Blockchain And Deep Learning Methods for Smart Cities: A Progression on Digital Healthcare

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Abstract— With the advent of artificial intelligence, Blockchain and IOT systems the Smart Cities are getting developed with high efficiency and growth to improve the quality of human life in terms of health, finance, security, travel, and tourism. Digital Healthcare system is globalized, COVID-19 pandemic is the biggest example the way things are unfolded and speeded up from diagnosis, essential medicine provision, treatment procedures, monitoring patients at quarantine to vaccination roll out and implementation across the globe. It's evident that many developed and developing countries put their resources together to find solutions for COVID-19 vaccination. COVID-19 is a challenging situation for many countries, especially in cities as the population is dense, which could increase the spread of infections. Deep Learning Techniques such as Neural Networks are playing a prominent role in human disease diagnosis, emergency care systems, mobilization of medical facilities to reduce the time taken for diagnosis and treatment processes involved increasing the human life span and quality of life. In urban cities, population growth is enormous due to migrations after industrial revolution because of increased demands of human services. Processing large data sets into informative source using Deep Learning algorithms enabled huge developments in healthcare system. Artificial Intelligence and e-commerce systems enabled many services like virtual consultations, speedy and efficient diagnostic systems at an early stage of the disease, emergency care services, mobile health services and online medicine delivery systems to facilitate health services in Smart Cities.

I. INTRODUCTION

Smart Cities facilitate high end technology with well-established infrastructure with IOT device integration to provide a better quality of life in cities. Government and private organizations are collaborating in various projects to collect huge amounts of data and analysing this data to build strategies to increase healthcare systems. The key areas are economic growth, the mobility of services, communication & transport mode availability, better public service provision including immigration and citizenship services, environmental sustainability, co-existing of different nationalities & ethnicity people, modern healthcare systems, smart housing facilities & tourism opportunities. (Rocha, 2019)

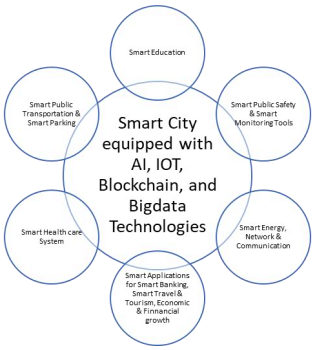

Fig. 1 Smart City model view

Smart cities are the solution for growing population needs in cities as the human intellectual grows to facilitate easy management in personal and professional time to lead a better quality of life. Rapid technology growth enhances the development of systems that enable automated systems such as IOT, Robotic devices for the individual service at home and workplace. With the augmentation of Artificial Intelligence, many human tasks are assigned to perform by the machines such as Robotic Vacuum Cleaner, Alexa. With the integration of these

devices with IOT enabled much more safety and security of systems from Home Monitoring to Automatic Alerting Devices for older adults and kids at home such as Switching of household electronic items. Smart Cities facilitate high end technology with well-established infrastructure integrated latest technology like AI, Blockchain and IOT systems.

With the integration of IOT systems with AI has provided many facilities in Smart Cities such as elderly people monitoring at home, medicine delivery management systems, handling emergency care situations. The electronic monitoring devices from BP monitoring systems, Diabetic monitoring systems to Intensive Care Units systems have made an enormous improvement in healthcare. Medical Practitioners can concentrate on patient care to provide better treatment and recommendations by offloading their monotonous work to machines. High population in smart cities causes the roads with heavy traffic congestion and jams, which put emergencies in trouble, hence big data and AI is helping come out of these problems and establish a peaceful urban environment lifestyle (Wang, 2020). Mobile health services are great help in seniors and needy people to avail the medical attention and procure safety from health hazards.

II. MACHINE LEARNING ALGORITHMS IN DISEASE DIAGNOSIS

Machine Learning models are prevalent in Predictive analytics for disease diagnosis in high-risk patients to save their lives with early detection and preventive mechanisms. Data collection, processing, storing, and analysing have become the biggest source of healthcare technological advancement. Electronic Health Records are stored and centralized to retrieve the records in case of emergencies across the healthcare centres irrespective of their medical insurance providers. The governments are spending financial and human resources to address the needs of patients to improve the healthcare systems with EHRs storage and centralization. For example, Dubai Government has started a project on Electronic Medical Records to store and centralize EHRs for the patients' quick recovery and ease of use by medical professionals to save the patients with timely diagnosis and treatment. Governments like Dubai are strategizing the city to Smart City, investing and collaborating to create e-health services relentlessly to provide the higher quality of services to public and use of the latest technologies. In this process, electronic health records are created to collect the data of patients with patient details such as diagnostic information, treatment records, and medical prescriptions. These patient medical records can be shared across health providers to provide quick and efficient services to the patients in case of any emergencies, knowledge transfer and research purpose. These records were exceedingly helpful in COVID-19 pandemic situations. Dubai Health Authority is concentrating on 3 key factors, they are patient care redesign (healthcare design model), payment incentives (reward systems), and patient engagement systems. Even though, these strategies benefit healthcare systems like DHA provide financial benefits over the long term, but they provide high-quality services to patients (El-Hassan, 2017).

Critical diseases such as cardiovascular and cancer diseases are diagnosed and treated at an early stage of the disease with Deep Learning algorithms. With the invention of smartphone technology, common people are aware of using health devices to reduce the chances of entering diseases by adopting healthy lifestyle standards like eating nutritious food, following an exercise regimen, managing stress with various techniques that has increased the average lifetime of human.

Few decades ago, diseases like cancer, CVD, and psychological disorders such as anxiety disorders, depressions are rate to find, but nowadays these cases are common especially in the younger generation. Irrespective of the reasons for these disorders, we must tackle these problems and save the humanity to have a better quality of life. Many people will not be able to express these conditions due to the lack of understanding and societal denial factors, but we as a human community need to get a solution. In urban areas, especially these conditions are prevalent for which new technologies such as smart applications, online consultations, virtual clinics are big help to guide lifestyle changes like exercise, meditation, and eating nutritious food, providing psychological consultations to treat the patients for better community healthy. Youth are biggest sufferers of

psychological disorders due to peer pressure, online games, lacking the motivation to lead a healthy life, we needed to address these critical issues to save our society and lead a healthy and happy life. Fortunately, many Governments and organizations are looking into this area to fix the issues in Smart Cities to provide high-quality services.

Healthcare applications enormously grown popularity nowadays due to developments in mobile and information technology. Individualized and personal care health apps are storing user data, providing timely alerts and recommendations in terms of health, exercise, meditation, and lifestyle in this busy era of urban population. Interactive applications are become popular. Public and private sector is investing in these apps to explore their commercial success and returns and promote their products to consumers, which is helpful for both consumers and companies. Targeted health behaviour and maintenance applications are big helpful tools for healthcare providers and organizations in addition to the consumers whether they are patients or healthy people who are willing to maintain their health (Boudreaux, 2014).

Data collected with the help of IOT devices such as public space usage, traffic movements, citizen mobility, drainage systems used for effective resource management in Smart Cities. The huge amount of data by IOT sensor devices is stored and analysed by researchers effectively using Deep Learning algorithms to better facilitate and use the resources in Smart Cities. Smart Cities are providing an ideal environment to live and work comfortably with the invention of new technology and infrastructure. For example, Parking spaces availability-checking systems (Smart parking system), airport-parking checkout procedures like consumer can make bill using smart machines, then the system will scrutinize whether vehicle can leave the parking space or should pay the bill, this procedure is avoiding the manual parking card payment system associated with delays and long queues. The sensor systems can read the vehicle number plate then decides whether bill has paid for the vehicle or not automatically, otherwise the bill is cleared at the exit gate to exit the vehicle from parking space. In this automation process, the vehicle owners no need to wait in the long queues to clear the bill at counter and exit points. Power supply and distribution are the biggest criteria in Smart Cities, which is managed efficiently with the help of high infrastructure technology such as smart street polls and solar system deployment in various public spaces like parks, bus, and metro stations to best use natural resources to preserve ecosystems inexpensively. Healthcare in Cities would benefit by DL routing mechanisms for better handling of network bottlenecks for data sourcing or transferring, autonomous self-driving refuse trucks for safer society by preventing accidents with automatic sensor systems, AI-based pedestrian detection systems to reduce accidents. Deep Learning technology is used extensively in the construction of buildings in Smart cities to facilitate home automation tools integrated with AI (Bhattacharya, 2020).

III. RECENT TECHNIQUES IN IMAGE ANALYSIS

In Smart cities, automated X-Ray, MRI, CT, PET scanning, image-screening systems are in place for quicker detection with minimal human efforts to reduce the cost of human resources and provide faster processing mechanisms using AI. Any healthcare provider can view these digital reports anytime in quick and safe method. Especially, DL techniques from CNN to autoencoders have helped to create solutions for medical imaging analysis and these methods are way better performed than human resources especially task-specific applications. AI-based applications are used heavily in the healthcare industry for patient monitoring systems remotely, discovery of new medicine, medical imaging and diagnostics systems, wearable systems like smart watches & gadgets integrated with mobiles, online consultations, virtual assistants, hospital management software. Many individuals use these devices nowadays due to affordability and ease of usage. Especially, in case of patients suffering from chronic conditions must be constantly aware of the potential risks for not following healthy diet intake and healthy lifestyle, for example cardiovascular diseases being one of the most widespread diseases across the globe. Patients must follow certain lifestyle to lead a better quality of life, which can be achieved with smart

applications and gadgets. DL models are exceptionally used in detecting and classifying high-risk diseases like cancer, cardiovascular with high precision and accuracy compared to manual methods that reduced the time to detect anomalies with better accuracy rate. AI methods are used extensively for image-based technology in various departments such as radiology, pathology, dermatology, and ophthalmology. Complex image patterns are detected, segmented, and categorized with AI-based technology for better accuracy than humans to provide quantitative assessment. Physicians identify patterns based on their own experience which can vary the output, but the AI-based applications are trained with huge data to detect complex images with high accuracy and precision. In many hospitals, physicians are allowed to use these automated tools to quicken the process and provide better results to patients. Such imaging data can be used for research in scientific world and useful for feeding large and complex DL models to train for feature-engineering purposes. Radiologists are getting good support from AI-based systems to detect such as lung cancers, tumour classifications in the diagnosis of diseases, for better image quality, data visualization, assessment and generating reports. Medical images are stored in digital form with consistency in systems such as Picture Archiving and Communication System (PACS). (Hosny, 2018).

Many issues associated with computer vision, robotics and language processing are solved by DL models like Artificial Neural Networks. Many famous and top organizations such as Microsoft and IBM are investing in AI to invent new applications in healthcare systems. Machine Learning models are trained with the data as input and test these models after validation to get better accuracy and precision, the larger the data available to train, the better the accuracy of results. ANN models are used extensively in ML due to the advancements in Bigdata and other AI related technologies. DL is used in radiotherapy, radiomics, for theragnostic in neurosurgical imaging to detect CLE images, in prostate biopsy, and in image-guided therapy, radio genomics, neuroimaging, neuroradiology, neuropsychiatric disorders, breast cancer, mammography, chest imaging, imaging in oncology, medical ultrasound, and medical image analysis. DL is used in Image segmentation, in predicting disease based on images and text reports in various organs like the brain, kidney, prostate and spine and in image synthesis. For example, 3D images are used to differentiate cysts, polyps, or fibroids in a uterus, it's a remarkable improvement in healthcare, many times the physicians unable to differentiate these and end up with repeated D&Cs to remove them, but they keep showing in the scanning, if fibroid is there it must be operated with laparoscopy (Lundervold, 2019).

68% of the population will reside in urban areas by 2050 (Kundu, 2019), in the process of sustenance the ecological environment gets destroyed for constructing living places, providing uninterrupted power supply, and to provide better living systems including roads and transportation. Smart cities are providing a solution to these problems by using the resources to the best usage to provide a better quality of life in terms of health, economy, happiness by preserving the natural eco system. In this process, ML and Data Mining are playing a major role in creating Smart cities (Souza, 2019).

IV. COMPUTER VISION AND ARTIFICIAL INTELLIGENCE

Deep Learning is used in Computer Vision. CV investigates digital images of radiology and pathology reports with high efficiency and specificity. CV used in applications such as screening in ophthalmology to detect diabetic retinopathy and automated detection of cancerous lesions in dermatology department. DL and CV jointly used in creating tools for radiation and magnetic exposure prediction. CV usage in surgery increasing day by day, the surgical procedure data are stored for analysing, using for new applications models' creation, educating other physicians, and for research. Surgeons are storing the data of Laparoscopy, endoscopy, and robotic camera procedures for future use, which is enhancing the healthcare industry growth in robotics and AI. Natural Language Processing combined with Computer Vision is a remarkable improvement in the field of healthcare. NLP is used for human language translations, unstructured data, to analyse and structure reports such as radiology, operative notes, for predicting the

status of patient's health, for diagnosing cancer patient's risk levels, and to find operative site infections. To predict the risks associated with operation before it has taken place gives better understanding of the situations and provide an opportunity to patients' and for physicians to make better decisions about surgery. Especially, cardiac, and metabolic related events are important to know these risks. The latest ML algorithms are used to make these risk predictions for estimating the outcomes with better accuracy. Duke University performed an experiment with three different models using Lasso Regression, RF models, and extreme GBM, out of these three models Lasso Regression has shown better accuracy to predict post-operative mortality rates and comorbidity predictions. Electronic Medical Records are not only to store the patients' medical history, but they are also used for the training and educating physicians, for example AI systems are studying EMRs to evaluate the best surgical procedures and recommendation systems based on the surgeries taken place earlier on a patient. Massachusetts General Hospital launched risk predictor tool based on Machine Learning algorithm, it has scored the best performance compared to other tools. Combining Bigdata with ML techniques has led to easier data storage and evolution of new applications to use in clinical and surgical environments with much better accuracy and precision than before, by merging EHRs has evolved into higher accurate pre-operative and post-operative predictions. Computer Vision is playing a major role in guiding and assisting in Operative Rooms to Physicians, which will enhance their experience and easy accessibility of the areas in the operation, which is difficult for humans to reach out. AI is playing critical role in intraoperative decision making as well, such as port placing, confirmation of critical view, by providing better camera systems. In the future, ML models will be trained with a greater number of cases, and with ample of data to feed, which will learn and provide guidance to surgeons to perform critical operations to improve the success rates in surgeries. EMRs not only used for calculating risk and managing the resources, but these have also been used to integrate preoperative information with intraoperative incidents and postoperative results of patients. With this information, AI systems can be trained more efficiently to acquire better recommendations to any physician in the world to learn and to operate virtually. Surgeons and Clinical Practitioners should work closely with clinical and surgical equipment engineers and with data scientists to improve the technology further (Hashimoto, 2020).

V. AI AND ROBOTICS IN OPERATING ROOMS

AI in the department of surgery made a remarkable change in the healthcare world with advanced developments in imaging, navigation, surgical instruments, and robotics. Surgeons use AI technology-based tools in various surgeries related to gynaecology, cardiology, oncology, orthopaedics, neurology, ophthalmology, nephrology, and gastroenterology in Operating Rooms to assist. Complex surgeries are made easy with approaches such as PET scan, Ultrasound, Computed Tomography (CT), and MRI. Nowadays, many procedures are operated with minimally invasive surgery methods, which are reducing the recovery period required for the patients and many gadgets are facilitating for the early discharge provisions to maintain post-operative care. Post-surgical recovery period is reduced with minimal invasive operations like laparoscopy surgeries, which has given better patient prognosis. Reduced complications like less pain and blood loss, lesser in-patient stay, fast recovery are few other benefits with robotic surgery methods. By detecting the post-operative complications early, the patient and doctor can work together to avoid complications at an early stage. AI is widely used in risk classification, genomics, image techniques, medical diagnosis, precision medicine, and new drug discovery. DL algorithms like Deep Convolutional Neural Network are used in analysing images for diagnosis. With the advent of sensor and motor features, surgeries are made easy and helping in early detection of diseases to prevent further damages in the body and provide targeted therapies to patients. These methods increase the accuracy of diagnosis and surgery such as constrained tendon-driven serpentine mechanism (CTSM), NeoGuide colonoscopy system, miniature robotic system (Endotics), and Neurosurgical Intracranial Robot

(MINIR) used in removing tumours of brain. Robotics is used to get better view of the organs with high precision and efficiency during surgeries. Robots are playing a key role in decision support systems in the healthcare system as well. Nowadays, DL models such as CNN are heavily used in pre-operative plans and able to use successfully in segmentation and classification of cancers. RNNs are used in the prediction of renal failures, bleeding problems in cardiovascular disease patients' post-operative times with better accuracy. DL models are used to detect and categorize malignant tumours with better sensitivity and specificity. Convolutional autoencoder models trained to detect prostate cancer with PET images. Pulmonary nodules are detected with 3D CNNs. CNNs are used in orthopaedics to detect cartilage lesions. Deep Reinforcement Learning models are used to detect breast cancer (Zhou, 2020).

Robotics in Operating Room is playing a vital role along with Surgeon by managing trajectory, pace, and depth of the equipment motion precisely. AI technology with Robotics can learn complex surgical procedures to enhance the surgical skills to use at a great precision and accuracy. Nowadays, collaborative robots (cobot) are popular in Surgical Rooms to perform multiple tasks together to assist physicians during complex surgeries. Otorhinolaryngology is a study of diseases of the ear, nose, and throat. AI-based tools are widely used in otorhinolaryngology (head and neck surgery) and neurosurgery departments. AI-based applications are integrated with hearing aids to patients, in addition to assisting to hear the noises, these devices are helpful to remember the places, filter the environmental sounds, check the physiological variances, and to predict the language speaking abilities. 13 Machine Learning algorithms are used in the classification of otoneurological disease diagnosis with 77% accurate results. ML methods are used for rotational testing. Dizziness is diagnosed with 93% accuracy in vertigo patients using ML algorithms. AI-based treatments such as speech recognizable hearing aid tools are used for brain stem evoked response audiometry (BERA) tests. Tonsillitis, Pharyngitis and Rhinosinusitis of ENT related diseases studied with 90% accomplishment with ML and ANN algorithms. ML algorithms are used in Meniere's disease, respiratory tract infections and influenza, oral cancer, and thyroid disease diagnosis, to predict bleeding problems in patients with tonsillectomy and adenoidectomy, to detect vocal cord disorders with better accuracy. Robotic surgery proved to be better than normal laser surgery in head and neck cancers surgery. Rhinoplasty surgeries are better projected and Glial tumours are better segmented in brain surgeries with AI. ANNs seem better in detecting lesions, glial tumours, tumour categorization with better precision in the neurosurgery department. MRI-guided robotic arms facilitate the surgeons with greater mobility in complicated surgeries such as brain surgery, neurosurgery, oncologic surgery, cervical surgery, lumbar herniated disc surgery, arteriovenous malformation surgeries. Random Forest, SVM models are used in diagnosing various tumours according to the size, shape, and volume to categorize. AI is used for stroke studies based on CT image diagnosis with CNNs, which will speed up neuroradiology workflow. AI technology is imparted in smartphone applications, surgical equipment, and clinical decision support systems in radiology. Augmented and virtual reality approaches are used in surgeries training to make better decisions in pre-operative scenarios to reach the targets of successful completion of surgeries in complicated cases (Lee, 2021).

VI. VR AND AR IN SMART CITIES

Virtual Reality and Augmented Reality (VR and AR) enable the digital reports to be viewed in 3-dimensional. VR enables to simulate the results for the procedures using images and noises. Stereoscopic glasses on headset create a 3D image to view digital information. VR provides complete simulation such as look and feel, whereas AR is an interactive experience where we look with smartphone, digital contact lens or headset. VR and AR are going to be a big game changer for Physicians or Surgeons, who can check the treatment options on organs before surgery occurs and it can be used for teaching students as well. Surgeons can study anatomical complexity using VR in surgeries before operations occur to simulate the results such as Plastic surgeries, and cardiovascular related surgeries. AR is used in Doctor's education, for navigating hospitals, defibrillator station wayfinding, intravenous

assistance, and vein detection, and for hospital automation (Vles, 2020).

Human resources like nurses, are the scarcity in city hospitals to attend patients and complete documentation process. The integration of applications to smartphones have enabled remote patient monitoring systems in place with Internet of Things and smart gadgets. Brain haemorrhage causes due to brain artery damage, which may burst and bleed, eventually effects the function of adjacent brain cells. If this condition is not diagnosed and treated on time, it may lead to death or permanent disability. Brain haemorrhage is 5 types: intraventricular, intraparenchymal, subarachnoid, epidural, and subdural. CT scans are used to investigate such cases. Deep Learning algorithms such as Support Vector Machine (SVM) and Feedforward Neural Network (FNN) are used in the investigation of Brain haemorrhage. Automated detection and screening tools to diagnose brain haemorrhage are commonly used in critical care facilities. Applications integrated with IOT are providing health facilities at hospitals without long queues and waiting period, home care diagnostic facilities, cancer care, continuous glucose monitoring (CGM) to detect blood glucose levels automatically. In smart cities, routine work performed by human resources in various departments the clinical environments are getting automated to reduce human efforts, increasing the work efficiency, and to perform things faster than humans. The development of IOT systems have greatly transformed health industry enabling home care services in various chronic conditions such as kidney disease, diabetes, cardiovascular diseases, cancer (Hang, 2020). Telehealth systems are in great help during the COVID-19 pandemic, many developed and developing countries are adapted these systems quickly to save the humanity from infections and get treatment being at home.

In Smart cities, people health at workspace is considered the most important factor for the financial growth of society. The absenteeism of employees may be associated with physical or psychological illness such as suffering from chronic conditions, depression, sleep disorders, weight gain and associated diseases. Larger organizations are focusing on employee's health to promote good health and healthy work environment by implementing health risk assessments. Various programs are designed to educate the employees for healthy nutrition, sleep, physical exercise, meditation techniques for stress management. These techniques implementation has become practical with the usage of digital devices with support groups like healthcare practitioners, professional development, volunteers, and online applications (Howarth, 2018).

VII. AI IN IMAGE ANALYSIS

Technological advancements in Internet of Things and sensor devices are inculcated smart healthcare system is an essential part of smart city amenities. Collecting information of people using wearable or sensing devices called crowdsensing. To acquire quality healthcare services, Deep Learning algorithms process and use the data or information acquired by crowdsensing. High level of computing resources such as bigger storage, CPU, GPU (processing power), and memory capacity, such as Bigdata environments enabled the processing and training of data with Neural Networks made easy and affordable in Smart Cities. These data are used for various developments in smart cities such as economic growth, to build better quality healthcare systems, ease traffic congestion, to provide public transportation, and public safety. Quality healthcare depends on social sustainability in smart cities, for example smart devices to measure air pollution levels. Machine Learning algorithms were unable to resolve some functions; hence Deep Learning algorithms are better implemented in sensor device relevance with data to develop new applications to resolve healthcare problems in smart cities. DL algorithms impersonate the human brain and create various perceptron layers to train the data and achieve results with high accuracy and specificity. Deep Learning algorithms need huge data sets required to train the models, but the results are more accurate than ML algorithms. DL models learn from experiencing rather than rule-based approach with huge datasets using bottom-up perspective to get the best approximation of function, they work better on non-labelled and unstructured data as well. The systems developed with DL algorithms can perform better in unforeseen events with the help of features such as back propagation. DL models could achieve 94.95% accuracy with ECG (electrocardiogram) reports of coronary diseases. DL algorithms could classify EEG (electroencephalogram) signals using Deep Neural Networks, such as in epileptic diseases, decision

making and blood glucose levels monitoring. Convolutional Neural Networks (CNNs) are used to diagnose Parkinson's (neurodegenerative disorder) with data collected by patient's wearable sensor devices to find different stages of disease to help the patient's timely needed treatment. CNNs are used to find energy consumption details with the help of monitoring device, to detect when elderly people have a tendency of falling. By including CNNs with physiological biometrics and behavioural Biometrics has provided higher security and spoofing in digital healthcare systems. Autoencoder Neural Network works on three layers, and it follows the minimalist approach with encoder and decoder functions. Autoencoders not only used in feature learning, but they are also used in generative model purpose. Types of Autoencoders: Undercomplete, Regularized, Sparse, Denoising, and Contractive. In Convolutional Neural Networks each layer identifies the image partially, then the output is passed on to the next layer with multi-spectral resolution, this process is repeated with each layer so that the end output image quality is much better to calculate and project the image with better clarity, for example in image analysis (MRI, PET scan). Convolutional, Pooling and Fully connected layers are represented with Convolutional Neural Networks. Deep Belief Network builds like a tree, based on random variables connected between various layers to categorize the data, it learns layer by layer. Boltzmann Machine neural network has uniform nodes connected, in which neurons assist to make decisions. BM algorithms are suitable for learning and search-related issues to solve. Deep Learning algorithms on wearable devices with sensors such as wrist bands, VR goggles, EEG headsets, smart watches are playing an important role in personalized healthcare system, with the latest developments in technology the data is acquired with high-quality, which will be useful for patient prognosis and medical industry research (Obinikpo, 2017).

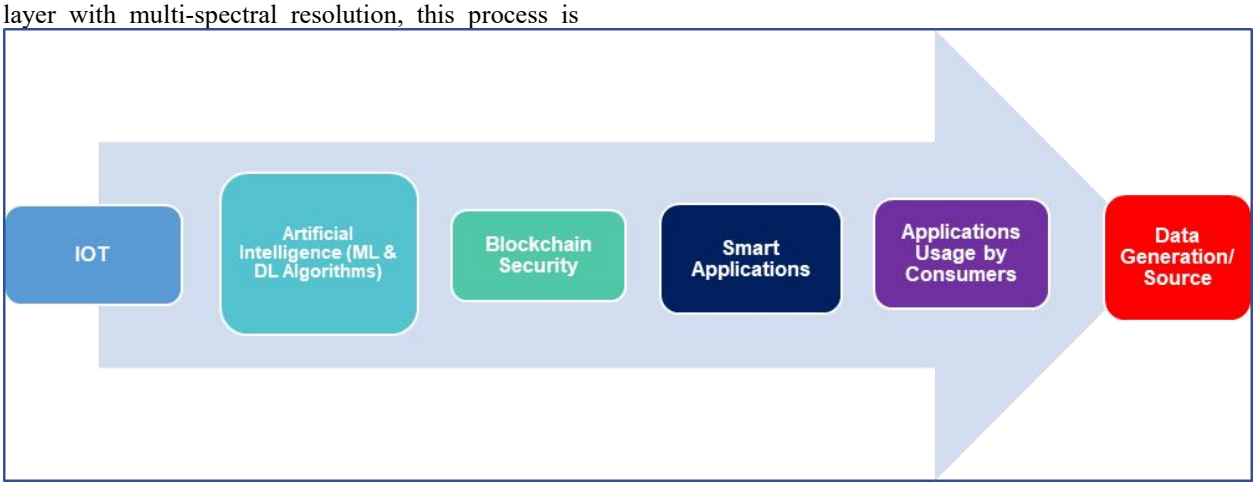

Fig. 2 – Workflow of IOT, AI, Blockchain, Bigdata, User data and Smart Applications

VIII. AI IN COVID-19 PANDEMIC

Deep Learning algorithms of Artificial Intelligence, Bigdata Analytics, Blockchain, IOT devices are made revolutionary developments in healthcare system. These technologies are inter-related to play a vital role in gathering data, training the data to learn, patient care, and to automate the processes in hospitals. The outbreak of COVID-19 coronavirus disease is contagious, which made chaotic situation in the whole world due to the quick spread of infection. Governments have spent lot of resources to trace down the infection, isolating infected individuals with quarantine rules, safeguarding the elderly people and kids. IOT, Bigdata, Blockchain and AI technologies are played an important role in monitoring, investigating, diagnosis, preventing and reducing the impact of COVID-19 disease. IOT devices enable to access the data by health groups such as worldometer to know the COVID-19 patients' number, which include daily infected cases in various countries and extremity of the disease (Ting, 2020). Bigdata enabled to transfer, store, and process the data with analytics to study COVID-19 cases, disease symptoms, treatment options, to reduce infections in populated areas like urban areas, so that the healthcare authorities take appropriate actions to prevent spreading the disease. For example, United Arab Emirates government was able to take appropriate timely actions to restrict the spreading of

infection by building emergency care centres, providing isolation wards, medicine distribution, guiding people across the country to follow COVID-19 rules in private and public premises. Enhancements in digital and telecommunication technologies enabled the individuals to aware and implement safeguard measures using Smartphone applications, Government health applications for example Dubai Health Authority application, thermal scanners to recognize people with high temperatures. Deep Learning algorithm developments in Artificial Intelligence enabled to find and diagnose COVID-19 cases by providing inexpensive and accurate tests to identify the disease was need of the hour. Many countries were not equipped with enough resources to test these cases, but DL algorithms with enormous data sets on these cases, enabled to train the models for screening symptomatic and asymptomatic cases so that the patients' will be given immediate treatment or send for an isolation. Even in the case of not severe cases, medical practitioners had to be extremely cautious and follow the treatment process, monitor, and isolate to avoid spreading infection. AI promoted drug discovery and vaccine for COVID-19 disease. In the initial months of COVID-19 many hospitals have stopped routine services such as non-covid cases doctor's visits, non-critical surgeries temporarily. Digital tools and e-commerce facilitated with virtual doctors, online appointments, home care systems during COVID-19 pandemic. Tele Medicine with blockchain technology has enabled facilities such as uploading the reports to hospital websites to diagnose, treat patients and deliver medicine at the doorstep. Many Artificial Intelligence based applications reduced the workload of medical practitioners such as chatbot for online help to identify symptoms, to educate individuals on hygiene measures to be followed, and recommend patients to medical attention in case of severe symptoms. Mobile applications such as Dubai Health Authority application has updated with current information and statistics on COVID-19, recording patient's information, and helped in preventing unnecessary hospital consultations in case of mild symptoms (Ting, 2020). AI, IOT, Blockchain technologies have contributed to developing, supply, and implement vaccination drive for COVID-19 across the globe successfully.

Blockchain is an essential component to provide trust to safeguard the data and sensitive information of people in a smart city. Blockchain enables trust factors with enormous developments in storing, processing and data across the globe to various organizations, individuals, agencies, and governments (Kundu, 2019).

IX. AI IN PHARMACEUTICAL INDUSTRY

Machine Learning algorithms are playing an important role in drug discovery development with magnificent results and accommodating research opportunities with the advent of technology developments in Bigdata to store enormous data sets and process data with high level computing resources. Many pharmaceutical establishments are exploring ML techniques to adapt, for getting financial benefits with the implementation of successful business models by reducing the resource intensive methods, and to prevent the need for animal experimentation. Most of the developers and researchers can use free software and easy programming languages such as Python and R to develop ML algorithms effectively with huge datasets. ML techniques such as artificial neural networks, random forest, support vector machines, k Nearest Neighbour, k-means, decision tree, principal component analysis (PCA) are popularly used in drug discovery. These algorithms and tools facilitate scientists to research without computer science knowledge like programming background. The collaborated third-party applications are easy to use for working with ML algorithms such as linear regression, categorization. ML algorithms have some limitations like dimensionality, performance, big data sets, sample size, lack of autonomy, and transparency. Post implementation of these algorithms in various applications, if the data is changed in data set, the maintenance of the applications is required, which adds up a lot of additional work and expense (Elbadawi, 2021). Reinforcement Learning is another ML technique to address the autonomy issue, this algorithm learns dynamically based on actions adjusted with a feedback system to increase reward, it's suitable for dynamic fields such as gaming, finance trading and robotics. Transfer learning is a Deep Learning technique used to address a smaller sample size data where transfer knowledge from one model to another to solve tasks, these models (supervised and unsupervised) can be deployed faster specifically to use in image analysis in the healthcare system. Transfer learning was significantly useful in the prediction of blood cancer with minimal data availability. Multitask learning algorithms explored to increase the performance to run models because transfer learning models perform sequentially, which will take longer time to run. This algorithm is useful with smaller data sets with significant noise and to study the effects of multi-target drugs. In patients

with cancer or tuberculosis, multi-target drugs are more effective in treatments. Multitask models can be combined with gradient boosting training models on smaller datasets. Low-labelled dataset issue is addressed with Active learning models. Generative models can predict the next data sequence, they can generate new sample data which can be used for data augmentation in case of a small sample size available to do the predictions. Bayesian Neural Networks do not need a larger data set to train the models and they can avoid overfitting problems. Explainable algorithms are used in decision-making processes (Elbadawi, 2021). Generating large size of datasets in pharmaceutical industry is an expensive task, hence data augmentation techniques are going to be useful to predict drug discovery with better accuracy and specificity. To address these limitations Deep Learning algorithms have taken front seat to drive large data sets to train with the models on unstructured data as well as the best results in terms of efficiency and accuracy.

Artificial Intelligence algorithms are not only used in drug discovery and development but also in drug testing, drug repurposing, increasing the productivity of the pharmaceutical industry by providing the best business models. AI is targeted to reduce human workload and increase profits, economic growth of the pharmaceutical industry with inexpensive drug testing models. Many web-based applications are in use to reduce the cost of drug testing, for example, to find the chemical compound toxicity in drugs. AI is helpful in structure-based drug design with the prediction of protein structure of the target, to predict drug-protein interactions with protein of receptors with better accuracy. Artificial Neural Networks are used to develop capsules with decision support systems. Mathematical tools integrated with AI establish enormous help in quick production of new drugs in pharmaceuticals (Paul, 2021).

With wireless and telecom revolution Telemedicine able to provide medical services to rural areas, remote areas, nursing facilities, jails, individual's home, especially during COVID-19 pandemic. Otolaryngology department protocols could successfully implement with the help of telemedicine services. With advanced cameras, high-speed internet services, and smart applications telemedicine services are feasible to implement. The patients' survey proved that 78.9% improvement in 2021 year in recovery rate. Telemedicine services solved most of the ENT problems in patients without the need to travel to the hospital for treatment (Wu, 2021)

X. CONCLUSION

A smart city services are well facilitated amidst of Artificial Intelligence, Blockchain, Big data analytics and IOT to provide smart services efficiently. The massive increase in data volume has led to the challenges of data protection, security, threat, and privacy. Blockchain has solved many data security problems still security threats and ransom demands are common in cybercrime recently. Performance, Speed and Accuracy are three key factors in developing and maintaining smart applications, another challenge is that companies need to allocate huge budgets to maintain the data and skill set of employees. Organizations should spend noticeable time and money to improve the processes and maintain the digital systems. Big data and Cloud Computing have resolved the issue of expensive hardware cost and scalability of organization data capacity requirements to maintain data, yet data security, privacy and performance are debatable to this day. Even though there is lot of improvement in Machine Learning algorithms to serve the growing needs of various industry requirements, there is yet lot of improvements needed on algorithms to work better with a smaller sample size as the data collection is a big challenge and expensive task for some fields. Deep Learning has revolutionized various fields with automation, image analysis, natural language processing, and facial recognition yet there is lot of work to be done to improve the efficiency, precision and avoid mistakes to the level of human intelligence. The field of Artificial Intelligence has taken the lead in digital technology development to make the systems for easy access, reachability with higher accuracy and specificity. Continuous progress and evolution in Deep Learning Algorithms, with the help of open-source software to develop, analyse and research to acquire astonishing results and developments by relentless efforts of computer developers' society in digital healthcare systems and various other fields is remarkable for the future of smart cities.

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