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A Healthcare System for Cardiac Disease Diagnosis Using Distributed Computing

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Abstract
The sector of health care makes extensive use of cloud computing and wireless devices that are based on the internet of things. These kinds of wireless and wearable sensors are being used to monitor patients who are at risk for developing chronic diseases. This not only shields patients from attacks that come out of the blue but also makes it easier for them to monitor their treatment regimen. However, the quantity of data acquired from numerous sensors is substantial, and if the data is kept in a centralised location, there is a possibility that the power supply will fail. As a result, in this paper, we suggest the creation of a technology called Smart Fog, which is capable of edge-fog computing and would be able to detect and diagnose heart patients at an early stage. It is anticipated that the overall efficacy of the system would improve as a result of the implementation of the suggested model, which is founded on the concepts of distributed computing and deep learning. With the application of the distributed computing approach, the risk associated with a single point of failure would be eliminated, and in addition, a less amount of data would be required to transfer the information between the cloud and the sensors.

Keywords: Heart disease, cardias diagnosis, smart fog, distributed computing

Introduction

Across the course of the last decade, there have been an extraordinary number of technological and digital shifts all across the world. The field of cloud computing has made a significant contribution to this cause in recent years. However, in recent times, the Internet of Things (IoT) has emerged as the next technology trend. This has the effect of shattering all norms of possibilities and so producing an exponential opportunity for technical requirements. One industry that has been successfully penetrated by IoT is that of healthcare; here, the entirety of the patient monitoring process is carried out by means of wireless wearable devices. These kinds of gadgets are able to function, generate a great amount of data, and eliminate the data that is superfluous to their needs. The information collected from these devices is uploaded to the cloud, where it is examined on their network and then processed before being saved. On the other hand, healthcare apps that are built on cloud architecture frequently fail to compute effectively when big data is involved in one or more of the scenarios. In addition, a cloud architecture functions as a centralised system, which makes it far more vulnerable to problems caused by a malfunctioning network. Applications in the healthcare industry can benefit greatly from fog computing in this regard [1]. In addition to this, if just the cloud is employed, there may be a delay in the transfer of patient information from wearable devices to the sensors of the cloud and from the cloud to hospitals or individual doctors. Due to the fact that the healthcare industry requires activities to take place in real time, this delay in speed and efficiency cannot be compromised. Sending such enormous volumes of data back and forth in this

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kind of situation is not likely to be a smart idea owing to the latency issues as well as the security risks that could arise from doing so. Because of this, it is necessary to have a distributed computing architecture as opposed to a centralised one because the distributed architecture would be responsible for dividing the work and then forwarding it to numerous nodes. Applications in the healthcare industry can benefit greatly from the theory of edge computing at this point [2].
Therefore, the primary objective of our proposal is to fill the gap in connecting the appropriate computing platform to a deep learning-based framework. our will allow for results to be generated in the health care business that are both effective and rapid, and it will also allow our work to contribute to the process of detecting a disease. To achieve this goal, we are submitting our study to diagnose heart-related issues and treat critically ill individuals who could be recognised at the appropriate time.
It has also been reported that numerous research has sought to use IoT to forecast heart-related health issues; however, they have not been successful in achieving the level of precision that was anticipated. This is due to the fact that system models are now more accurate. As a result, the fundamental objective of the project is to integrate the ideas of deep learning and fog computing in order to develop an Internet of Things-based health care model that is capable of effectively detecting heart problems and mitigating the problem of a lack of doctors.

A system that is constructed on the theory of the Internet of Things, cloud computing, and deep learning serves the objective of giving technical answers to a variety of sectors that are connected in some manner to problems that require the highest attention of research researchers. As a result, the plan that was submitted takes into account this growing demand. In order to create a healthcare system, the idea is to make use of distributed computing and to further link it to devices that are connected to the internet of things. The following are some of the reasons that serve as a driving force behind my work in the area of applying deep learning to diagnose heart diseases:

- To provide healthcare with a minimal response time and acceptable precision, a computation model that is embedded at the edge, in the fog, and in the cloud is required. This work was prompted by the lack of such models, which led to the integration of deep learning with the development of high accuracy
- In earlier research, healthcare data was classified as being acquired either from fog nodes or cloud centres. However, the usage of edge computing is required so that vast amounts of data may be evenly spread among the fog nodes, and so that the frameworks that are already in place can be made more flexible [3]
- Many researchers have tried to merge the cloud, Internet of Things, and health care systems into one paradigm; however, only few have proved the deployment of deep learning with edge computing to improve overall accuracy and provide the best service [4] [5]

Related Works

The fog computing environment is an emerging paradigm for effectively evaluating healthcare data gathered from a wide variety of Internet of Things devices. Fog computing may handle the relevant information of cardiac patients at edge devices or fog nodes with massive processing ability while simultaneously minimising latency, response time, and lag. This is possible because edge devices are physically closer to IoT devices than cloud data centres are. This part of the paper summarises other research that cover the same ground and are being carried out in the same field.

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Electrocardiography, or ECG for short, is a technique that is routinely used to diagnose people who are experiencing heart problems. ECG is typically only performed in emergency circumstances because the equipment required to perform one is cumbersome, expensive, and has a high-power consumption rate. On the other side, the rise of IoT is making it easier to provide patients who are in need with health care that is delivered in real time. The authors of [6] advocated implementing an IoT-based health monitoring system that required little to no maintenance and could remotely regulate the operation of an electrocardiogram (ECG) while also providing the same service in an automated fashion. On the sensor nodes, the system appears to be built using fog computing in conjunction with the internet of things. These sensor nodes are in charge of monitoring a variety of patient symptoms, including but not limited to breathing rates, body temperature, and blood pressure levels. In contrast to this approach, the work of Akrivopoulos and colleagues [7] also proposed the performance of an electrocardiogram. On the other hand, this strategy involved the collection of raw information through the use of several feature extraction algorithms. As a result, when compared to the work described in [6], this strategy produced exceptionally high levels of accuracy. In addition to this, the latency time model presented in [7] used less energy while also improving the system's overall performance.
Another researcher scholar carried out patient health tracking in [8], whereby the author built cloud-fog architecture that might be utilised in the medical field. This application also contained a method for scheduling tasks and allocating responsibilities in order to ensure an equitable division of hospital duties. In addition to that, an iFog-simulator was incorporated into the research, which assisted in reducing the latency. While the study in [8] moved the paradigm to evaluate the health state of cardiac patients, it was observed in [9], [10], and [11] that the authors only focused on health care applications. On the other hand, performing a survey in the same area revealed that [9], [10], and [11] only focused on health care applications.
A work that was proposed by Amir et al in [12] made use of the services of data analysis and real time data processing. The author of this work took advantage of cloud gateways and then transferred patient information to corresponding edges of the network. The Smart-e-Health-Gateway was the name that was given to this framework. The author established a connection between the gateway idea and a geographically dispersed intermediary layer, which performed the function of providing an insight between the cloud and the sensor nodes. As a consequence of this, the system's overall effectiveness was significantly improved. In addition to this, the author put this model on a mobile-based application that has the capability of validating the health monitoring system.
Alam et al. in [13] recommended the introduction of services that might supply necessary healthcare requirements for the patient with the intention of lowering the overall cost of data processing. The model was founded on the Edge-of-Things concept and provided a solution that was maximised by putting the principles of virtual machines into practise. This model was further developed by combining it with the ideas behind distributed computing, which resulted in the creation of a method called the Alternating Direction Method of Multipliers. In addition to this, the proposed framework was able to produce the intended results with a small increase in the amount of time complexity while simultaneously increasing the amount of storage space for memory.

Proposed Methodology

The creation of an intelligent health care system that is capable of being hosted on the cloud is the fundamental objective of the project. In addition to this, it would be the responsibility of the healthcare system to identify cardiac patients based on the symptoms that were entered by the user.

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In order to accomplish this, the user would be provided with an interface that would allow them to enter their symptoms and send this information to the doctor. The medical professional would access the report collected from the patient using cloud storage in order to continue the diagnosis of the ailment. Interaction between the two parties can then take place as a result of this arrangement. On the other hand, the collection of data from patients falls under the purview of a fog-based Internet of Things device in the back end. In addition to this, the cloud architecture that was implemented offers a route for safely securing the patient's data in an appropriate manner. The fact that the gathered data would be dispersed equally across all nodes is one of the most significant benefits of utilising an edge and fog-based system. This would prevent the system from having a single point of failure, which is one of its primary advantages.
In this section, we will discuss the three-tier architecture that we have developed for cloud and fog computing, which is based on the latency delay health monitoring. The sensors, the fog computing, and the cloud computing make up the three layers of the architecture. Wearable sensors include gadgets such as fitness trackers, smart phones, wearable eyewear, and any other wearable or non-wearable equipment that are connected to the patient. All of the edge devices that are situated in the cloud or the fog layer will be equipped with a system that can be performed in wearable accessories that are utilised for health monitoring. The cloud and fog layers will have the ability to exercise control over the gadgets at the edge.

Implementation Details

The approach that has been suggested utilises a cloud computing-based IoT ensemble technology that also makes use of fog computing. The model is intended for use by medical care facilities that are able to efficiently manage the information of cardiac patients and conduct in-depth assessments of the situation in order to ascertain the severity of coronary disease. The structure of the model is depicted in the figure that can be found below.

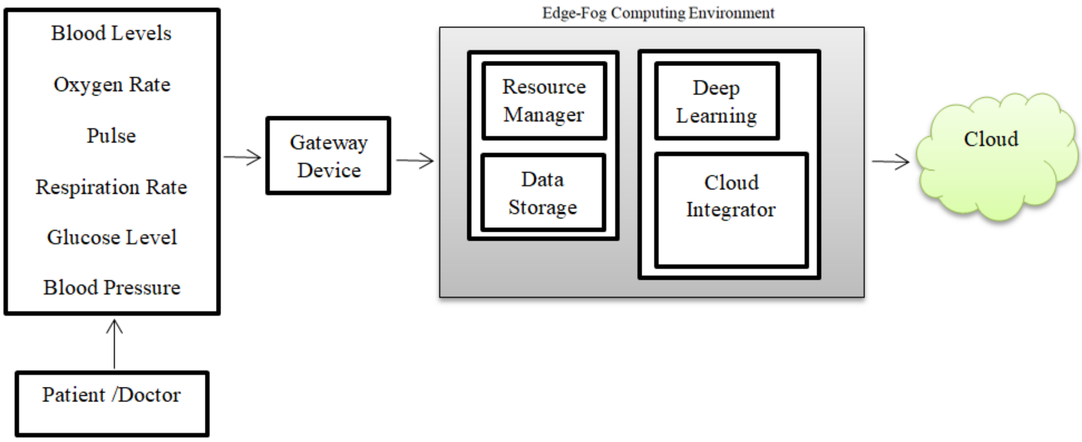

Figure 1: Architecture of the Proposed Approach

Earlier on, we discussed the anticipated approach that will be utilised in the execution of the proposed activity. The implementation of the same, on the other hand, requires the use of deep learning techniques, which would be carried out with Python as the language of choice for the programming. It is anticipated that the model will use base classifiers and neural networks as the computing methods in order to carry out the work. The following components would make up the fundamental architecture of the cloud-based health care system, in addition to the operationalization of the model itself:

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- Cloud Datacenter: A cloud datacenter is regarded as the best environment for Internet of Things (IoT) healthcare interpretations because it enables large-scale calculations to take place in a dependable and secure manner. On the other hand, the resources that are involved in a cloud have the potential to be systematically organised as follows:
    - The primary responsibilities of a resource manager include the organisation of cloud-based resources and the management of cloud-based user data security. A resource manager may also be responsible for other administrative tasks. On the other hand, the resources could be abandoned as and when they are put to use as an alternative
    - Cloud data centres can be either homogeneous or heterogeneous in terms of the server hardware configurations that they use. Homogeneous server configurations are the most common. The two sorts of servers that are utilised in this architecture are application servers and database servers. The application server is responsible for hosting both the web infrastructure and the queries sent to the backend. In databases, the association operation and the data source are the only two things that can be switched
- Smartphone: Due to the fact that it has limited computing capabilities, a smartphone is widely believed to be the most prevalent type of device utilised in the IoT. The use of smartphones confers an extra benefit in the form of built-in GPS functionality, which makes it simpler to adjust to a setting characterised by cloud computing

Evaluation Metrics

In order to demonstrate the practicability and efficacy of the proposed Smart Fog model, it has been suggested that the implementation of the model be carried out on a fog simulator. This will make it possible to utilise the model in real-world applications and will also facilitate the accurate diagnosis of cardiac disorders through the application of deep learning algorithms. As a consequence of this, the precision and response times utilised in the evaluation of this distributed computing environment are taken into consideration to guarantee a low overhead.

The following criteria were taken into consideration when making the evaluation:

- Latencies: During the deployment of the proposed system, there will be a significant amount of information transferred. The doctor and the patient are going to be the ones to carry out this information exchange between the two of them. Latency refers to the length of time that elapses while this data is being transferred.
- The complexity of computation: the computations that take place in the fog layer need to be able to respond in real time and to latency. As a result, it is essential to put into practise a variety of strategies for simplifying the computational process. The data packets can be kept at the fog nodes for an extended period of time, which eliminates the need to repeatedly reload the same information. According to the criteria of certain renewal algorithms, these data packets could be swapped out with brand new data packets. It is of the utmost importance to distribute data packets in a methodical fashion to the greatest possible number of edge devices

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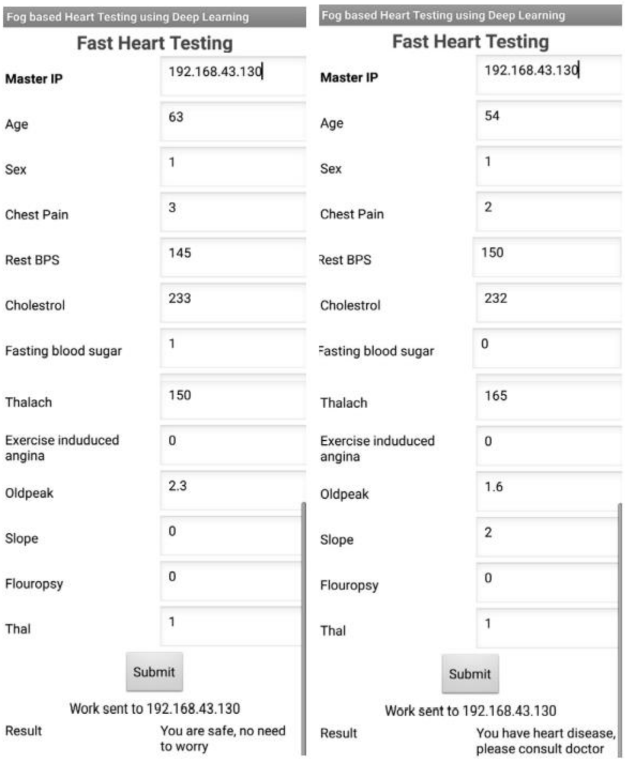
Results



(a) Negative example (b) Positive example

Figure 2: Interface of Smart Fog

Conclusions

It is necessary for a large number of research academics to focus their attention on the provision of medical care because this is a significant field. The authors of this proposal present a Fog-based Smart Healthcare System for Automatic Diagnosis of Cardiac Diseases utilising Deep Learning and IoT. This system places its sole emphasis on the medical care that cardiac patients require. Because the use of deep learning requires a significant amount of processing power, it has been suggested that the system model be integrated with distributed edge computing in order to provide high accuracies while maintaining a low level of latency. In addition, the report concentrates on developing a Smart Fog by means of a simulator in order to facilitate the efficient management of patient data.

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