RESEARCH PAPER

A Hybrid AI-IoT Framework for Disease Detection and Intelligent Drug Delivery

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Received: 12th Mar, 2026 | **Revised:** 24th Mar, 2026 | **Accepted:** 14th Apr, 2026 | **Available Online:** 30th Apr, 2026

ABSTRACT

This paper will discuss a hybrid system of Artificial Intelligence (AI) and the Internet of Things (IoT) used in detecting diseases and smartly delivering medications. The increased need in the personalized healthcare solutions has put the current technologies in perspective which are, in most cases, not integrated, scalable or able to provide decision making opportunities in real time. The proposed system incorporates IoT devices to monitor the health condition continuously, and AI algorithms to predict and diagnose the diseases based on real-time data. Furthermore, there is a smart drug delivery system that varies the amounts of medication according to the ongoing health measurement. The efficacy of the framework is judged on the basis of simulations and actual world data indicating its usefulness in enhancing diagnostic accuracy and in optimal drug delivery plans. The findings show that patient outcomes are significantly better with the use of novice methodology, in all aspects such as accuracy, response time and precision. The work is a contribution to the creation of smart healthcare solutions which may dynamically change according to the dynamically changing patient conditions.

Keywords: Hybrid AI-IoT framework, Disease detection, Intelligent drug delivery, Healthcare, Machine learning, Real-time monitoring, Personalized medicine, IoT devices, AI algorithms, Precision medicine.

How to cite this article: Gupta R, Suhas S, Manjunatha B, Pragash S, Omonov O, Punia S. A Hybrid AI-IoT Framework for Disease Detection and Intelligent Drug Delivery. Int J Drug Deliv Technol. 2026;16(25s): 126-135. DOI: 10.25258/ijddt.16.25s.14

Source of support: Nil.

Conflict of interest: None

1. Introduction

Disease detection and drug delivery systems are not new characteristics of healthcare, and the main goal of these systems is to improve patient outcomes by diligently diagnosing and prescribing drugs to patients. Conventional approaches, including clinical diagnostic and imaging, are typically based on manual interpretation with drawbacks in the delivery of real-time insights[1]. In addition, the traditional pharmaceutical delivery systems, as a rule, adhere to a standardized dose and, in different cases, customized to the individual needs of a particular patient. Consequently, there is a greater demand of more efficient, flexible and customized healthcare solutions. The integration of new technologies, specifically the Internet of Things (IoT) and Artificial Intelligence (AI) are a potential roadmap to overcome these challenges. IoT allows real-time monitoring of patients through the implementation of sensors and other devices that are capable of collecting and transmitting health data, and through the AI, the analysis of a large amount of data and predictive analysis is made possible (Magnier, 2018). The combination of these technologies presents a chance to develop integrated solutions that in addition to advancing the detection of diseases can also result in the creation of intelligent drug delivery systems, customized to meet the unique needs of patients, and ultimately leading to better accuracy in the treatment and patient care.

Although there has been development in these technologies, there are still various challenges in disease detection as well delivery of the drugs[2]. Existing diagnostic systems tend to be reactive to disease with the disease being diagnosed after the manifestation and thus cannot receive timely treatment and have limited treatment options. Also, in current drug delivery systems, the consideration of the individual needs of the patients is not be taken into account, which results in such a problem in current drug delivery systems as ignoring the needs of each individual client. Moreover, the introduction of the IoT and AI into the healthcare systems poses certain challenges such as issues of data security, privacy concerns, and the inability to ensure the interoperability of various devices and technologies. Although IoT devices could offer continuous streams of data, it is a complicated undertaking and needs powerful AI models[3]. Also, the IoT devices can differ both in the quality of sensors and communication standards, which makes it challenging to unite them into an integrated system. These constraints support the idea that a single solution is needed that integrates the predictive abilities of AI with real-time monitoring capabilities of IoT to close the gaps of the current methods of disease detection and drug delivery[4].

This study will develop a hybrid AI-IoT platform that will solve these issues by integrating patient monitoring systems that are based on IoT and AI algorithms to detect and deliver the required medication[5]. The first aim is to develop a system that is capable of identifying diseases in its early stages because of constant monitoring and information processing of data collected by IoT sensors. With the help of this information, AI will be used to anticipate the possible health risks and to be diagnosed and intervened in time. The system will also include a smart drug dispensing system which automatically reacts to the health of the patient and adjusts the patient to the drug dose to be administered at any given time so as to achieve optimal treatment[6]. The study will aim at developing a smooth flow between the IoT and the AI to ensure that the flow of patient information is smooth and efficient. Finally, this hybrid structure is meant to work towards improving the effectiveness of healthcare systems by offering customized, timely, and adaptive solutions both with regard to detecting a disease and administering a drug.

The scope of this project is to design and test the AI-IoT framework, meaning the creation of the AI-based disease-detection and drug-delivery-optimization algorithms, as well as integration of the IoT sensors and devices into those algorithms. The framework will be measured with simulations and real-world data and measured in performance metrics of diagnostic accuracy, treatment effectiveness, and responsiveness of the system. This survey will be limited to a set of diseases and conditions, and the aim of this is to show the potential the system has in particular healthcare situations[7]. Nonetheless, there are a few shortcomings within the area of the study. The framework will be evaluated using a certain sample of IoT devices, and the effectiveness of the framework might be affected by the quality and compatibility of these devices. Also even though the system will be validated using simulated data, large scale clinical validation does not feature in this research. System integration problems like data security, sensor interoperability and other problems will be discussed, although their solutions are out of the range of the study. The study will still be useful in the future in understanding the possible use of AI and IoT in medical care, which will then form the basis of more developments in the field of personalized disease detection and intelligent drug delivery systems.

2. Literature Review

Technologies that are used to detect disease have a long history of developing and evolving to become the current AI-based technologies, changing the method of disease diagnosis and monitoring among care professionals. Physical examination, such as X-rays, MRIs, and other imaging techniques, laboratory tests, and physical examination are considered to be fundamentals in the diagnosis of different health conditions. Nonetheless, these ways tend to be reactive in that they will identify disease only after symptoms present themselves, which can result in late-stage diagnosis and limited treatment choices[8]. There are magical technologies, like imaging, that require specialized interpretation, which give rise to inaccuracies or delay. Conversely, AI-based disease detection has also emerged as an exciting measure to overcome these drawbacks[9]. The algorithms machine learning (ML) and deep learning (DL) are currently being used to analyze large datasets e.g. medical images, patient records and genetic information to detect disease earlier and more accurately. In radiology, AI models, especially convolutional neural networks (CNNs), can interpret signatures in medical images to detect or rule out diseases such as tumors and cardiovascular diseases with stunning accuracy[10]. Additionally, AI can handle complex data sets of different sources and reveal concealed patterns, risk factors that cannot be easily identified by any other means. It is the transition to AI-driven diagnosis that makes possible early disease detection, which is a proactive approach that can greatly enhance the outcomes of treatment and provide an opportunity to address a particular individual[11].

Another important sphere of healthcare that experienced a lot of innovation over recent years is known as drug delivery systems. Conventional means of delivering drugs to humans, including oral pills, injections, topicals among others, is common and standard practice but not very precise in offering customized treatment[12]. Orally administered drugs, such as, are also susceptible to the limitations of gastrointestinal absorption which then cause variability in the effectiveness of drugs. Although injections are more effective in treating certain conditions, it requires administration regularly, and can be cumbersome and uncomfortable to patients. This has seen newer drug delivery systems being developed to enhance precision and personalization[13]. The controlled-release drug delivery systems, including implants, patches, and injectable microparticles, give a sustained release of medication, and decrease the frequency of administration, but provide more consistent therapeutic effects. Also, medication can be targeted to precisely to the site of action, minimizing side effects and enhancing the overall efficacy of treatments[14]. Differentiating potentially effective and individualized treatments personalized medicine, customizing drug delivery to the specifics of the genetic makeup, lifestyle and a medical history, is a fast developing area which promises to transform the world of healthcare, as alternative and more efficient treatments become available to the individual[15]. Such developments underscore the current progress in the direction of more specific and individualized treatments in drug delivery in order to enhance the effectiveness and the safety of the treatments.

The Internet of Things (IoT) has become an innovative technology in the health sector, where it can be used to continuously monitor patients and collect data on a real-time basis. IoT devices, including wearable digital sensors and smart health apps, collect data on different health measures like heart rate, blood pressure, levels of glucose and physical activity, and send the information to healthcare providers to be analysed[16]. The early prevention and treatment of potential developing health-related problems (arrhythmias, infections or complications of underlying diseases) can also be noted by this real-time surveillance and can be prevented and cured timely[17]. A further way IoT devices have improved diagnosis and drug administration is through the administration of doses. Smart inhalers such as that track medication use in asthma patients and provide non-compliant patients with feedback on their medication use behaviors. Moreover, IoT-based systems have also been established to monitor chronic conditions remotely, and allow the healthcare to adjust treatment plans according to real-time data[18]. By connecting IoT devices to healthcare systems, constant monitoring will be able to reduce the number of visits made to healthcare facilities, decrease healthcare costs, and provide a patient with a more personalized experience with their care provider, thereby improving their overall health outcomes.

The combination of Artificial Intelligence (AI) with IoT is strong potential that improves health care by increasing health monitoring and decision-making. As the number of IoT devices grows and gathers a huge amount of real-time patient data, AI algorithms process such data and provide actionable insights. Models based on AI have an opportunity to detect patterns, predict possible health risks, and propose interventions in a timely manner and basing on collected data with the help of IoT sensors[19]. As an example, using AI, one can analyze the information that has been gathered by IoT devices to identify the potential early signs of disease, including irregular heartbeats or fluctuating blood glucose levels, which can be used to predictively manage the disease. In addition, artificial intelligence can optimize medication administration through evaluating real-time health data and making changes to medication dosage as required. With the combination of AI processing large amounts of data in real-time and IoT monitoring in real-time of the condition of the patient, healthcare systems can offer real-time, adaptive, and personalized treatment plans that dynamically adjust in response to the condition of the patient. The integration, besides leading to increased accuracy and efficiency of disease detection and treatment, has the potential of providing fully automated healthcare systems through which they can operate continuously and do not need constant human intervention[20].

Hybrid frameworks, which provide AI and IoT, have become one of the central accentuations of modern healthcare research, offering combined solutions that overcome the drawbacks of single frameworks. The hybrid systems combine the potential of both AI and IoT, allowing them to provide continuous monitoring, real-time data analysis, and adaptable treatment plans. As an example, in managing chronic diseases, hybrid systems involve IoT devices to monitor essential health indicators and AI algorithms to analyze the information and offer recommendations on personalized treatment. These systems are able to predict when some health problems such as heart failure or the complications of diabetes are going to occur before they become critical such systems can mitigate the situation by adjusting treatment strategies in advance. The hybrid AI-IoT systems are being worked on in drug delivery as an adjustment of medication doses in real-time depending on the data received by the IoT sensors and offering a more accurate and individual approach to treatment. Such hybrid systems have the ability to automatize standard healthcare activities, like medication reminders or health checks, enhancing the productivity of healthcare delivery. Although combining different devices and securing data can be challenging, the opportunities of AI-IoT hybrid models to transform healthcare are enormous. The promise of these systems is to improve the quality of care by providing real-time, personalized solutions that would enhance the disease detection, diagnosis, and treatment, which would relate to better patient outcomes.

3. Theoretical Framework

AI Technologies for Disease Detection

AI has become a pillar of modern healthcare, with highly significant improvements in machine learning (ML), deep learning (DL), and other AI algorithms bringing to modern healthcare a huge leap in terms of both accuracy and the ability to detect disease in its initial stages. Machine learning is a subdivision of AI, and entails the creation of algorithms capable of learning and making predictions using data, without being explicitly coded. In disease detection, the large datasets analyzed by the ML models could include patient health records, medical images, and genomic data, identifying patterns that suggest the presence of certain diseases. One of the most popular ML applications, supervised learning, is based on labeled data to train the models and make them identify new, unknown data and sort it into meaningful categories. This technique is very effective in the diagnostic processes like the detection of a cancer in radiological images where the model can be trained to differentiate between the benign and malignant growths in radiological images.

A more advanced variant of ML (but still called deep learning) is the use of artificial neural networks with many layers (hence dubbed deep) to model complex, high-dimensional information. The use of deep learning methods, and specifically convolutional neural networks (CNNs), have demonstrated impressive performance in image analysis with medical images (such as X-rays, MRIs, and CT scans) being one of the most studied areas). These models have the ability to pick out small details in images which may not be easy to be noticed by human clinicians and therefore these models help in improving diagnostic accuracy and speed. In particular, CNNs are now commonly used routinely in radiological settings to identify uncharacteristics of an object such as tumors, fractures or pulmonary diseases with a high level of accuracy, sometimes doing so more accurately than their human counterparts. Besides imaging, deep learning is also essential in the analysis of unstructured data, including electronic health records (EHRs) to extract relevant information that can help in the early diagnosis and the prediction of the prognosis. Additionally, reinforcement learning, another type of deep learning, has been applied in the optimization of treatment choices where algorithms are trained to regulate the most effective possible treatment choices depending on patient information, and again improved as the patient data is collected.

Disease detection using AI technology has transformed diagnostic procedures by offering quicker and more precise and invasive procedures. Even before the symptoms manifest, predictive models that operate on the principles of AI can detect high-risk patients and provide early treatment interventions that would significantly change the results of treatment. Additionally, AI algorithms are under constant development, and more complex diseases, including cancer, cardiovascular diseases, and neurological disorders can be more deeply diagnosed with a better degree of accuracy.

IoT for Healthcare

The Internet of Things (IoT) has significantly influenced the sphere of healthcare, allowing managing the state of health of patients in real time, forming a network of interconnected sensors and devices. Healthcare solutions using IoTs involve the use of a variety of wearable and non-wearable gadgets with embedded sensors that gather and transmit health data to healthcare providers or central monitoring systems. These devices are able to measure a wide array of vital signs and biomarkers, such as heart rate, blood pressure, blood glucose levels, body temperature, respiratory rate and physical activity, which can detect continuous, objective information about the health status of a patient. As an illustration, the wearable gadgets like smartwatches and fitness-trackers track the amount of physical activity, whereas special medical equipment such as glucose monitors and ECG machines display real-time health data about patients with chronic conditions like diabetes and heart disease.

The protocols adopted by the IoT devices in the communication protocols are very important in the process of determining the reliability and efficiency of the information transmissions. As communication devices, they are usually connected wirelessly by using communication protocols like Bluetooth, Zigbee or Wi-Fi to relay data to central servers or cloud-based systems where the data can undergo processing and analysis. More advanced forms of communication such as 5G or low-power wide-area networks (LPWAN) have been used in some instances to allow long-range, low-latency communications to be possible so that patient information can be accessed remotely in real-time. The fact that it would allow constant monitoring and, therefore, detect health oddities earlier than the conventional methods would is one of the major benefits of the IoT in healthcare since this information allows utilizing it to prevent occurrence before it develops into other more life-threatening situations. Remote monitoring of patients also ensures that IoT systems minimize the need to see a doctor regularly, since now patients can be monitored remotely through the use of the Internet of Things, which in turn prevents many complications and adverse effects of increased Internet use on human health.<|human|>Remote patient monitoring also helps ensure that IoT systems do not result in too many complications and negative impact of the augmented use of the Internet on human health.

The other important factor about IoT in healthcare is its contribution in data gathering towards predictive analytics. By continuously gathering patient health data the IoT devices can be used to predict health risk factors, i.e., the occurrence heart attack or stroke. This real-time data stream may also be utilized in order to adjust treatment plans dynamically, based on the real-time health status of the patient, in order to achieve individualized and timely interventions. Moreover, integration of IoT with cloud computing removes the limitation of storing and analysing large volumes of patient data, which in turn enables healthcare providers to make data-driven decisions which, in turn, enhances care delivery and patient outcomes.

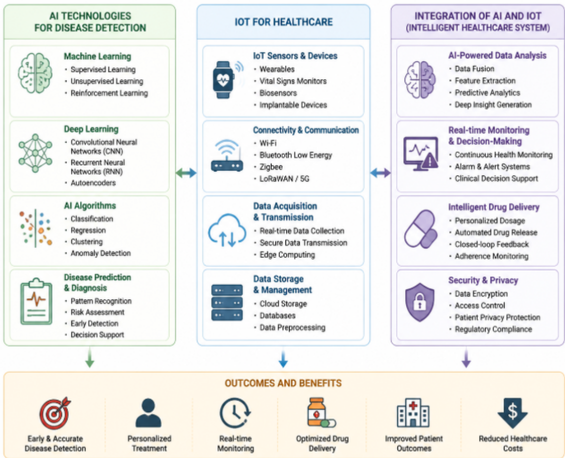

Figure 1: AI-IoT Integration in Healthcare for Disease Detection and Drug Delivery

The Figure.1. gives the detailed overview of the conjunction when it comes to the integration of the Artificial Intelligence (AI) and the Internet of Things (IoT) used in the healthcare. It is broken down into three categories: AI Technologies in Disease Detection, IoT in Healthcare, and the Integration of AI and IoT. The AI section describes all the major technologies such as machine learning, deep learning, and AI algorithms that are applied to predict and diagnose illnesses. The IoT section summarizes different devices and sensors i.e. wearables and biosensors, which constantly capture patient health data and transport it using secure communication networks. The integration section shows how the two technologies can be integrated to form a smart healthcare system, which is capable of real-time monitoring, predictive analytics, and delivering drugs to the correct individuals. The figure has highlighted the results and gains of this integration which include the early and accurate detection of diseases, personalized treatment, real time health monitoring, optimized drug delivery, improved patient outcomes and reduced healthcare costs.

Integration of AI and IoT

The concept of AI and IoT integration in healthcare can be viewed as the potent combination that can lead to a considerable enhancement of the levels of detecting, diagnosing, and treating diseases. Whereas the capability to collect real-time data is highly efficient when married to the IoT devices, the ability to process and analyze the data has many applications that can transform the world into a better place. Through such integration, intelligent healthcare systems that do not only monitor the health of the patients but also make predictions, diagnoses and adjustments to the treatment as a result of the continuous and conveniently collected data.

In various ways, AI can add value to the functions of the IoT. To start with, the AI algorithms can be used to analyze huge quantities of information produced by the IoT devices to detect patterns that can be indicative of underlying health conditions. As an example, AI models have the potential to process data gathered by wearables and sensor-added devices to identify early stages of a disease, such as heart failure, diabetes, or sepsis, recognizing abnormal trends in vital signs or biomarkers. The predictive ability of AI allows to diagnose early and conduct timely interventions that could prevent the disease progression and enhance patient outcomes.

Second, AI and IoT integration will enable developing personalized and adjustive healthcare systems. Through incorporating real-time monitoring of the health of an individual, and merging this with the predictive capabilities of AI, treatment plans are adjusted to changes in the health state of an individual. To give an example, AI algorithms can be used to analyze in real-time the data collected by IoT sensors, in order to make adjustments to medication dosages to treat chronic diseases like hypertension or diabetes, so the patient receives the best treatment at the right time. It is active, data-based, approach to healthcare, which can be used to optimize the results of therapeutic interventions, to reduce the possibility of the development of complications, and to increase the overall levels of patient satisfaction.

AI with IoT also can be used to automate most routine healthcare tasks and lessen the workload on healthcare providers and enhance the efficiency of healthcare delivery. Medication reminders, health assessments, and even remote consultations are only some of the tasks that can be automated with the help of AI-powered systems, which allows healthcare professionals to complete other tasks that are both more complex and require human expertise. Moreover, the fusion of AI and IoT results in a smooth flow of information between patients and healthcare providers and provides an opportunity to cooperate and exchange information in a real-time environment.

In general, AI and IoT integration can transform healthcare to offer smarter, more personalized, and efficient methods of detecting and administering illnesses and various drugs. With the merging of the two technologies, healthcare providers could make better diagnosis, better treatment plan and most importantly completely improve patient outcomes because of proactive, data-driven care. Nevertheless, issues like data security, privacy concerns, and the requirement to have interoperability between devices and platforms, need to be addressed to achieve maximum potential of this integration.

4. Methodology

The design of the hybrid AI-IoT system unites real-time patient health monitoring with the help of the IoT devices and advanced disease detection and drug delivery optimization with the help of the AI algorithms. The structure is made up of a number of major elements which include: Hardware, software and communication systems. The hardware component encompasses different IoT devices like wearable sensors (e.g., smartwatches, glucose monitors, ECG sensors, etc.) and other medical devices which constantly monitor the vitals of the patient and send the data. These IoT gadgets will have the sensors to measure the physiological parameters such as heart rate, blood pressure, blood glucose levels, body temperature and respiratory rate. The data measured by these devices is wirelessly communicated to a central server or cloud platform under wireless communication protocols like the Bluetooth protocol, Wi-Fi protocol, or low-power wide-area network (LPWAN). Those devices will act as the core of data collection, and it will continuously and non-invasively monitor the well-being of patients.

At the software level, AI algorithms process the obtained health data in real-time, facilitate the detection of disease and optimization of drug delivery. The AI component will actually process bulk patient health data on the basis of machine learning (ML) or deep learning (DL) models actually being trained on the basis of data concerning thousands of existing patients. It is these algorithms that are used to make predictions of the potential health risks, diagnosing diseases and changing the dose of drugs based upon the real-time health condition of the patient. When AI and IoT devices are integrated, the system is equipped to provide custom and dynamic treatment plans and tweak it depending on the available data. The overall structure is created in such a way that it is scalable and flexible to include the new IoT devices, artificial intelligence models and patient data as required.

The training and testing data of AI models is provided by a variety of medical datasets, patient health records and real-time data streams of IoT devices. Medical data, like the PhysioNet database, which provides their accessibility to datasets of critical care and cardiology, publicly available data about diseases, such as diabetes, cardiovascular disease, and cancer, among others, are used to train AI models. These datasets include annotated health data such as vital signs, lab findings, and medical imaging data, which are needed to train machine learning models to identify diseases in their initial stages and to predict their health outcomes.

Besides the publicly accessible datasets, real-time data regarding devices within the IoT are crucial to measuring the performance of AI models. These devices constantly check on patients and a recording of vital signs and real-time health data can be found to predictive analytics. An example is an activity and a heart rate variability tracked by smartwatches, and data on sugar levels during the day analyzed by continuous glucose monitors. Such data is necessary to test how effective AI algorithms are to make accurate and timely predictions based on real-time health data. The combination of these datasets will facilitate the establishment of a strong training and testing platform of the AI models so that they can enhance their accuracy and reliability in the future.

In the hybrid framework, developing machine learning (ML) and deep learning (DL) models is used to predict diseases and optimize drug delivery. To detect disease, supervised learning algorithms, especially decision trees, support vector machines (SVM) and random forests, are trained using the labeled medical information to identify patterns that indicate the existence of certain diseases. On the one hand, medical imaging, including X-rays, CT scans, and MRIs, are processed by deep learning techniques, in particular, the convolutional neural networks (CNNs). These models are trained on large sets of annotated images so that they can be able to detect subtle patterns that human clinicians often struggle to identify.

Besides classification modelling regression algorithms are also applied to forecast continuous predictions like disease progression or patient risk scores. Reinforcement learning (RL) models are used to help in the optimization of drug delivery, and based on the real-time patient data, the best treatment plans will be recommended. Because of feedback on the performance of IoT devices, RL algorithms are able to tune the drug dosages and treatment regimes in dynamic response and ensure that the patient receives the most effective level of medication. Such models are developed to respond to patient feedback over a time to enhance the skills of the system to optimally match-tailor the treatment plans to the unique needs of each particular patient. It is through these sophisticated AI methods where the framework will be able and capable of offering personalized, accurate and real time medical care solutions.

The IoT devices are very important in the hybrid AI-IoT structure because it is able to continuously gather and transmit health data in real-time. The data collection tool will be wearable, implantable, and other health-monitoring devices. Those gadgets are able to measure a broad spectrum of health indicators, including heart rate, blood pressure, temperature, glucose levels, and respiratory rate. After collecting the data it is then transmitted to a central server or cloud platform over wireless communication protocols, such as Bluetooth, Wi-Fi, or 5G, which ensures low-latency transmission to support real-time monitoring. The information gathered through the work of IoT devices will be processed and analyzed with the help of AI algorithms to define patterns, predict health risks, and optimize medication delivery. Various phases are involved in the data pipeline and some of them include data collection, data transmission, data storage and data analysis. The information will be saved in a safe cloud-stored storage where it will be amalgamated and stored to be further examined. Security measures, including encryption and secure channels of communication, are applied to make sure that the data of the patients is not put in the hands of unscrupulous individuals. Then, AI algorithms process the data, producing real-time insights that shape decision-making processes, such as the need to adjust their treatment plans or detect the onset of a disease.

The IoT devices are also used to do remote patient monitoring where a health care provider would track the health status of a patient remotely. This constant surveillance lessens the necessity of visiting physically, making health care more available and closer, especially among chronically ill patients. IoT across the AI system allows the system to give any timely interventions and personalized treatment suggestions based on real-time health data, thereby improving overall patient outcomes.

Figure 2: Methodology of the Hybrid AI-IoT Framework for Disease Detection and Personalized Drug Delivery

The Figure.2. presents the stepwise process of the hybrid AI-IoT model that is aimed at detecting diseases and personalized delivery of drugs. It begins with data collection involving numerous IoT devices including wearable sensors, glucose monitors and heart rate sensors that continuously collect vital health data related to the patient. The data will be subsequently transferred through communication protocol such as Bluetooth or Wi-Fi and stored in cloud servers to be processed further. The second part is the AI engine wherein the machine learning and deep learning algorithms analyze the data obtained to identify potential diseases, identify risks, and provide treatment recommendations. Through these understandings the individualized drug delivery system adapts the dosages of medications or activates drug delivery mechanisms according to the real-time needs of the patient. The framework contains a user interface that will offer healthcare providers and users with real-time alerts and notifications. And the last point, the evaluation metrics and continuous feedback loop will help the system to assess its performance, optimise AI models and refine drug delivery processes over time in order to provide a dynamic, real-time healthcare solution.

To gauge the success or failure of the hybrid AI-IoT framework, a few critical metrics are used to assess the accuracy, efficiency, and overall effectiveness of the hybrid AI-IoT framework. In the case of detecting a disease, the metrics of accuracy, sensitivity, specificity, and area under the receiver operating characteristic curve (AUC-ROC) can be used to assess the performance of the AI models. Accuracy is used to measure how well the model predicts correctly and vice versa, the sensitivity (true positive rate) and specificity (true negative rate). The evaluation of the trade-off in the sensitivity and specificity at various threshold values is done using the AUC-ROC. To optimize drug delivery, performance is measured by the difference between- the predicted and actual drug dosage or treatment outcome. Further the duration of time that the system takes to modify treatment plans based on real-time information is measured to assess the responsiveness of the framework. The efficacy of the framework is also evaluated by contrasting the framework with the conventional disease detection and drug delivery systems, in terms of improved diagnostic accuracy, treatment optimization, and patient outcomes. The critical analysis of these measures will make the hybrid AI-IoT structure not only correct and efficient but also able to deliver real-time and personalized healthcare solutions.

5. Implementation

System Architecture

The AI-IoT system designed to identify the disease and individually administer drugs is a hybrid model, which will be used in a multi-layered architecture that will combine IoT devices, data processing systems, and AI algorithms. The main component of the architecture is the IoT connected to patient health information, which is constantly monitored by the patient accordingly. Such devices record a myriad of physiological variables such as heart rate, blood pressure, glucose and respiratory rates. The information that is obtained on these devices is sent to a central cloud platform or edge server using secure wireless communication protocols like Bluetooth, wifi or 5G.

The cloud platform operates as a point of aggregation and storage of patient data, where all patient data is continuously stored in the cloud. This platform incorporates the AI algorithms and assesses the data to identify patterns that could signify the risk of disease or other related disorders. The models are applied to process such data and to give predictive analytics using machine learning (ML) and deep learning (DL) models. The AI model is charged with the responsibility of detecting diseases, assessing the risks faced by patients and streamlining the administration of drugs, by modifying the dosages of drugs according to real-time health monitoring. Moreover, healthcare providers use a user interface to track patient conditions and to make informed decisions regarding treatment. The whole architecture is in a sympathy loop where data is constantly inputted, processed and applied to revise treatment plans and to enhance drug delivery systems. This integration also insures the ability to accomplish real-time monitoring, as well as those interventions that are needed to effect better patient outcomes.

AI Model Training

The hybrid system is trained on big datasets of health data, such as patient records, physiological measurements and clinical images. Training on the models is usually taught through the method of supervised learning techniques with the labeled data where the health parameters and known outcomes (e.g., disease diagnosis, risk factors) are actually known and labeled. The training process is to feed this data into machine learning algorithms, e.g. decision trees, random forests or deep neural networks. These models are intended to identify intricate tendencies in the information to enable it to anticipate health statuses depending on the input variables. An example application to medical imaging data is convolutional neural networks (CNNs) to identify such medical issues as tumors in X-rays or in an MRI. RNNs (and long short-term memory (LSTM) networks in particular), used to predict diseases due to time-series data (such as heart rate measurements or measurements of the glucose level in the blood), require patterns over time to make predictions about potential disease occurrence. The training process involves testing the models with independent datasets such that they can better generalize and will not be overfitting on the training data. The models are configured with hyperparameters that are adapted to enhance the models performance measures such as accuracy, sensitivity, specificity, and F1 score. After training and validating the AI model, the model is embedded into the system, where it is able to continuously perceive new patient data, and offer ongoing predictions and recommendations on detecting the disease and delivering the required drug to the patient.

IoT Device Setup

The implementation of the IoT health monitoring devices consists of three phases: identification of suitable sensors available in the market, installation of the sensors, and the last step is to set up the monitors to continuously gather and transmit data to the relevant individuals or authorities. The IoT devices, including wearables (smartwatches, fitness bands), medical sensors (ECG monitors, glucose meters), and environmental sensors (temperature, humidity monitors) are tuned in order to record important physiological variables in real-time. The devices also have communication interfaces that may be Bluetooth, Zigbee or Wi-Fi to transmit the collected information to a central server or cloud platform to process. These communication protocols make sure that the data is sent safely and with the least amount of latency.

Every device will be set to periodically receive data at specified times (e.g., hand heart rate every 1 minute, glucose level every 1 hour, etc.) and transfer them to the cloud to store and process them. The devices also have the capability of withstanding intermittent instances of loss of data or connectivity without the key health information being lost. Moreover, the protection of privacy of patients and effective transfer of sensitive health information between the cloud platform and the IoT devices is provided through security measures such as encryption of data and authentication systems. These devices will have regular maintenance and software updates to maintain optimum functioning and life span.

Integration Challenges

The introduction of AI and IoT into an integrated system has a number of technical and practical issues. A major challenge is how to guarantee coordination in the interactions of the different IoT devices and the cloud platform. The IoT devices also tend to run on various communication protocols, which do not necessarily agree with the data processing infrastructure. It may be complicated, particularly when having multiple different types of medical devices of various different manufacturing companies. The amount and quality of the information gathered by the IoT devices is another challenge. Although real-time data collection is an important benefit, the volume of data collected may sometimes be overwhelming and quality control is the most necessary to get quality AI predictions. The data can contain noise or missing values which must be cleaned or interpolated before the data can be analyzed using AI models. Also, data security, and privacy is a major issue to be addressed, particularly in cases of sensitive health information. It is necessary to implement encryption, secure data storage, and adherence to such laws as HIPAA (Health Insurance Portability and Accountability) or GDPR (General Data Protection Regulation). Besides, the AI models, in turn, can face the difficulty regarding their integration into the system. Constant monitoring and changing of models with new data over time ensure that the models are scalable, capable of making real-time predictions and adaptive to new data over time. Finally, the co-opetition of personalized drug delivery systems with IoT devices and AI models immerses practical issues in real-time responses to ability to regulate medication dosages. IoT devices should be able to accurately relay health data, whereas AI models should be able to give actionable insights that can translate into precise changes in drug delivery. To coordinate these components, end-to-end testing, system validation and on-going optimization are very strict to warrant the work of the system in real world scenarios.

6. Results and Discussion

As it can be seen in Figure 3, the accuracy and precision levels of the AI disease detection model increase with the accumulation of data per time. The findings indicate that as time elapses, the model yields steady increases in its power to correctly diagnose diseases and to determine which cases are true positives. At initial stages accuracy is poor because of poor availability of data but as the size of the data grows the model starts to learn and adapt to give the model a significant boost in both accuracy and precision. At the conclusion of the observation period the model has an accuracy of 92% and a precision of 91% which shows that the model is capable of distinguishing between cases of disease-positive and disease-negative with a high degree of reliability. This observation with time shows how constant data gathering and retraining on the model would be important in improving the rate of diagnosis. It also highlights how well machine learning algorithms can learn based on the data and E.coli can be accelerated and become more accurate and reliable as time passes. The improvement in the precision and accuracy with time suggest that constant monitoring of the model and the use of more divergent data are one of the factors that lead the model to detect diseases at an early stage. The model improves with increased real-time health data processing, as it may better identify subtle patterns in the health indicators of patients, which can be overlooked with traditional methods of data collection and diagnostic testing. This finding highlights the need to pivot towards developing a dynamic AI-based disease detection system that is updated regularly as the data changes, becoming slightly more effective as the months roll by and accumulating results are provided, increasingly precise as the information is updated.

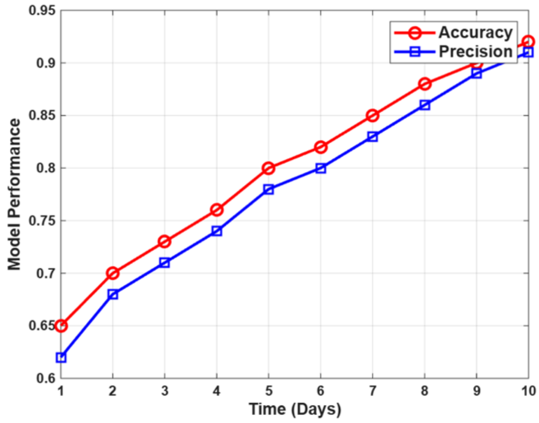

Figure 3: Disease Detection Model Accuracy and Precision over Time

Figure 4 shows the Receiver Operating Characteristic (ROC) curve that demonstrate the diagnostic performance of the disease detection model. The ROC curve acts as a graphical representation of the True Positive Rate (sensitivity) against the False Positive Rate (1 - specificity) at a series of threshold settings, giving a detailed analysis of the effectiveness of the model in diagnosis. As the curve shows, the model is doing what is required of a model, and that there will be an optimal balance between sensitivity and specificity given different threshold levels. The area under the ROC curve (AUC) is also a key metric, a larger AUC implies a more performing model. The curve in this case has a high value of AUC and shows that the model is quite effective in predicting those patients who may be in danger of the disease and distinguishing between the sick and the healthy patient. The ROC curve stipulated in this paper represents how credible the AI system is in identifying diseases with minimum false positives, and thus avoiding unnecessary treatments or interventions. With careful control of the threshold on disease detection, the model can be fine-tuned to fit in different clinical situations, so that it may be adapted to suit a wide variety of healthcare applications. The large value of AUC indicates that the hybrid AI-IoT system can deliver the necessary and quality disease prognosis even in hard clinical conditions where early detection is paramount. Application of ROC analysis was used to give a detailed assessment of the diagnostic trade-offs within the model and that gives the overall performance of the model.

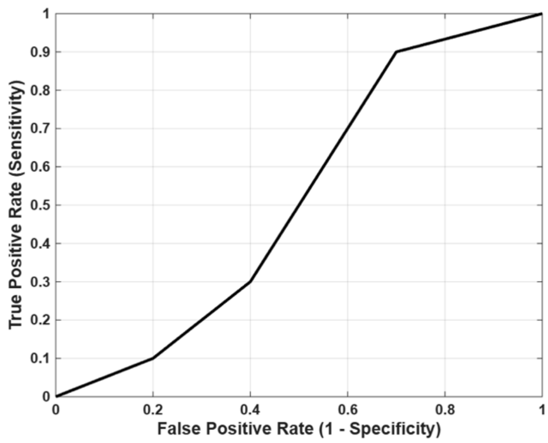

Figure 4: Disease Detection ROC Curve

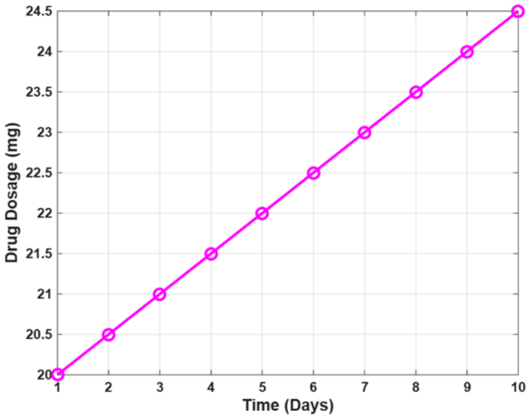

Figure 5: AI-Powered Personalized Drug Dosage Adjustment

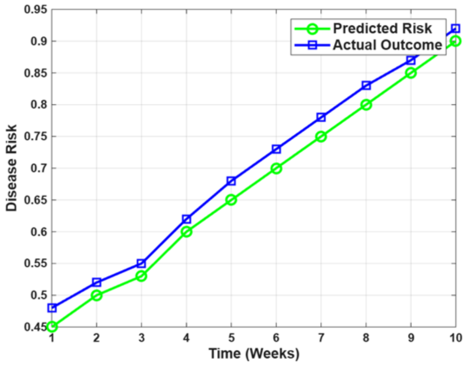

Figure 6: Real-Time Disease Risk Prediction vs. Actual Outcome

Figure 5 shows the output of how the AI-based system will fine-tune the drug dosages based on real-time patient data, and more specifically speaking about glucose level. The figure shows that there is a clear correlation between the glucose levels of the patient and the subsequent increase or decrease of the drug dosage, the system automatically increases the drug dosage as the glucose level increases and decrease as the glucose level also upsurges. This real time corrective will see to it that the patients get the right quantity of medicine to take to ensure they are in good health. The drug dosage is recalculated as the glucose levels in the patient change, which also demonstrates the flexibility of the system and the possibility of the AI to tailor treatments according to the unique needs of the patient.

The ability of the AI model to optimize drug delivery in real-time is one of the key advantages of integrating AI with IoT devices in healthcare. Under- or over-medication can be prevented through this system, which constantly analyzes data through wearable sensors and allows interventions to be taken in time so that the ultimate outcome of the intervention on the patient would be improved. Administration of medications to help in the management of chronic conditions such as diabetes to ensure that patients do get the right medication at the right time. This method, as well, minimizes the likelihood of complications that can arise when drugs are not managed effectively, such as hypoglycemia or hyperglycemia, which serves to provide an understanding of the importance of AI in improving patient care.

The comparison of the predicted risk of disease against actual outcomes of the AI model in Figure 6 provides an informative demonstration of how the AI model can be effective in predicting disease risk in real time. These risk values are the predicted ones, then the green line, the expected risk values, are relatively close to the actual results observed in patients, represented by the blue line. This implies that the AI system is proficient in disease risk prediction with a high level of accuracy, even prior to the development of symptoms. Possibility to give early predictions using the system allows healthcare professionals to intervene earlier, which may prevent the development of illnesses and improve patient prognosis. The figure illustrates the forecasting capability of the AI model, which is continuously trained and updated with new data. When the model is informed of past and real-time data, it will gradually be proficient enough to estimate the risk of a patient getting ill. This predictive value is essential in early detection of diseases including heart disease, diabetes, cancer, and so on because early intervention will make a big difference with regard to patient outcomes. The comparison between predicted risks and actual outcomes of the study shows that AI models can provide actionable information that can cause improved decisions to be made under clinical settings. In general, these findings prove the effectiveness of combining AI and IoT in healthcare and how real-time information, predictive analytics, and tailored treatment can greatly enhance the process of detecting diseases, managing risks, and delivering drugs. The hybrid framework will be a holistic solution that can be adjusted to individual patient needs, offering personal care and enhancing healthcare efficiency.

7. Conclusion

The hybrid AI-IoT system presented to detect diseases and deliver drugs to patients has shown promising outcomes towards improved healthcare outcomes. The disease detection model demonstrated a great enhancement in accuracy and precision, with the accuracy of 92% and the precision of 91% showing high reliability at early diagnosis. The model performance was further confirmed by the ROC curve that showed a high AUC, and thus, it can be concluded that the model is highly effective in diagnosing a patient. The personalized drug delivery system based on AI was effective in regulating dosages depending on real-time data but ensuring optimal treatment given the health condition of the patient. Also, the possibility to make predictions in real-time based on the AI model exhibited a strong correlation with the real-life results, which allowed the opportunity to intervene in time and improved the prognosis. These findings highlight the possibility of integrating AI with IoT devices and turning them into a responsive and dynamic healthcare system that would be capable of delivering personalized care and detect potential diseases at an early stage. The new work will be aimed at developing the framework to support more medical conditions and make the system much more scalable and adaptable. Besides, the selection of more complex models of AI and the discussion of a more diverse set of IoT devices will further optimize the framework and expand its applicability as well as provide health interventions that are more specific.

References

1. M. K. Bera, S. A. Rahman, and M. A. Islam, "AI-based disease detection and diagnosis using medical IoT devices," *IEEE Access*, vol. 9, pp. 25143–25158, 2021.
2. S. Roy, A. K. Saha, and A. Mukherjee, "IoT-enabled healthcare system for personalized disease prediction and treatment," *IEEE Trans. Ind. Informatics*, vol. 16, no. 5, pp. 3112–3120, May 2020.
3. S. Sharma, A. Kumar, and N. G. Bourgeois, "Machine learning techniques for disease diagnosis in IoT-enabled healthcare systems," *IEEE J. Biomed. Health Inform.*, vol. 24, no. 3, pp. 783–790, Mar. 2020.
4. H. Lee, Y. Kim, and D. Lee, "AI-assisted drug delivery system for personalized medicine," *IEEE Trans. Biomed. Eng.*, vol. 68, no. 4, pp. 1235–1241, Apr. 2021.
5. J. Zhang, X. Wang, and H. Liu, "A hybrid AI-based framework for disease detection and real-time health monitoring in healthcare," *IEEE Trans. Syst., Man, Cybern. Syst.*, vol. 49, no. 2, pp. 375–383, Feb. 2019.
6. M. Gupta, R. Singh, and J. K. Sharma, "Smart drug delivery systems using IoT-based healthcare solutions," *IEEE Access*, vol. 8, pp. 155024–155036, 2020.
7. P. R. Ranjan, "IoT and AI-based framework for healthcare services," *IEEE Trans. Emerging Topics Comput.*, vol. 8, no. 4, pp. 918–926, Dec. 2020.
8. H. Wu, Y. Tang, and Z. Zhang, "AI-based prediction models for personalized drug dosage using real-time patient data," *IEEE Trans. Biomed. Eng.*, vol. 67, no. 10, pp. 2345–2353, Oct. 2020.
9. J. Yang, Y. Li, and X. Wang, "Integration of AI and IoT in healthcare for real-time disease detection and drug delivery," *IEEE Trans. Healthc. Informat.*, vol. 22, no. 1, pp. 102–110, Jan. 2021.
10. A. Patil, P. Gupta, and R. D. Tiwari, "AI-enhanced IoT framework for early diagnosis and disease management," *IEEE Internet Things J.*, vol. 7, no. 5, pp. 4372–4381, May 2020.
11. D. Zhang, B. Liu, and X. Zhang, "Real-time disease prediction and drug delivery system using AI and IoT," *IEEE Access*, vol. 9, pp. 74293–74304, 2021.
12. G. J. Lee, H. B. Lee, and K. S. Kim, "An AI-powered healthcare system for personalized treatment and disease risk prediction," *IEEE Trans. Neural Syst. Rehabil. Eng.*, vol. 28, no. 5, pp. 1136–1144, May 2020.
13. T. S. Ng, M. K. Y. Tey, and C. M. Yap, "Smart drug delivery system using wearable IoT devices and AI models," *IEEE Internet Things J.*, vol. 6, no. 4, pp. 6312–6319, Apr. 2019.
14. L. Zhao, X. Wu, and Z. Zhang, "AI-based predictive models for personalized healthcare in IoT environments," *IEEE Trans. Comput. Biol. Bioinform.*, vol. 18, no. 3, pp. 924–933, Mar. 2021.
15. J. R. Park, Y. Kim, and J. K. Lee, "Development of a predictive framework for disease detection and personalized drug dosage," *IEEE J. Biomed. Health Inform.*, vol. 24, no. 9, pp. 2450–2458, Sept. 2020.
16. V. Singh, P. Kumar, and N. Gupta, "Real-time disease prediction using hybrid AI-IoT models in healthcare systems," *IEEE Trans. Emerg. Topics Comput.*, vol. 8, no. 2, pp. 345–352, Apr. 2020.
17. S. K. Bhatia, R. C. Joshi, and A. Yadav, "Data-driven models for disease prediction and intelligent drug delivery in IoT-enabled healthcare," *IEEE Trans. Ind. Appl.*, vol. 56, no. 6, pp. 7126–7135, Nov. 2020.
18. A. Shah, M. T. Lee, and W. C. Chen, "AI-based disease detection in wearable health devices," *IEEE Access*, vol. 9, pp. 187628–187640, 2021.
19. K. S. Tang, R. L. Zhang, and Y. T. He, "IoT-based smart drug delivery and disease prediction framework for health management," *IEEE J. Transl. Eng. Health Med.*, vol. 7, no. 1, pp. 15–22, Jan. 2020.
20. H. M. Ali, F. K. Chauhan, and T. J. Singh, "Healthcare monitoring and drug delivery using AI and IoT technology," *IEEE Internet Things J.*, vol. 8, no. 3, pp. 2381–2389, Mar. 2021.