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Deduction of Efficient Scanning Machines using Big Data Technology

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Abstract: ***Nowadays, the advancement in the field of information technology has witnessed stupendous growth in various industries, especially the medical imaging technologies in the healthcare industry. However, these advancements in the different technologies have not only made the data bigger but also a bit difficult to process and handle it. Though, these advancements may have resulted in huge amount of unnecessary data, it still cannot be considered as a major problem in today's world as nowadays, the various advancements in technologies such as Big Data Analytics, Cloud Computing and several others, have made it really easy and effortless for storing huge amount of datasets and handling them. One of the boon that the advancement in technology has given to the world in the field of healthcare industry is the evolution of the scanning machines which can be used for the diagnosis of different diseases and to assemble the conclusions in the form of various medical reports for different scans such as ECG (Electrocardiogram), MRI(Magnetic Resonance Imaging) Brain scans, Ultrasounds, X-Rays, CT-Scanners and much more. But, the interesting part here is that though these scanning machines have their own advantages, one of the main disadvantages of them is that the efficiency of the results produced by them are yet to be known when comparing their performance's to justify their enormous costs. Therefore, in the paper, the key challenges and various methodologies are being investigated in the healthcare industry with prime focus on comparing the scanning machines such as ECG, MRI, and Ultrasoundetc. by using Big Data Analytics. The various manufacturers of the scanning devices which are used by the hospitals or diagnostic centers have already fixed their price to such a high level that, even the hospitals have to spend lots of money to buy those machines and install them. Therefore, as a management side it becomes difficult to cope up with the performance related cost effectiveness of machines, which even shatters the trust of patients related to technical issues with a particular hospital. The prime aim is to focus on the precise implementation, performance efficiency and cost effectiveness of all the medical scans. The idea can also be implemented in improving theperformance along with the cost effectiveness of machines and devices other than the medical industry as well.***

Keywords : Big Data Analytics, Health Analytics, Medical Imaging, SQL database, Text Analytics, Feature Extraction using Python.

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I. INTRODUCTION

Medical industry is a field which faces new and burdensome challenges on a day-to-day routine. The increase in the number of patients being admitted to the hospitals each year has made it quite obvious that the percentage of severe diseases that might result into an individual's death has grown up to a very high rate. Of the 56.9 million deaths worldwide in 2016, more than 54% were due to the different disorders such as heart diseases, brain tumors and several others as cited by the World Health Organization (WHO) on 24th May 2018 [1]. So, here comes the important part of managing and handling all these dangerous disorders to reduce the number of deaths occurring each year. To investigate the various disorders and the key challenges in the healthcare industry, the use of something called 'Medical Imaging' is the one which all the hospitals need and demand of. By investigating and studying the process of medical imaging in various types of scans, it will be convenient enough to check for the efficiency of the results produced by the different scanning machines for various disorders and it will also provide a reality-check of how efficiently the machine is performing and if it is really justifying its huge costs or not. The paper will also acknowledge about how far the management sides i.e., the hospitals have been able to bring advantages and reliefs to the patients, when it comes to the use of the scanning machines for the follow-up diagnose and treatment. The comparison of these scanning machines is necessary because of the extravagant prevalent health care systems across the country which has made it very difficult for a normal individual to pay the enormous amount of price needed for a medical scan for diagnosis. The next section of the paper gives an idea about what actually medical imaging is and how is it processed using the various scanning machines.

A. Medical Imaging

Medical Imaging is the technique of creating visual representations and images of the various internal body parts for the purpose of treatment and diagnostic. It is majorly a part of digital healthcare. The process of medical imaging is mainly undertaken for a follow-up or after a diagnostic surgery. Nowadays, the increase in the number of patients being admitted to the hospitals has been an advantage in one way as the different healthcare policies adopted by various healthcare centers and clinics have been increased and that too in an improved manner. The number of healthcare centers adopting the medical imaging process has also increased to a higher level because of the increased availability of the latest technology medical equipments.

More use of medical imaging based procedures also acts as an advantage as it reduces the number of unnecessary procedures while being more efficient, convenient to handle, good in decision-making and producing high quality scanned images as cited by World Health Organization (WHO) [2]. For example, during the pregnancy period, the use of ultrasound technique can avoid several surgical interventions.

The different scanning machines using the medical imaging process are ECG (Electrocardiography Mammography), MRI (Magnetic Resonance Imaging) Brain scans, CT-Scanners, X-Rays, Ultrasound, Endoscopy and several others. In the next section of the paper, there is a discussion about the various types of scans done by the scanning machines and how medical imaging is implemented and carried out in them.

1. MRI

MRI (Magnetic Resonance Imaging) is a confined imaging technology that is used to produce three dimensional detailed structural images of the internal body organs such as brain, chest, lungs and several others. It is a non-invasive test that is used in the treatment monitoring, disease detection, and diagnosis. MRI uses a powerful magnetic field and radio waves to produce a detailed image of the internal body structure. The final reports maybe printed, copied or stored in a digital cloud server. The MRI scans are more useful to image the soft tissues or the ligaments in the body. As they do not use the injurious ionization radiation of X-rays, they are mainly used to produce the imaging of the body parts such as brain, spinal cord, nerves and ligaments to detect any sort of fracture or for diagnosis of a particular disease. In the brain scans, MRI can be used in the treatment of tumors and swelling as well as it can be used to differentiate the grey matter and the white matter. One of the specialized functions of the MRI is that it can be used to detect the structure of the brain and identify which part of the brain consumes more amount of oxygen as cited by the National Institute of Biomedical Imaging and Bioengineering [3].

2. ECG

An ECG (Electrocardiography) is a test which is used to measure the electrical and muscular activity of the heartbeat. Whenever a heart beats each time an electric impulse or wave travels through the heart. The muscles start to squeeze and pump blood from the heart as a result of this wave. The ECG may be used in situations when evidences of a previous heart attack (Myocardial Infarction) are required. An ECG graph also shows the enlargement of heart when in case of high blood pressure (Hypertension). The ECG is a simple test which uses around 10 electrodes to produce the 12 different angles or views of the heart activity as cited by British Heart Foundation [4]. Most of the times, an ECG test is completely painless but sometimes very rarely, someone might have a slight skin reaction to the electrode.

3. ULTRASOUND

An Ultrasound test is a type of imaging which uses the high frequency sound waves to view the structures and organs inside the body. It is also known as Sonography. The professionals in the medical industry use this testing technique to view the heart, liver, kidneys, blood vessels and other organs. It is mainly used during the pregnancy period to view the fetus. Its advantage over the X-rays is that it is not exposed to radiation. Mainly, ultrasound can be divided into two categories- Diagnostic and Therapeutic. During the ultrasound test, a device known as transducer moves over the body part which sends out waves to the tissues inside the body and captures the wave back which is used to create the image of the internal body part as cited by Medline Plus [5].

4. X-RAY

X-Rays are generally a form of an electromagnetic radiation that is able to pass through solid objects, including the human body. Mainly, X-Rays are used to detect the bone fractures in the body as well as different internal structures. A type of an X-ray detector is a photographic film, but there are several others that can be used to produce a digital image. The images that are produced as a result of this process are called radiographs. When the machine is turned on, the X-rays travel through the body and are absorbed by several tissues, depending upon the density which they pass through. The internals structures are displayed on the radiograph in some shades of grey and white. The various procedures of X-rays tests are mammography, fluoroscopy, computed tomography and several others. Most of the times X-Ray scans may result into life-threatening conditions such as infections, bone cancer and blocked blood vessels because X-Rays produce ionizing radiations that has the potential to harm the living tissues as cited by National Institute of Biomedical Imaging and Bioengineering [6].

II. RELATED WORKS

The field of data analytics has recently acquired so much of attention that various technologies have played an important role in the healthcare industry. The following sub-sections summarize the contributions of the different works or reviews done on the medical industry.

A. A survey is done on the various technologies that are used to improve the existing healthcare systems and to develop an integrated medical application. In the study, the main highlight is on the key challenges and the methodologies in the healthcare industry. Since the numbers of patients admitted to the hospitals or being affected by any sort of disease are increasing each year, all the medical records or data of these patients have also increased to a very high level. And due to the extensive accessibility of data, additional focus has been transferred to the medical industry. The medical records or the health data have increased to such a high level that it has become more complex and has also resulted into an increase in its sources. All these various sources include the cyber-physical systems, medical Internet of Things, electronic medical records, imaging reports, clinical decision support systems and genetic data. Due to the huge availability of data, the personalized healthcare systems have also started to come in existence from various new sources such as genetic data and social network services. The paper also aims at reducing the analytical tasks or work done by the physicians manually. Hence, now the latest computational intelligence technologies such as Big Data Analytics, Artificial Intelligence, Cloud Computing and several others also play an important role to effectively accumulate and the handle the vast medical records or data. All in all, the paper investigates the new technologies, techniques and the key challenges in the health care industry by mainly focusing on Big Data Analytics (Hadoop platform).

It also provides an evaluation that delivers simplified, convenient and easy ways of implementing and handling various technologies that are used to develop a homogenized healthcare system [7].

B. As it is obvious, in the couple of past decades the information technology has made its huge name in the medical industry. However, these new technologies have resulted into a large scale of data which is somehow difficult to process and manage. Therefore, the paper provides with an idea called the Cyber-Physical Systems called Health-CPS which is more convenient in the healthcare applications and services as the huge amount of medical records or the data can be stored easily using Big Data Analytics and the Cloud Computing techniques in these Health-CPS systems. The Health-CPS systems also provide a convenient and an easy way for the patients to interact with the healthcare systems so that they can view their medical record and report with full ease and are always aware of their past, present and the future diagnosis. It is recognizable that the previous study also focused on the proper implementation and analysis of the health care industry using Big Data Analytics [7]. However, one of the extraordinary challenges for building an integrated healthcare system is the handling and processing of the diversified data encapsulated from various multiple sources. This is the prime reason why a Health-CPS system is presented in this paper using technologies like Cloud Computing and Big Data Analytics [8].

C. Nowadays, various Health organizations are very easily able to collect more and more amount of data from wider range and multiple sources. The key thing to note here is that the collection of this data is occurring at a relatively very high speed. As more amounts of data is available, it also results into creating new opportunities to convey social healthcare services and contemporary personalized healthcare systems. In the paper, Big Data Analytics is a technique which has been implemented to analyze and process the huge amount of data into some relevant perception and information for the improvement of the sustainability and the efficiency of the healthcare systems. Due to the vast availability of data, the digitization view the healthcare systems is also opening new opportunities and possibilities to enhance the quality of the existing and prevalent healthcare systems. Some new technologies such as Enterprise Resource Planning (ERP) and Electronic Health Records (EHRs) have resulted into developing more integrated healthcare systems since they provide easy information about the medical records to the patients such as their next diagnose medical images and much more facilities. In addition to the convenient services provided by these new technologies, they are also cost-efficient which also acts as an advantage to the patients and empower them in managing their own healthcare services. However, these new technologies should use a unique and diversified approach in establishing themselves to provide some meaningful insights. Therefore, Big Data Analytics is a technique which is used in this paper as it involves technologies that manages and processes the visualized datasets in ways which are very much different from the pasts. In addition to it, Big Data Analytics also uses techniques known as Data warehouses, structuring and data processing resulting into approaches which evolve as a unique technology while accumulating multiple approaches. Therefore, in this paper, various methodological approaches have been acquired and addressed that produces malleable and extensible analytical frameworks that can be adopted for a wider range of demands [9].

D. It is a well-known and highly acknowledgeable fact that cardiovascular disorders are responsible for over 31% of deaths worldwide as cited by World Health Organization (WHO) [10]. Therefore, it is necessary to identify the patients at a higher risk at earlier stages and the working professionals or physicians should have a better interpretation and understanding of the various mechanisms used in the ECG analysis so that the efficiency of the treatment and diagnosis is increased. Electrocardiogram (ECG) is a technique which is used to determine the electrical activity of the heartbeat which signifies the various conditions of the heart stages such as pump rate, heart beat and much more. ECG analysis and implementation can therefore be a pivotal part to help treat and diagnose the patients suffering from cardiovascular arrest or disorders and can also be used to predict the cardiovascular disorders in time which may also reduce the percentage of deaths occurring due to heart problems or disorders each year. As cardiovascular disorders are a major problem worldwide, it can result into large scale data related to ECG analysis and heart diseases, so studying and handling them can be time consuming and tiresome. Therefore, a muscular computational techniques such as applications of machine learning methods are needed which can work upon the large scale ECG datasets and extracts information which is more amplified and useful in a maximized manner. In the first section of the paper, the main focus has been given to the classification of heartbeats and the techniques used to extract the abnormality from the orderly heartbeats. In the second section, emphasis has been given to the diagnosis of the patients. The next sections of the paper highlight the ECG analysis simulations and detailed explanations along with its critical evaluation [11].

E. According to the various studies, it is quite obvious that the identification of brain abnormalities is very much convenient and easy to identify in case of Magnetic Resonance Imaging (MRI) when as compared to the other types of scans. MRI is a technique which can be used to produce the three dimensional structural images of the internal body organs such as the brain, spinal cords, nerves and several others. Since it is generally a limited and non-invasive technology, it produces the most accurate results. Magnetic Resonance Imaging (MRI) of the brain is at present a well-accepted imaging technique which is used in the estimation and the assessment of abnormal and the normal conditions of the brain. However, the use of MRI Brain scans can be costly in terms of the medical equipment utilization and time. Therefore, it is important that the accurate and correct information or the result is produced by the MRI scan so that it can be considered and regarded as efficient in terms of performance and should also justify its cost. The different radiology reports of the MRI Brain scan often uses the data from Electronic Health Records (EHRs). The use of these radiology reports for the further diagnosis acts as an advantage and offers great prospective in terms of improvement of quality assurance, research studies, clinical care as well as other decision making process when it comes to the proper implementation of the MRI scans for the brain classifications.

Though these radiology reports or records are stored for the identification or manifestation of diagnostic imaging, the information or the data stored in them are in the form of free-text whereas the data stored should be in a structured manner for the proper implementation. Therefore, this paper solves the challenge of obtaining the structured data from the free-text for data analysis and the proper implementation. The study in this paper mainly aims and focuses to develop different brain scans classifications using various machine learning models such as Support Vector Machine (SVM), Logistic Regression, Random Forest (RF) and several others [12].

III. ARCHITECHTURE MODEL

Based upon the studies and the various methodologies explained in the paper previously, an analytical framework i.e.,an architechture module has been created that capitalizes on the contemporary evolution on various technologies such as Big Data Analytics, Text Analytics, Big Data Processing(creation of datasets) and storing it in databases to provide a scalable and adaptable health care systems. These health care systems work in a way such that the equipment used in these system, for example, the scanning or imaging test like MRI, ECG, Ultrasound and several others produce the results with maximum efficiency which maintains a balabnce between its performance and cost.Figure 1 below provides the architectural view of the proposed model.

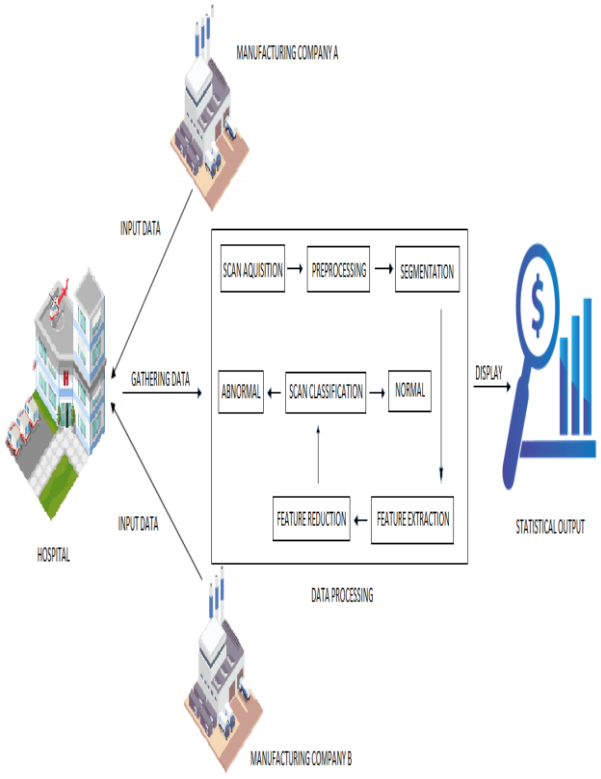

Figure 1-Architecture Diagram

A. Module Description

Basically, the architecture model can be described in three different stages. The three stages can be classified as –

1. Data Input

This is the first stage of the architecture model. In this stage, the collection of data takes place from multiple sources which act as the input data for the further processing. In this paper, as is easily recognizable from the architecture model, the collection of data is being done from multiple manufacturing companies which provide the equipments needed for different medical imaging scans and all the data related to the diagnosis and treatment of patients who have undergone some sort of a medical scan or will be in need of it in the future, so that the performance and cost can be compared of the particular scan based upon the accuracy of the results produced by them. The data collected from the different sources act as the input data for a particular hospital. This input data from the hospital is then gathered and processed which gives rise to the second stage of the architecture model.

2. Data Processing

The second stage and the most important stage of the architecture model is the Data Processing. During this stage, the gathered input data go through a cycle of phases for categorizing the data and classifying it as per the requirements before it is displayed as a statistical graph or a table in the form of final output. This complete procedure is known as Data Processing. As it is visible from the architecture diagram, the data processing stage is divided into a number of phases which can be described as follows.

2.1. Scan Acquisition

Basically, this phase includes the creation of datasets from the gathered input data. The datasets can be taken from various multiple sources. Some sources from where the datasets can be taken or acquired are the various websites such as Kaggle, BuzzFeed News, FiveThirtyEight, Socrata, Google Public Datasets, Data.gov, Academic Torrents and several others. It can go the other way round also i.e., instead of taking the datasets from any source, sample datasets can also be created itself. The required software is used for the creation of datasets and storing them. For the implementation of the work, the datasets needed will be related to the healthcare industry in the field of medical imaging. For example, number of patients undergoing ECG test each year, safe and unsafe range for the cardiovascular disorders treatments done by ECG, normal and abnormal range of the brain tumors disorders which are diagnosed by MRI scans, number of pregnant ladies undergoing ultrasound test each year, percentage of X-Rays and CT-Scans each year and several others.

2.2. Preprocessing

The most important and necessary phase of data processing is the Preprocessing. Generally, preprocessing is a technique in which the raw data or the initial structured data is processed for the further implementation of the work. Initially, when the datasets are created, it is in the form of unstructured or clustered form of data i.e., text file. This unstructured data is generally referred to as a string format data. But for the data analytics to play its role in the process, it is necessary to convert the string format i.e., the unstructured data into numerical format data, or if possible to the binary format as it is the most suitable format for the analysis of data for any computational technology. This process to convert the unstructured data into some meaningful data for analysis is known as text analysis.

Once the unstructured data is converted into the numerical format data, data analytics technology can easily be applied to it and further processing part can be implemented. Once the numerical data is available, an efficient way is used to store these datasets in unique columns into array variables using the preprocessing algorithms. To load the data from the specific files, necessary algorithms and methods are used. Figure 2 below shows the workflow diagram.

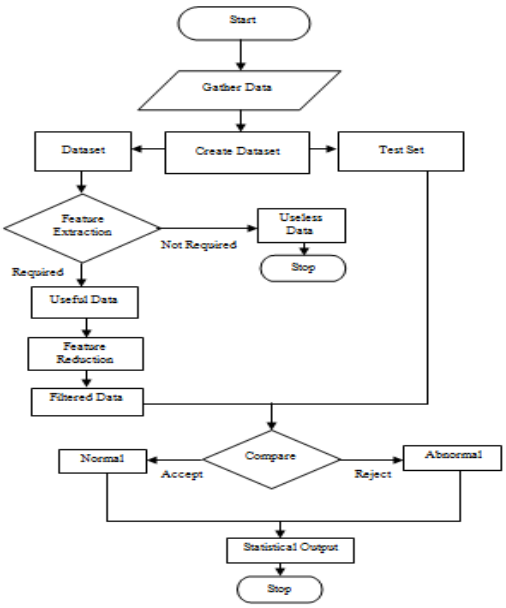

Figure 2- Workflow Diagram

2.3. Segmentation

The extension of the preprocessing phase can be known as the segmentation phase. After the text analysis process when the meaningful or the numerical data has been converted from the unstructured string format data, the work has to done on the numerical data for the further processing and implementation. Once the meaningful data is available completely, an effective algorithm can be implemented to segregate the data as per the requirement and then the further implementation follows. For example, the results produced by a MRI Brain scan can be segregated into two different datasets in two different columns as normal range and abnormal range and then the further processing can take place.

2.4. Feature Extraction

After the preprocessing and the segmentation phase follows another important phase knows as the Feature Extraction phase. Feature extraction is generally an insight technique of data analytics and machine learning. The feature extraction technique is the one which involves and extracts only the most informative and condensed i.e., the most useful and compact information from a set of features or datasets to improve the efficiency of the proposed model. The technique of feature extraction involves the transformation of more amounts of data into fewer amounts of data. The main benefit of using the feature extraction technique is that it provides only those datasets or features that can have an effect or characterize the response of what is going to happen in the model i.e., it extracts only that important information which is related to the output needed by the model. For example, to check for the percentage of abnormalities of brain disorders in a particular year, the feature extraction technique will produce the data and information only related to the MRI imaging scan of brain and not for other disorders like cardiovascular disorders in which the ECGs are used. Another example can be of a pregnant woman, for whom only the data related to ultrasound test will be produced and not for other tests like MRI, ECG or X-Ray. The algorithms used to implement the feature extraction technique can be the Speeded-Up Robust Features (SURF), Local Binary Patterns (LBP) and Color Histograms of the machine learning and data analytics model.

2.5. Feature Reduction

Feature reduction is generally an extension of feature extraction. The role of feature reduction is to reduce the number of variables in the data. One of the components of feature reduction is feature extraction. Feature reduction is an advantage to developers working with huge amount of datasets and analyzing more complex data because this technique is used in the process of data compression. As a result of data compression, the computational time is reduced and the data also takes less storage space. Some of the methods and algorithms used to implement feature reduction technique are High Correlation Factor, Missing Value Ratio, Random Forest, Factor Analysis and several others which can be solved using Machine Leaning and Data Analytics models.

2.6. Scan Classification

This phase can be regarded as the final phase of data processing stage. In this phase, a test set is created based upon all the necessary information and data collected and using this test set, a compulsory value is generated. Using this generated value, comparisons are made based upon the output produced at the end of the feature reduction phase. For example, the normality range for MRI Brain scans is 1-5 and the abnormality range is 6-10, so on comparing the output against these test sets, it will be very convenient and easy to identify the final result and based upon it there can be a reality check of the how good is the performance efficiency of a particular scanning machine while maintaining or balancing its cost.

2.7. Normal

When the comparison is made in the scan classification stage, if the result falls into the range of normal category, then the final scan is verified as normal.

2.8. Abnormal

After the comparison is made in the scan classification stage, if the result falls into the range of abnormal category, then the final scan is verified as abnormal.

3. Data Output

Finally, after the data input and the data processing stage, based upon the final results obtained, an output is produced in the form of a graph or a table. To display the output in the form of a graph, the required method is used. The final graph obtained gives an approximate idea about the performance efficiency of various scanning machines while maintaining or balancing their costs. Therefore, using this graph as a statistics, the various hospitals i.e., the management sides will be aware of what all scanning machines are best suited and provide full maximized profit for them as well as for the patients. The following graphs were derived considering 5 categories

0.0 - Normal beat
1.0 - Supraventricular premature beat
2.0 - Premature ventricular contraction

3.0 - Fusion of ventricular and normal beat
4.0 - Unclassifiable beat

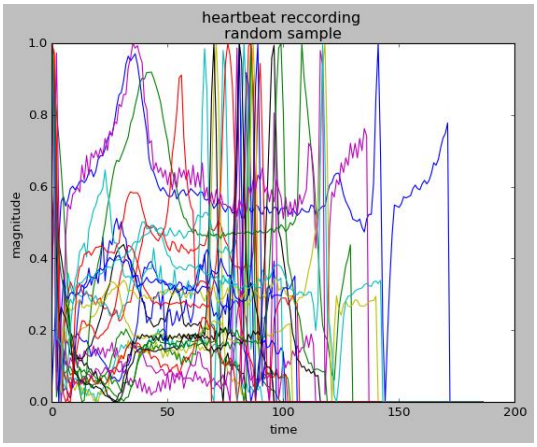

Figure 3- Line plot

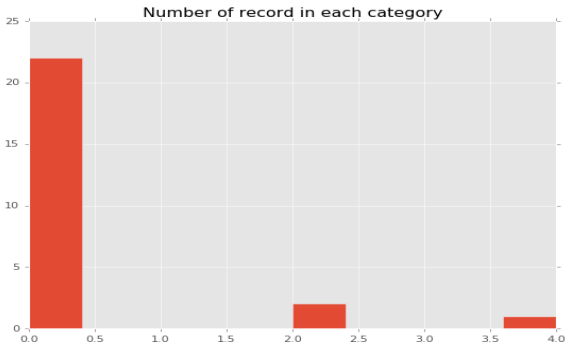

Figure 4- Bar graph

IV. CONCLUSION

Nowadays, more and more powerful computational technologies are being used by the modern healthcare industry. Especially, the technique of Medical Imaging has developed and progressed to such a high level that now it is one of the key resources and techniques used in the healthcare industries. This technique of medical imaging has also brought a lot of advantages to the medical industry such as the evolution of patient-pivotal preventions, treatment and diagnosis of various disorders, prediction of the diseases in time and much more. Various technologies in the past such as Big Data Analysis, Cloud Computing and Machine Learning have also developed moderately and gradually, and in today's era, these technologies have evolved to such a high extent that they are used in almost 90% of the different industries around the world. These technologies such as the Big Data Analysis can be used as an important aspect which acts as a source of transformation in the growing healthcare systems and also in the support of rational decision-making in the medical field. Therefore, this paper presents an idea of improving the healthcare systems in the field of medical imaging assisted by technologies such as Big Data Analysis and various models of Machine Learning. Using the various models of these technologies and by using the different algorithms like, a model has been developed that can easily identify the different types of various scan classifications. Firstly, the feature extraction technique is processed in which the various algorithms used are Speeded-Up Robust Features (SURF), Local Binary Patterns (LBP) and Color Histograms. After the feature extraction, the feature reduction technique involves the use of High Correlation Factor, Missing Value Ratio, Random Forest, Factor Analysis and several other algorithms in the machine learning and data analytics model. Based upon the results generated, the model will help us to identify whether the scan classification falls into the normal category or the abnormal category of the particular type of disorder. Therefore, in the last stage using the matplotlib () library of python, a graph will be plotted which will help to identify the efficiency of a particular type of scan. Therefore, by studying the details of the resultant graph's statistical results, it will be easy and convenient enough to detect the performance efficiency of the different scanning machines, and by using these stats, the hospitals i.e., the healthcare systems will be aware of what all scanning machines are best suited and provide full maximized profit for them as well as for the patients.

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