic profile of an individual's tumour. This is

The *MinION* portable device was used to sequence viral genomes in West Africa's 2014 Ebola outbreak



Prof. Partha P. Majumder, founding director of National Institute of Biomedical Genomics

Robotic telemedicine can be used to assess patients with stroke

helping transform the way we can treat diseases such as cancer. Patients with breast, lung, and colorectal cancers, as well as melanomas and leukaemias, for instance, routinely undergo molecular testing as part of patient care, enabling physicians to select treatments that improve chances of survival and reduce exposure to adverse effects.

In India, Precision Medicine is considered to be at an early adoption stage. A diverse country like India, with over 4000 population groups, and a significant percentage of consanguineous marriages presents a high-risk and prevalence of inherited genetic disorders that require attention for early diagnosis, right treatment, and management. India has a heavy burden of inherited diseases driven by the unique genetic characteristics in the population. With 1.4 billion people, the absolute number of patients suffering from diseases in which genetics plays a role is significantly large. It is reported that Indians witness a loss of around $23 billion from their annual income in treating or getting tested for non-communicable diseases.

The CSIR-Institute of Genomics and Integrative Biology (CSIR-IGIB) has initiated a unique programme on this front, pioneering the application of Genomics for Precision Medicine in India. IGIB has initiated projects like Genomics for Understanding Rare Disease, India Alliance Network (GUaRDIAN) and Omics for Precise Therapeutic Interventions Minimising Adverse Events (OPTIMA) which is a large-scale collaborative network of clinicians from around India trying to integrate genomics in clinical practice, with the singular focus to elucidate the genetic structure of Rare Genetic Diseases in India and implementing pharmacogenetics in clinics.

According to Prof. Partha P. Majumder, founding director of the National Institute of Biomedical Genomics based in Kolkata, precision medicine is gaining momentum in India at least in cancer treatment. In most cases, cancer patients have to suffer a lot because of the traditional way of treatment, without finding any solace from the disease and leaving them in heavy debt. Precision medicine offers a possible answer by reducing the costs of hospital stay, and reducing the overall financial, physical and psychological costs of the try-and-test approach of medicine. He hopes that reduction in the cost of DNA sequencing and adoption of technology by doctors from government sector will considerably reduce the cost involved making it affordable to an average Indian.

Already our doctors have accepted the technology and many hospitals like Tata Memorial Hospital, National Institute of Mental Health and Neurosciences (NIMHANS), All India Institute of Medical Sciences (AIIMS), CMC Vellore, LV Prasad Eye Institute, Sir Gangaram Hospital (Delhi), etc. are practising precision medicine on their patients.

Artificial intelligence is revolutionising our world in many unimaginable ways. It has been adopted in diagnostics as well as well as in curing of many diseases. We are at the verge of the Fourth Industrial Revolution and its impact is more in the health care sector. Humanity itself needs redefinition in this AI-ruled world. The machine only knows what it is programmed to do. The concept of compassion and ethics can be provided only by the human touch.

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