

Disrupting Primary Healthcare Industry with Artificial Intelligence, Computer Vision, and IoT Enabled Engine

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Healthcare industry is rapidly evolving and quality of healthcare has been improved significantly compared to the last century. However, the primary healthcare industry is still not evolved much. We are still relying on human judgement while identifying diseases. Many times, wrong diagnosis leads to loss of life [1].

Problem

As per the WHO report [1], wrong diagnosis can occur because of many factors such as the knowledge, experience and skill of primary care providers as well as the resources available to them. Not all primary care providers are trained and gained experienced on all the diseases. And often, the lack of knowledge may lead to misinterpretation of the symptoms of the patients. Wrong diagnosis also cause delay in the actual treatment or completely miss the opportunity to provide a proper care. All these problems lead to one common factor and that is human judgement. If we eliminate this factor, we will be able to identify the right disease and treat properly on time.

Another challenge is the lack of availability of medical facilities in many parts of the world and especially rural areas where not many doctors are willing to work. This problem is not much in the metropolitan cities, however the quality of service may not be equal. In a third world country like India, the problem is more stagnant since the majority of the nation's population belongs to the rural areas. People literally have to travel over 100 KMs to get good medical facilities. The available medical facilities are obsolete; there is often a shortage of medicine and medical professionals in such areas. Even the present medical professionals often need to handle thousands of patients every day. People living in the remotest part of the world are more affected as they never receive any proper medical facility. These people are often compelled to rely on primitive medical solutions and superstitions. Any epidemic virus means guaranteed death or mass extinction. People from these areas wouldn't even get enough time to get diagnosed in the first to start any kind of treatment.

Solution

Eliminating the human involvement is essential in reducing the wrong or missed diagnosis problem. This is only possible with the use of technology. Artificial Intelligence can play an important role in performing diagnosis at the primary healthcare level. Researchers have started thinking of using AI in medical diagnosis for decades [2] but yet the implementation at the primary level is not ubiquitously available in the market. Efforts are under way to diagnose various diseases using expert systems like coronary artery disease [3], breast cancer [4], etc. All these efforts can be combined and brought into an interface which can act as a primary healthcare portal which will be installed physically in various parts of the world. This will specially be useful in the rural part of the world which will help to save millions of lives.

The implementation

The implementation requires the following three parts to work together,

1. Machine learning and computer vision based application to perform analysis and give diagnosis
2. IoT powered user facing application to feed data to the machine learning and computer vision based application
3. Medical coordinator application (middleware) to work with hospitals, medical service providers, doctors, pharmaceutical companies, and related organizations as well as medical devices

Machine Learning and Computer Vision based Application

Artificial intelligence is making it possible to mimic human thinking abilities to do repetitive or complex tasks. AI-enabled programs can obtain information, use logical policies to analyze or process data. This helps the AI bots to recognize and fix mistakes. Machine learning is another important component of Artificial intelligence, it is a form of learning in which the machine can learn by itself without having the need of being programmed by humans. This is a long process, but in the end, the machine is smart enough to learn by itself. The system can be improved with experience. Machine learning and artificial intelligence are playing a major role in the healthcare sector. Instead of replacing the existing workforce, AI is making the medical experts work more efficiently. Both are helping medical equipment makers to develop better healthcare products and improve overall patient care.

Machine learning-enabled machines are more efficient, affordable, faster and able to manage larger workloads than humans are. The best thing about machine learning is that it keeps improving itself from experience. The day is not far away when

we will have absolutely no errors in the medical industry. Machine learning is seeing a gradual acceptance in the healthcare industry around the world. In fact, Google has also developed a machine-learning algorithm to discover cancerous tumors.

Machine learning is helping the healthcare industry by analyzing various data sets and advise outcomes, risk scores, resource allocation, and other applications.

Diagnosing diseases and ailments are one of the primary applications of machine learning in healthcare. This diagnosis includes diagnosing critical diseases like Cancer during its initial stages. It also assists humans in the early stages of the drug discovery process. With machine learning, we may find alternative ways for therapy of multifactorial diseases. It is also causing a major breakthrough in another technology called computer vision. Data sources from varied medical images will soon become part of this AI-driven process. The machine will be able to see and understand almost everything that we could.

Documentation and maintaining up-to-date health records by using vector machines and machine learning-based OCR are slowly coming into the mainstream. Google's Cloud Vision API as an example of machine-learning-based handwriting recognition technology is gaining great popularity in the healthcare industry. Machine learning is also proving to be a great boon in the field of clinical trials and long researches. Usually, it takes a lot of time and resources to conduct clinical trials. Utilizing machine learning with predictive analytics can significantly help the researchers to draw conclusions from a huge variety of data points. AI and ML are enabling us to ensure real-time monitoring of the trial participants, discovering the best sample size for testing. Scientists and researchers are also using AI and machine learning for monitoring and predicting epidemics around the world. A large amount of data is collected from satellites, social media, website information, etc. This information can be consolidated together to predict anything from cholera outbreaks to severe chronic viral diseases. Predicting the epidemics could be really helped especially in third-world countries. These countries usually lack important medical infrastructure and organized education systems.

As mentioned earlier, computer vision can assist in analyzing images like X-rays, MRIs, or even patients' symptoms' images like screen rashes. Combining these three technologies can drastically improve the quality of the diagnosis. Hence, we are working on SYMPTO engine (<https://www.everythingtech.co/open-source-projects/sympto/>).

SYMPTO is an open-source project that aims to develop a machine-learning algorithm to diagnose medical diseases based on various symptoms, medical history and other conditions of the patient. SYMPTO can work with any project as it takes input of patients' vitals, recent conditions, symptoms or health issues, and patients' medical history. It also considers various images like X-rays, MRIs, and symptoms images like rashes, etc. Based on this, it analyzes and output diagnosis with confidence level. High confidence level signals the possibility of accuracy and medium to low level signals the lack of data or input to come up with proper diagnosis. For medium to low diagnosis level, further processing is necessary. SYMPTO engine is a standalone engine which can be plugged into any medical IoT system. Hence, it is widely applicable to many existing products. In this paper, we will discuss a case study of ZPOD [5][8] as an user facing medical IoT system. We will discuss about ZPOD in more details in the next section.

IoT enabled User Facing Application

IoT made it possible to create a world of interconnected objects that can communicate through the internet. We can use hardware components like RFID tags, actuators, sensors, mobile devices, etc. to develop an interconnected world. Most of the medical IoT systems will have a similar architecture in which sensors are connected to a central module and communication takes place among sensors. Some healthcare organizations have already adopted the different form of IoT enabled medical devices to handle the shortage of medical professionals in remotest areas [6]. So this type of setup is successfully working and helping individual patients. IoT medical devices can help to drastically reduce the time of diagnosing and providing treatment to the patients. Usually, these medical devices are equipped with a fast processor and a feature-rich operating system interface, which makes the work much easier and faster. Cloud computing has enabled these devices to store diagnosis data of each patient to conduct in-depth analysis and provide a better diagnosis [7].

ZPOD is also a similar system. ZPOD comes in a form of a kiosk which looks like an ATM machine or also come in a variant of briefcase style case which contains all the required sensors. ATM style machine is a standalone kiosk which is equipped with various sensors to measure blood pressure, blood sugar, weight, body temperature, ECG, ultrasound, blood test, pulse rate monitor, X-ray, urine test, and even eye check. With ZPODs in place, people won't need to travel hundreds of kilometers to get proper error free medical diagnosis and with extended ZPODs get basic treatment. Extended ZPODs are the pods or kiosks which have more equipment and a few health support staff personals to assist patients. The idea is to provide primary healthcare facility remotely without having the physical presence of the medical professionals on the site. This will eliminate the human error as the diagnosis will be carried out by AI modules and coordinated by a middleware application. The kiosk will be equipped with all the necessary sensors and basic medicines. As mentioned in the ZPOD patent, in some cases, medicines will be delivered via drone to the remoted parts of the world. Life expectancy in rural areas can be greatly improved by this invention.

The SYMPTO engine powers ZPODs' hardware modules to collect the vitals of the patients and acquire patients' medical history through the ZPOD's cloud storage to perform the diagnosis. ZPOD kiosk contains a touchscreen interface for users to interact with the system. For a common user, the interface is very simple and user-friendly to operate. It is just like any regular touchscreen device. The ZPOD kiosk will ask user credentials like username/password or biometric authentication

like retina scan or finger scan before starting the diagnosis. Users may need to utilize the sensors attached to the ZPOD kiosk in order to send the vital to the system. This means that a regular patient may need to provide urine/blood sample, check blood pressure or blood sugar, conduct X-ray/ Ultrasound/ECG, etc.

The user inputs then get sent to the middleware application "SYMPTO Connector" which communicates with the SYMPTO engine to analyze the patients input and come up with diagnosis. Based on the SYMPTO's diagnosis middleware application then communicates with the ZPOD kiosk. If the prescription came from SYMPTO is readily available in the ZPOD kiosk's storage, the middleware application sent a message to deliver the medicine upon the required payment. Upon successful payment, medicines will automatically be dispensed if they are available in the kiosk. Otherwise, they will be delivered from the nearest warehouse via an automated vehicle, drone, or human driven vehicle.

The user-facing application will be very simple to use. In fact, it would require the minimum qualifications to operate. ZPOD aims to provide the user experience in multiple languages instead of just plain English. This will help people in the remotest areas who are not familiar with English. Instead of having plain text, the interface will also show symbols and lights to guide the user through the diagnosis process. There will be easy tutorials to provide guidance to the new users. These tutorials will be created with large icons and interesting animations to help users.

The ZPOD is the only remotely controlled machine with such a huge variety of sensors and technologies. Following are some of the most innovative features of the ZPOD:

1. Remote-controlled X-ray: ZPOD comes with an X-ray module attached to the machine. Doctors can remotely control to move the X-ray module and make adjustments for the patients looking for an X-ray scan. This eliminates the need for a medical professional who needs to be physically present on the site to operate the X-ray module. The people from the remotest locations do not get the chance to get an X-ray, ultrasound, ECG, etc.
2. Remote-controlled ultrasound: An ultrasound belt is also present in the ZPOD machine and it can be controlled remotely. Doctors or medical professionals can adjust the ultrasound belt remotely according to the patient. To obtain the best ultrasound images from the patient's body, doctors can control the pressure.
3. Advanced Interface: The device will be equipped with a microphone, speaker, fingerprint scanner for authentication, retina scanner, camera, printer, and a touchscreen. This provides 360-degree communication and security measures. Any communication gap is also eliminated and video calling narrows down distances.

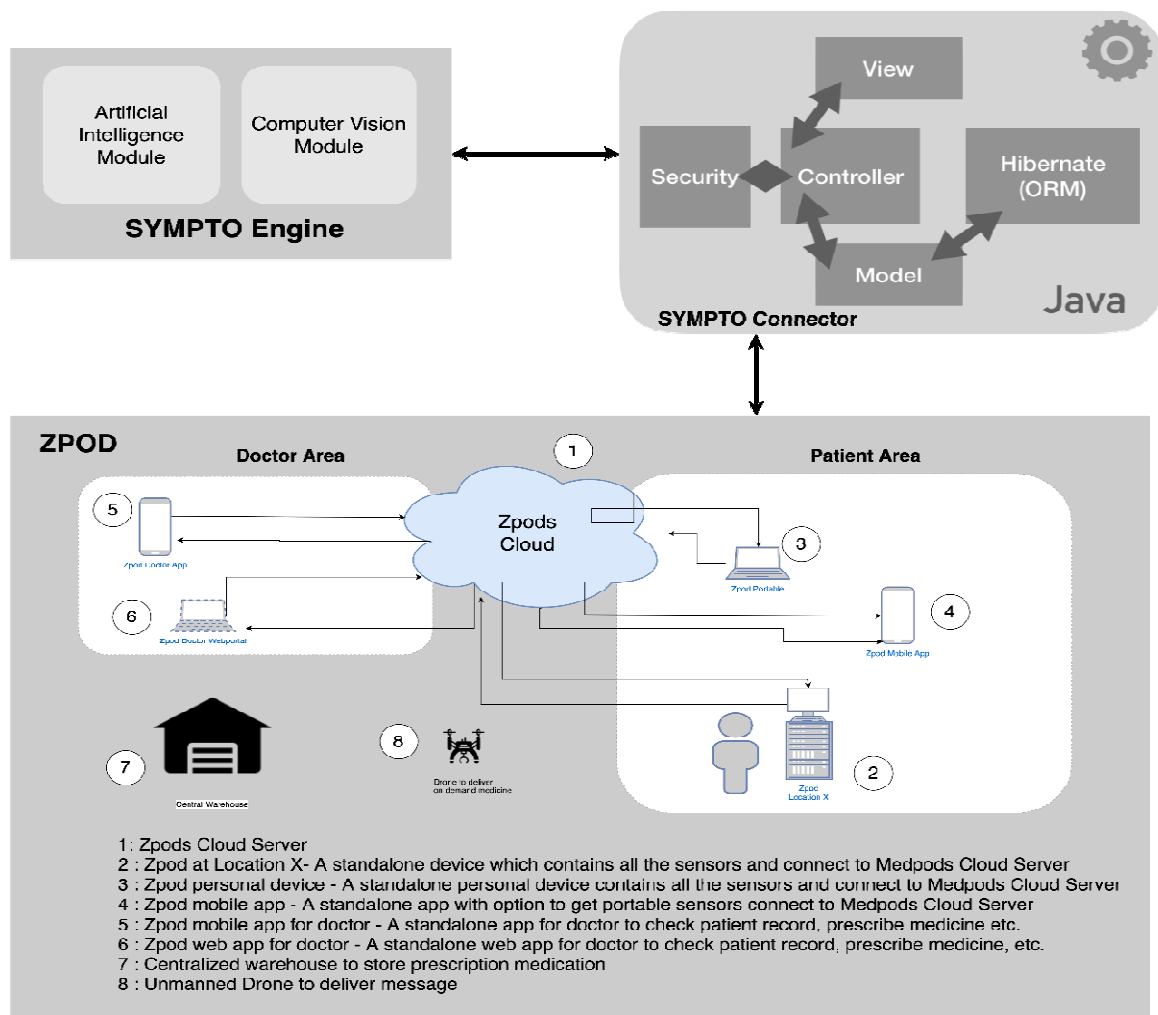
Medical Coordinator Application (Middleware Application)

The SYMPTO engine comes with a middleware application called as "SYMPTO Connector". SYMPTO Connector uses Java, a programming language developed by Sun Microsystems in 1991. This language stands as class-based, object-oriented and developed to have minimum implementation dependencies. Using Java means we can develop modular programs that could be used in any operating system. Due to this great compatibility, more than 3 billion devices are running Java. Java consists of a compiler, an execution engine and a bunch of libraries. These rich standard libraries make it easier to code with Java. This is why the team of SYMPTO has chosen Java for the middleware application.

SYMPTO Connector communicates with SYMPTO engine, user facing IoT application like ZPOD, and external medical institutions and devices like hospital beds, etc. It provides various interface APIs to enable data exchanges among the entities involved. SYMPTO Connector is modular in nature and can be extended by external developers via APIs.

The future of Project SYMPTO

The project SYMPTO has very ambitious objectives and aims. It could become one of the greatest revolutions in the medical industry. People from the remotest areas will be able to take the best benefits of SYMPTO powered machines to receive proper healthcare facilities. The patients will be diagnosed and, in some cases, treated remotely without even having any doctor's presence at the device site. This could be a great achievement for an instant response during an epidemic. Medical professionals would not have to risk their own lives and visit the place. SYMPTO powered IoT machines can help patients, prescribe medications and recommend IoT medical centers like extended ZPODs to provide treatments. People wouldn't need to go anywhere for the medicines since the machine itself could dispense medicines. In case, of a medicine shortage, the nearest warehouse can deliver medicines to the machine or doorstep of the patient.



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About the author



Mayur Ramgir has more than 18 years of experience in the software industry, working at various levels. He is a Sun Certified Java Programmer and Oracle Certified SQL Database Expert. He completed his MS in computational science and engineering from Georgia Tech, USA, and M.Sc. in multimedia application and virtual environments from University of Sussex, UK.

He is a fellow of The World Technology Network, which is a curated membership community comprised of the world's most innovative individuals and organizations in science and technology. Other members of WTN are Elon Musk, Tim Berners-Lee, Emmanuel Macron, and Xi Jinping.

He was honored with the Champions of Change award in 2018 by Mr. M. Venkaiah Naidu, Honorable Vice President of India. He was also awarded the Pride of The Nation award by Mr. Rajnath Singh, Honorable Home Minister of India, at the Vijay Diwas Celebration 2018.

Mayur Ramgir was featured on various TV and printed media including Fox News, NBC News, CBS News, Fox Business, Bloomberg International TV, Forbes, Inc. magazine, Daily Mirror, and The Huffington Post. He is a contributing author of the New York Daily Newspaper, Software Development Times magazine, Newsmax Finance, and Singapore's top entrepreneurship magazine Young Upstarts.

What's New?

Computational Storage

Computational storage is an information technology (IT) architecture in which data is processed at the storage device level to reduce the amount of data that has to move between the storage plane and the compute plane. The lack of movement facilitates real-time data analysis and improves performance by reducing input/output bottlenecks.

In many respects, a computational storage device may look just like every other solid state drive (SSD). Some products have a large number of NAND flash memory devices that actually store the data, a controller that manages writing the data to the flash devices and random access memory (RAM) to provide a read/write buffer. What is unique about computational storage devices is the inclusion of one or more multi-core processors. These processors can be used to perform many functions, from indexing data as it enters the storage device to searching the contents for specific entries to providing support for sophisticated artificial intelligence (AI) programs.

Computational storage products and services are starting to appear on the market and the ability to integrate them is still in the early stages of development. However, with the growing need to store and analyze data in real-time, the market is expected to grow very quickly. As of this writing, computational storage can be implemented by using one of two key products currently being defined by the Storage Networking Industry Association (SNIA) Computational Storage Technical Working Group (TWG):

More at <https://searchstorage.techtarget.com/definition/computational-storage>

Conversational Commerce (Voice Commerce)

Conversational commerce is the process of interacting with a brand or buying a product or service through non-traditional channels, such as voice assistants, SMS text and online and social media chat. Usually powered by artificial intelligence, a combination of technological advances and consumer preferences paved the way for conversational commerce to gain traction, primarily in B2C retail. It works by consumers choosing a non-traditional, one-to-one channel to interact with a business and to complete a purchase at their own speed and on their own time.

More at <https://searchcustomerexperience.techtarget.com/definition/conversational-commerce-voice-commerce>

Passwordless Authentication

Passwordless authentication is a verification process that determines whether someone is, in fact, who they say they are without requiring the person to manually enter a string of characters. Authentication methods include biometrics, security tokens and piggybacking off of another application, service or device which has already authenticated the user. Passwordless authentication is commonly used on mobile devices such as smartphones, tablets or laptops and applications such as Slack or WhatsApp. The benefits of using passwordless authentication include:

- Improved user experience (UX).
- Faster login times into applications or devices.
- Less maintenance of passwords required for IT staff.
- Reduced chance of phishing attacks, password re-use or password leaks.

More at <https://searchsecurity.techtarget.com/definition/passwordless-authentication>