ISSN: 2581-3242

Universidad de Oviedo

CMR INSTITUTE OF TECHNOLOGY
EXPLORE TO INVENT

International Journal of MACHINE LEARNING AND NETWORKED COLLABORATIVE ENGINEERING

Vol.2 No.3 2018

PPREFACE

The International Journal of Machine Learning and Networked Collaborative Engineering (IJMLNCE) ISSN 2581-3242 continues to evolve and expand, receiving more and more quality articles for evaluation and possible publication. We are happy to share with you that apart from the existing indexing, we are able to place our journal manuscript with two more indexing e.g., WorldCat-OCLC and Dimensions. We are now proud to present the Volume No-02 Issue No-03, on this occasion, we have selected five interesting papers that are framed in the scope of the journal, covering different aspects related to machine learning and collaborative engineering.

Küçük and Kiani [1] published a work entitled “Smart Advisor: An Intelligent Inventory Prediction Based On Regression Model”. Authors focus on inventory management of raw material and stock amounts in enterprises and present a model to predict the demand of stock items by using a regression model. They analyze the outputs of the model on a sample dataset to enable accurate estimation of the amount of stock to be consumed in the future and to facilitate decision making.

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Kalaskar et al. [2] published a work entitled “Forecasting Ventricular Deviation in Monitoring of Live ECG Signal”. This work shows the problem of the increasing number of coronary artery diseases and ventricular arrhythmias cases. Authors propose a novel platform for real time diagnosis of Ventricular Tachyarrhythmia with the help of a portable electrocardiography device. In addition, it includes a solution for signal analysis and cloud-based processing for the diagnosis.

Hoang et al. [3] published a work entitled "Cow Behavior Monitoring Using a Multidimensional Acceleration Sensor and Multiclass SVM". In this work, authors talk about the health of cows based on their daily behavior. Thus, they propose an automated monitoring system for suitable management. Cow's activities are monitored by using a multidimensional acceleration sensor and data is processed in a server through an algorithm based on multiclass support vector machine.

Kumar and Sairam [4] published a work entitled "Machine Learning Approach for User Accounts Identification with Unwanted Information and data". Authors focus on identifying fake and suspicious accounts in Facebook in an effective way through a novel architecture and a process flow. They also apply machine learning supervised models for text classification and machine learning unsupervised models for image classification respectively.

Puri et al [5] published a work entitled "Internet of Things and Healthcare Technologies: A Valuable Synergy from Design to Implementation". In this work, authors introduce a review on various enabling Internet of Medical Things technologies based on the latest research work and technology available in the marketplace. The work also analyzes different software platforms available in the field and the current challenges that the industry is addressing.

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https://doi.org/10.30991/IJMLNCE.2018v02i03.005

DOI : https://doi.org/10.30991/IJMLNCE.2018v02i03

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EDITORIAL OFFICE

CALL FOR PAPER

International Journal of Machine Learning and Networked Collaborative Engineering (IJMLNCE) with ISSN **2581-3242**, is a quarterly published, open access, peer-reviewed, international journal, focuses on publishing authentic and unpublished

quality research papers in the emerging field of Machine Learning and Collaborative Engineering.

This is a scientific journal aims to promote highly qualitative and innovative research works, not limited to but focuses on the area of machine learning, collaborative engineering, and allied areas. We publish only original research articles, review articles, and technical notes.

The journal is registered with CrossRef **10.30991/IJMLNCE**. Each accepted manuscript shall be assigned a unique digital object identifier for identification. The abbreviated key title for our journal allocated by ISSN is **Int. j. mach. learn. Networkedcollab.eng**.

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In this present technological era, the areas like machine intelligence, machine learning, and its associated domains are one of the most popular and demanding choices for the researchers as well as the industry personnel.

In last few years, numerous uses of machine learning and its related domain, has drawn ample attention of the people, that has generated a large number of applications in this field, making machine learning and collaborative engineering highly admired one.

Machine intelligence or machine learning is not a new concept. In terms of Artificial Intelligence, we were familiar with several aspects of the field, but nowadays with the introduction of machine learning, the use of this has been highly evolving, especially for improving the lifestyle of the human being.

There are numerous application areas of machine learning or machine intelligence, irrespective of any famous sector, from Healthcare, Space, Automation, Aviation industries etc. to entertainment industry and even in academia.

With this insight, IJMLNCE invites quality and authentic research works in form of manuscripts, for our forthcoming version. The Journal solicits latest research work carried out by the researchers, academicians and industry practitioners, in the domain of machine learning and collaborative engineering.

Plagiarism is considered as a serious ethical and professional malpractice in case of IJMLNCE. So similarity check should be taken care at its highest level. The originality of the work will be highly appreciated. Each paper will be peer-reviewed by the expert reviewers and in a multilayer approach. The editorial board of the journal believes in high moral and ethical practices.

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IJMLNCE JOURNAL

International Journal of Machine Learning and Networked Collaborative Engineering

Journal Homepage: http://www.mlnce.net/home/index.html

DOI : https://doi.org/10.30991/IJMLNCE.2018v02i03.001

Smart Advisor: An Intelligent Inventory Prediction Based On Regression Model

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Abstract

Today one of the biggest expense items of the enterprises is raw material and stock amounts. Therefore, proper inventory management is very important for the profitability of the enterprises. Products that are not purchased on time cause interruptions in production and products left over because the expiration date has passed will also cause losses for businesses. Therefore, proper inventory management is critical for profit / loss situations of businesses. In this paper we presented a model to predict the demand of certain stock items by using a regression model. Our model can analysis and computer the prediction results on given dataset. We evaluate our model on sample dataset and provide the analysis as well calculations over the existing inventory. Accurate analysis of stock consumption enables accurate estimation of the amount of stock to be consumed in the future. Accurate forecasting of stock consumption helps to take corrective steps in decision making. That is, it only allows you to buy in sufficient quantity when necessary. These stages are critical for economic stock management. For this reason, robust and adaptable approaches that can provide models ensure that stock consumption can be managed properly. It is difficult to find previously written sources on estimating the direction of stock movements. One of the most important reasons for this is the lack of incentive to make such studies in the academic literature. As a result, articles written about the subject and the work done have been limited, the results have not reached the reproducible level.

Keywords

Machine Learning, Linear Regression, Inventory Prediction, Smart System.

1. Introduction

Machine Learning is a subordinate of Artificial Intelligence. The basic logic is to conduct a self-learning activity by analyzing data. Artificial Intelligence is the ability of computers to use intelligent methods to accomplish certain goals, and is broader in the context of machine learning. Machine Learning is

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the realization of artificial intelligence by learning only the data obtained without the programming of computers.The machine learning and artificial intelligence, which are increasing in importance in recent years, are being implemented in many areas.With the emergence of new concepts such as smart systems, distributed systems, big data analysis, their working and application areas are increasing. Smart cities [1], IoT [2] and mixed of them [3, 4], big data [5] can be pointed from these application fields.Therefore, the importance of machine learning is increasing day by day and the workings in this area continue with the latest speed.So machine-learning methods are described in this section.Machine learning algorithms are generally classified into three groups [6].

1.1. Supervised Learning

In this method called controlled learning, an objective function is learned to obtain the desired output set Y from the input set X. There is an artificial education for supervised learning. Inputs and outputs for each sample are included in the training data. It is assumed that there is also a connection between this input and output. We have a good understanding of how supervised learning should be in the dataset. In supervised learning, collected observations related to the concept to be learned are entered into the system as a training set. In the training set, the desired output values are also given for each sample. Using this information, a relationship is established between input and output. Using the generated relation, the Y values corresponding to the future X inputs can be estimated. Supervised learning problems are divided into regression and classification. In regression problems, it is tried to map the input values to some continuous functions. Classes are separate in classification. It is tried to map input values to different categories. Each observation is assigned a class.

1.2. Unsupervised Learning

It discovers the indirect relationship between unattended learning data chunks and improves rules that define behavioral changes in variables with the greatest causal effect on other variables. The Y output values are observed as well as the X input values observed in supervised learning. For unattended learning only focus on the X input values. Since there is no set of Y values associated with X, the Y output values are not predictable. It provides the opportunity to have an idea about the structure of the problems that have no knowledge about the results of unattended learning. The goal is to discover information about the measurements available. For example, the possibility of dividing the observations into subgroups is investigated, or the data are examined in an informative manner. The relationship between X data is exploited to reveal this in problems.

1.3. Reinforcement Learning

Reinforced learning demonstrates how a system that can perceive itself and make decisions on its own can learn to make the right decisions to reach its goal. Reinforced learning methods can be applied in dynamic or uncertain environments where they cannot know about. This method is often used in areas such as robotics, game programming, and disease diagnosis and factory automation.

There is an instructor in the reinforced learning, but it cannot give or give much detail to the system like supervised learning. Instead, the learning system rewards the system for making a decision when it is correct and punishing for mistakes. Reinforced learning methods increase their experience by interacting with their environment. The aim is to check whether the probable situation of the learning system is the target and to remember all the right or wrong cases tried.

If the decisions are remembered in the form of consecutive sequences, then each decision in the sequence of consecutive situations that is remembered depends on the success of the situation. It tries to maximize its success by choosing movements that receive continuous prizes.

There is usually a function (V) that determines a prize or a penalty. With the behavioral policy (π), optimum can be selected from the actions that can be made in . Reinforced learning prefers a behavioral policy with the greatest payoff generated by the value function. The preference policy of optimum behavior is expressed as equation 1.

$$\Pi = \text{argmax}(V($$ (1)

In our work, we will use the Linear Regression technique from Machine Learning techniques to construct a prediction model of stock consumption. We will perform prediction on stock infrastructure by using an application developed by us names Smart Advisor. Smart Advisor analyses the inputs and checks coefficient of system characteristics and tries to predict outputs.

Rest of the research paper is organized as follows. Related work and limitations of existing systems are discussed in Section 2. In Section 3, the proposed architecture and its implementation are discussed. In Section 4, we explain our experimental setup and results with discussion. Finally conclusions and finding are discussed in Section 5.

2. Related Work

As mentioned the machine learning methods are categorized in three general groups. There are many studies in the literature in these group studies. In this paper, we were benefited in some general and new approaches [7-9] so we could inspired from some of them to work on our own. One of the earliest works in Artificial Intelligence is the checkers game developed by Arthur Samuel [10]. Arthur Samuel defines machine learning as a computer's ability to learn a job without being explicitly programmed. Arthur Samuel developed a checkers game in 1950s. The feature that made this game different from the others was that it was one of the first examples of machine learning. The program, which analyzes good and bad positions by analyzing and comparing the data in the games played, eventually became a better player than Arthur Samuel.

One of the paper on stock estimation using machine learning is “iJADE Stock Advisor” [11] which published by RayJam S. T. Lee in 2014. Lee has developed a “smart” agent based stock advisor application names “iJADE stock advisor” for intelligent web mining and other intelligent e-commerce applications for this paper. A hybrid RBF repetitive neural network was previously developed for stock estimation. The study is an extension of the traditional RBF network and adds two main features: First, a 'forgetting factor' emerges in the back propagation algorithm. Second, there is”decay" in the repetitive time-difference mechanism. Both additions effectively increase the importance of newer observations. Another study is related to the Stock Estimate published by Pyo [12] in 2017. He offers a simple Artificial Neural Networks based stock estimation solution, based on an introductory literature review. Concepts of basic and technical analysis and efficient market hypothesis are examined and the near-time populations of Artificial Neural Networks on the basis of traditional time series estimation and stock movement estimation using linear models are discussed. Michael David Rechenth is researching forward predictability in the thesis study of machine learning classification techniques for inventory analysis and estimation. The framework adapts to changes by using the stochastic subgroups of past data and by creating thousands of traditional base classifiers (SVM, Decision Tree and Neural Network) that cover similar inventories and optimally combine the best of these base classifiers. It also deals with stock data flows, especially class imbalance, quality creation, size reduction [13].

Chatsiz [8] proposed another study in forecasting stock markets. This will contribute to the ongoing debate on the nature and characteristics of the spreading channels for international accident events. In particular, we examine the transfer mechanisms of stock markets, together with the effects of bonds and currencies. Our approach involves a comprehensive forecasting mechanism for the probability of a stock market crash that occurs at different times. The development approach is a combination of daily stock information from 39 countries covering a wide range of economies, different machine learning algorithms presented with monetary and monetary units. In particular, a number of technical linguistic and deep neural networks such as classification trees, support vector machines, random forests, neural networks, extreme gradients are strengthened. For further information, it is believed that in-depth learning and development approaches in the literature are the tools for predicting stock market crises for the first time. In our data, arguments that contain information about link of channels that can be triggered by financial risks: returns and fluctuations.

N. Zadehhas developed a prediction approach for drug sales [14]. The intent of their work is to suggest a new method for estimating PDC sales. The presented method is a combination of network analysis tools and time series estimation methods. Due to the lack of sufficient past sales records for each drug, a research-based network-based analysis is used to find clique sets and group members and use stakeholder sales data for sales forecasting. Later, time series sales forecasting models are created with three different approaches such as ARIMA methodology, neural network and advanced hybrid neural network approach.

The hybrid method of applying each drug and its recorders to historical records makes it easy to accurately capture linear and non-linear sales models. The performance of the proposed method was evaluated by a real data set provided by one of the leading PDCs in Iran. The results showed that while the proposed method accurately predicted drug sales, the number of past records might be low. Here, unlike our work, we carried out a study to estimate the sales of the stock from the stock.

Jui-Chang Hun et al. were proposed an improvement model in inventory model with a company example [15]. This study aims to help companies improve inventory control. In their work, they tried to manage inventory entry by production rather than stock consumption as a different way. First, the products presented in the portfolio are divided into groups, with the help of the R programming language, to promote and forecast future sales of different products. Simulation and forecasting of future sales based on categorization results and classification techniques for the creation of different formulations and control techniques based on simulations and estimations are used to manage stock levels according to the results of the estimations. The results can be used to improve inventory control and inventory management.

Cardenas et al. proposed a multi-product inventory model in Columbia example [16]. In this study, we present a comparison of the demand model estimates for multiple products, choosing the best among the following: autoregressive integrated moving average (ARIMA), exponential smoothing (ES), a Bayesian regression model (BRM) and a Bayesian dynamic linear model (BDLM). For this purpose, the cases in which the time series are normally distributed are first simulated. Secondly, sales forecasts for three products of a gas service station are estimated using four models and BRM is the best model. Then multi-product stock model is optimized. Bayesian search elements that combine a Tabu search item to develop a solution are used to define policies for order, stock, costs, and profits. This stock model optimization process is then applied to a petrol service station in Colombia. In these last two studies, we are forecasting sales values instead of inventory outputs.

3. Smart Advisor Architecture

Our calculation flow chart is at the following diagram figure 1. A test dataset for calculations is created. First sample quantities of material and drugs were defined for using in calculations then, purchased from these materials at different quantities on different dates. And at different dates, some of these materials were consumed. Finally monitored and analyzed the results of Smart Advisor and discussed prediction rates.

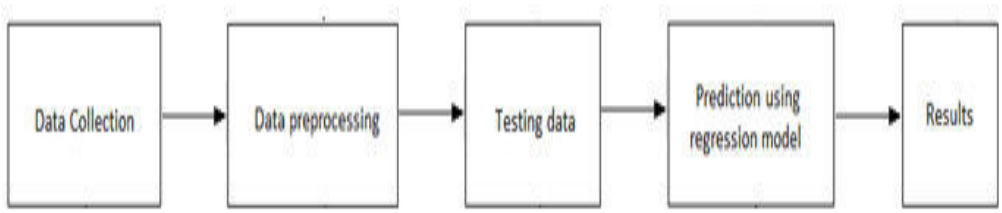

Figure 1. Flow Chart of proposed Smart Advisor System

Now let's analysis inputs and outputs of Smart Advisor infrastructure.

3.1. Material Expiration Date

Expiration date information of the material is one of the important points at the system. Because the materials that are closest to the expiration date are used first. And system will decide and calculate consumption, considering expiration date of the material.

3.2. What is minimum level?

The duration of time from material is ordered to material is delivered. The amount of material consumed during the period of deliver is the minimum level for that material. That is, when material is ordered, the minimum level of material must be enough until received. The main purpose here is to order material without reach to the minimum level so that the material in the stock is never reset. The minimum level depends on the material, so it is kept on a material basis.

3.3. Consumption Speed

Stock Consumption Speed is the rate at which materials are used in unit time. The period between the date when the material was first used and the date when it was last used is calculated by proportioning to the amount of total material used (output) in that interval. In this study we will calculate at daily.

3.4. Prediction

For the most efficient inventory management at the lowest cost, we estimate when how much to buy from which materials.

The stock outputs in the system are the input (X) values for the prediction part. The prediction part analyzes material stocks, monitors instant stocks, calculates stock consumption speed, and calculates when minimum values will arrive according to minimum level values.

The inputs and outputs of the prediction section are shown in figure 2.

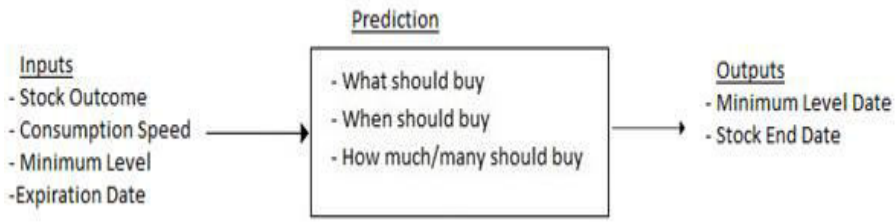

Figure 2. Prediction Process

Daily consumption speed is calculated with considering the outputs of the materials in the system. This information is the average rate of consumption of that material in unit time. The extreme over and extreme under of this speed are the noisy records for the prediction part. There is a filter part to exclude these noisy records from the prediction part. How much below or above records will be filtered, we determine the level by considering the outputs.

3.5. Smart Advisor

The steps we have discussed in this study are realized with our application called Smart Advisor, which we have developed in Java. In this stock management application, we made predictions based on the stock data of the classical system as well as the input and output transactions.

4. Results

The result of the proposed system is presented in two parts as they are described in this section of the paper.

4.1. Stock Status Report

In figure 3, we see the material code, name, and name of the species as well as the minimum level of information in the stock. We can also see the stock consumption rate that the system calculated for materials and used in forecasting. If the material goes below the minimum level, we can see the state "Under the Minimum Level" and the stock is exhausted, but in the field "No Stock". And at the far right we see the information generated by the forecasting structure. There is information about how many days the material is left to go down to minimum level, how many days are left for the stock depletion, at which minimum date will be reached and the date of the stock will be consumed. Notice that the number of days that the minimum falls to the minimum level is negative. The figure 3 is a snapshot of the software product we have developed.

STOCK STATUS

CODE	NAME	TYPE	MIN LEVEL	COUNT	CONSUMPTION SPEED	STATUS	DAYS TO MIN LEVEL	DAYS TO STOCK END	MIN LEVEL DATE	STOCK END DATE
21	PANTOPRAZOL	DRUG	53	19	0.45	Under Min Level	-77	43	30/05/2018	27/09/2018
15	EPOETIN BETA	DRUG	55	33	0.37	Under Min Level	-61	91	15/06/2018	14/11/2018
2	KATATER	MEDICAL MATERIAL	15	0	0.41	Zero	-37	0	09/07/2018	15/08/2018
28	ZIPRASIDON	DRUG	48	7	1.28	Under Min Level	-32	5	14/07/2018	20/08/2018
19	NAPROKSEN	DRUG	51	34	0.67	Under Min Level	-26	51	20/07/2018	05/10/2018
1	ASPİRİN	DRUG	10	0	0.45	Zero	-23	0	23/07/2018	15/08/2018
8	DRENS	MEDICAL MATERIAL	31	25	0.60	Under Min Level	-10	42	05/08/2018	26/09/2018
9	GLOVES	MEDICAL MATERIAL	35	33	0.60	Under Min Level	-3	55	11/08/2018	09/10/2018
3	KAĞIT HAVLU	MATERIAL	20	20	0.41	Available	0	50	15/08/2018	03/10/2018
22	PROPOFOL	DRUG	38	39	0.47	Available	2	84	17/08/2018	06/11/2018
23	SODYUM FOSFAT	DRUG	39	46	0.89	Available	8	52	23/08/2018	06/10/2018
27	X PHE KID SE MAMA	DRUG	47	58	1.30	Available	8	45	23/08/2018	29/09/2018
16	LENALIDOMIT	DRUG	66	76	0.86	Available	12	89	27/08/2018	12/11/2018
5	KAN SETİ	MEDICAL MATERIAL	24	31	0.45	Available	16	70	31/08/2018	24/10/2018
18	MENOTROPIN	DRUG	41	52	0.61	Available	18	86	02/09/2018	09/11/2018
4	SONDA	MEDICAL MATERIAL	14	22	0.45	Available	18	49	02/09/2018	03/10/2018
20	OKTREOTID	DRUG	42	64	1.08	Available	21	60	04/09/2018	14/10/2018
6	DİYALİZ MALZEMESİ	MEDICAL MATERIAL	27	36	0.45	Available	20	82	04/09/2018	04/11/2018
14	DEKSTROZ (GLUKOZ)+SODYUM KLORUR	DRUG	44	66	0.89	Available	25	75	09/09/2018	29/10/2018
24	TEMOZOLOMID	DRUG	40	57	0.68	Available	25	85	09/09/2018	08/11/2018
29	ÇARŞAF	MATERIAL	46	99	1.96	Available	27	51	11/09/2018	04/10/2018
12	BUDEZONID	DRUG	28	50	0.77	Available	29	65	13/09/2018	19/10/2018
13	CADI FINDIGI DISTILATI	DRUG	33	56	0.63	Available	37	90	21/09/2018	12/11/2018
30	PERDE	MATERIAL	11	69	1.58	Available	37	44	21/09/2018	27/09/2018
26	VALSARTAN	DRUG	32	63	0.77	Available	41	82	24/09/2018	05/11/2018
25	UROKINAZ	DRUG	34	75	1.01	Available	41	75	24/09/2018	28/10/2018
17	MANNITOL	DRUG	13	66	0.98	Available	54	68	08/10/2018	22/10/2018
11	ASETAZOLAMID	DRUG	19	49	0.56	Available	54	88	08/10/2018	11/11/2018
10	ALBUMIN	DRUG	27	50	0.42	Available	55	120	09/10/2018	13/12/2018
7	IV KANUL	MEDICAL MATERIAL	16	41	0.40	Available	63	103	17/10/2018	26/11/2018

Figure 3. Stock Status Report

4.2. Linear Regression Schema

It's the report showing the system's characteristics. Each output in the system appears in graphical form with information on the daily consumption speed and how many outputs are made. The ratio of these two values gives the knowledge that the output of the material is above or below the average output value. The average of these ratios of materials gives us the general characteristic of the system. The function of this characteristic is mentioned in equation 2.

$$h\theta(x)=\theta 0+\theta 1x \quad (2)$$

Calculation of these equations coefficients is performed by the application. The coefficients of the function which shows the characteristic of the system are calculated according to the dataset which consists of daily consumption speed and output quantity of material outputs. Here θ0 corresponds to intercept and θ1 corresponds to slope information. In this case it is calculated by equation 3.

$$Y=slope*X+intercept \quad (3)$$

The function obtained with the calculated coefficients is shown under the Linear Regression Graph in figure 4. The line of this function is shown in red color in the graph. This red line is the general characteristic of the system, which is the average of the ratios of the materials we mentioned above. That is, the average of the ratios of the values of the material outputs in the system to the daily consumption rate of that material gives the slope of this linear regression line.

In this case, outputs equal to the daily consumption rate appear directly above this line. Outputs below or above the daily consumption speed appear above or below this line.

The records extreme below or extreme above this line are noise records for the system. In order to eliminate these noise records, the application also has a filter part. This filter will work to calculate records below or above a certain percentage of the linear regression line and to exclude records outside those. We

declare this ratio as a percentage. For example, for an 85% ratio, the Linear Regression graph will look like figure 5.

Note that for every change in the rate of filtration, the coefficients of the Linear Regression function change as well and the values in the Inventory Report change. That is why these values are only calculated from the output values included in the calculation.

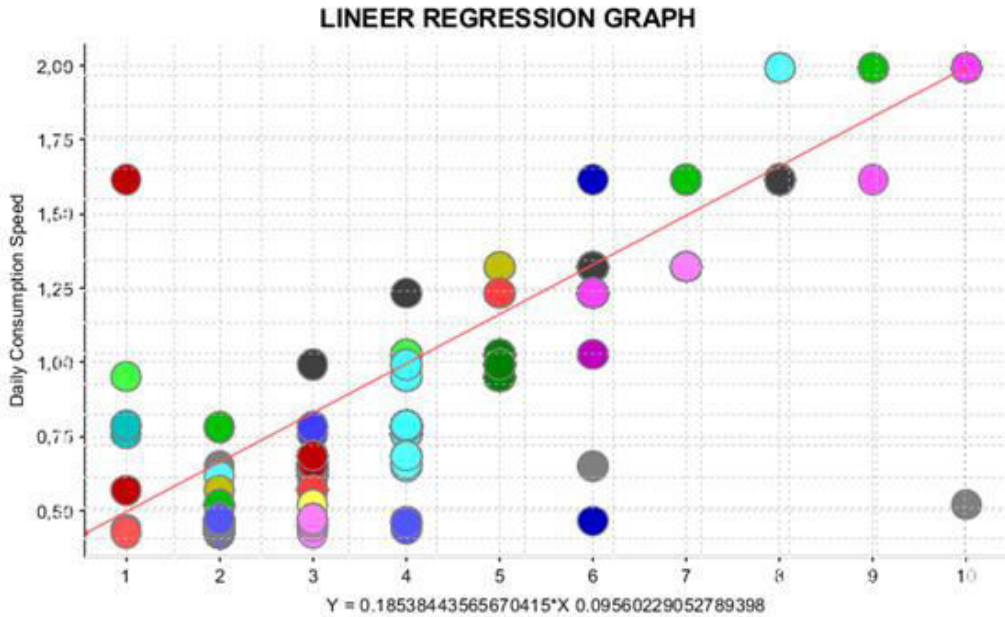

Figure 4. Linear Regression Graph

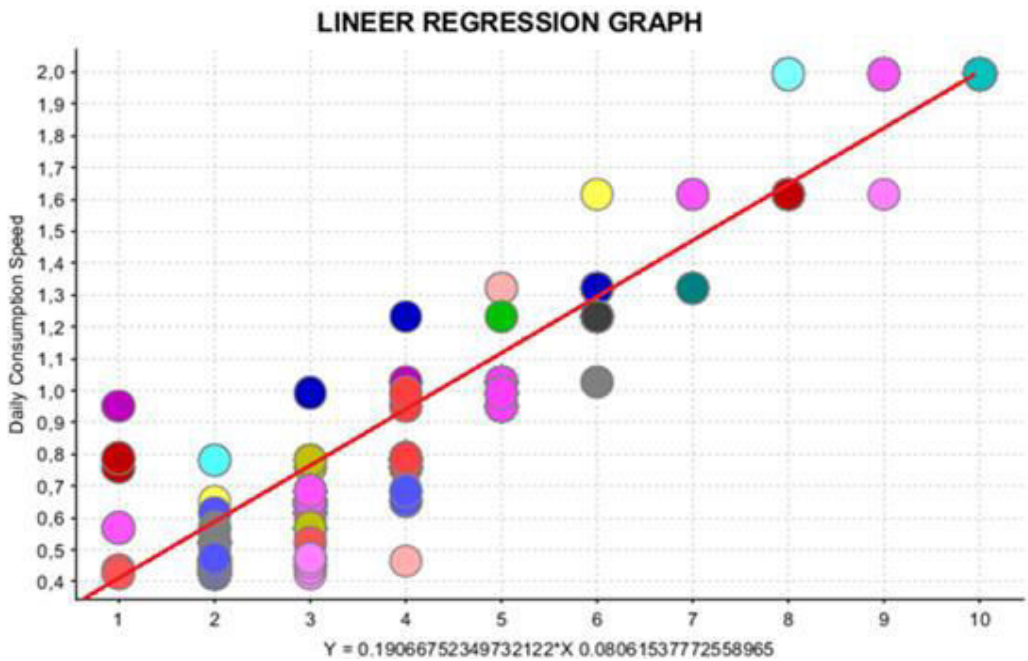

Figure 5. Linear Regression Graph with %85 Ratios

5. Conclusion and Future Works

In this work, we tried to predict outputs for each material will be possible in the future by analyzing the current outputs. We analyzed current output values (X) and the required output values (Y) to derive the characteristic of the system and the linear regression equation (the relation between X and Y). We tried to get a more stable estimation by filtering the system's exceptional behavior (noise). We observed how the estimated values produced by the system change as the current output values. There are studies in the literature about forecasting different stages from stock output, product development to product sales. Which method should be selected here depends on the type of product. For example, if direct selling products are kept in stock, estimates for product sales may be needed more. In our work, we used inventory data to estimate the inventory output as the material received was not directly sold.

In our work, we analyze the inventory outputs of the system in order to make more efficient inventory tracking with minimum inventory levels at lower cost, calculate the stock consumption rate and make forecasts of future stock outputs. Our Smart Advisor, developed for this purpose, reads the stock outputs of the application and finds out what material the system consumes in what time and consumes it and calculates which materials will be consumed. This work can provide efficient results in systems that produce new products/services using existing stocks. For example, it can be used in hospitals in the healthcare sector. This work could produce the next step, cost-tracking, or data needed for budgeting and provide resources for work to be done in these areas.

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How to Cite

Küçük, Ömer, & Kiani, F. (2018). Smart Advisor: An Intelligent Inventory Prediction Based On Regression Model. *International Journal of Machine Learning and Networked Collaborative Engineering*, *2*(03) pp 86-94. https://doi.org/10.30991/IJMLNCE.2018v02i03.001

IJMLNCE JOURNAL

International Journal of Machine Learning and Networked Collaborative Engineering

Journal Homepage: http://www.mlnce.net/home/index.html

DOI : https://doi.org/10.30991/IJMLNCE.2018v02i03.002

Forecasting Ventricular Deviation in Monitoring of Live ECG Signal

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Abstract

Number of coronary artery disease cases and ventricular arrhythmias have been increasing in India. One of the common forms of cardiac disorder is Ventricular Tachycardia (VT). Due to improper electrical activities in the ventricles, consistent and rapid heart rate occurs, which produces Ventricular Tachycardia disorder. Short time period may not lead to severe heart problem, but the longer duration increases; it may be a severe heart issue. In this disorder, for short durations it is possible that there may not be any symptoms or few symptoms with palpitations (increase / decrease in heart beats), dizziness or pain in chest. This disorder may result in cardiac arrest. This may also results into ventricular fibrillation. Initially it was found that near about 7% of people in cardiac arrest are caused by Ventricular Tachycardia. In this work, a novel platform for real time diagnosis of Ventricular Tachyarrhythmia with the help of a portable Single lead ECG device is proposed. The gateway for signal analysis and combined edge and cloud based processing for the diagnosis is used. The bio-signal captured by the device in LEAD II configuration is pushed to a cloud based diagnosis API through a mobile gateway. An algorithm in the cloud analyses this signal and finds out P, Q, R, S, T, their amplitude positions, onset and offset. From the onset and offset ST segment slope, elevation, depression, S morphology and ST segment variation statistics is captured and classified using rule based classifier. The work evaluates the performance of the classifier with PhysioNet dataset. The accuracy of the system was found to be 90% with accuracy of detecting normal ECG being 100% where as the accuracy of detection of VT being 80%. Results shows that the system is extremely efficient in detecting Ventricular Tachyarrhythmia and many related cardio vascular diseases.

Keywords

Ventricular Tachyarrhythmia, Ventricular Fibrillation, Heart Rate, Heart Rate Variability, Cardio Vascular Disease, Artificial Intelligent, Machine Leaning, Rule Based Learning, Semi Supervised Learning, Decision Support System.

1. Introduction

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Heart is one of the most important part of human body. India has a huge number of cardiovascular patients (approximately 50 million) and the number is growing by every day. Very low cardiologist to patient ratio is another factor that adds to the problem. India is on the verge of near epidemic of CVD by the year 2022 (as per WHO). Several handheld and mobile ECG devices have been proposed in the past. Many of these ECG devices are also available commercially. The devices are broadly categorized as Holter, Tact-3, Event and Physiological monitoring. Most of the existing Holter ECG devices which are used for heart diagnosis are not portable and affordable enough. Also due to less number of trained pathologists and Cardiologists, timely and accurate diagnosis of signal acquired from these devices remains a major challenge.

Ventricular Tachycardia is a disorder caused by irregular heartbeats that includes ventricular tachycardia, ventricular fibrillation, and pointes of Torsade. ECG is used to diagnose this disorder. An ECG (Electro-Cardiogram) signal is a representation of the electrical activity of the heart. Usually 12-lead ECG is used where 10 electrodes are used on the patient's chest. A lead in ECG is a vector potential of the electrical signals across two points in Heart's electro-magnetic field.

Aortic stenosis, coronary heart disease, electrolyte problems, cardiomyopathy, or a heart attack may be the cause for Ventricular Tachycardia disorder. This can be diagnosed by an electro-cardiogram. ECG, showing a rate, greater than 120 bpm and at least three wide QRS complexes, in a row shows the presence of this disorder. If it lasts less than 30 seconds then it can be classified as non-sustained otherwise it can be classified as sustained.

Anatomically, a heart is divided into upper left and right artery and lower left and right ventricle. The electrical impulse in the heart is generated from a small node called Sinoatrial node. Sinoatrial node is also known as natural pacemaker of the heart. Sinoatrial node generates electrical impulses. These impulses are carried through the two arteries to artio-ventricular node. Artio-ventricular node stops the signal for short time duration to complete ventricular depolarization. The electrical signal is then sent through artio-ventricular chamber to the ventricles. The signal is finally sent out of the ventricles to complete the ventricular repolarization and in turn the electrical cycle of the heart which is represented by the ECG signal. The processed discussed above is depicted by figure 1.

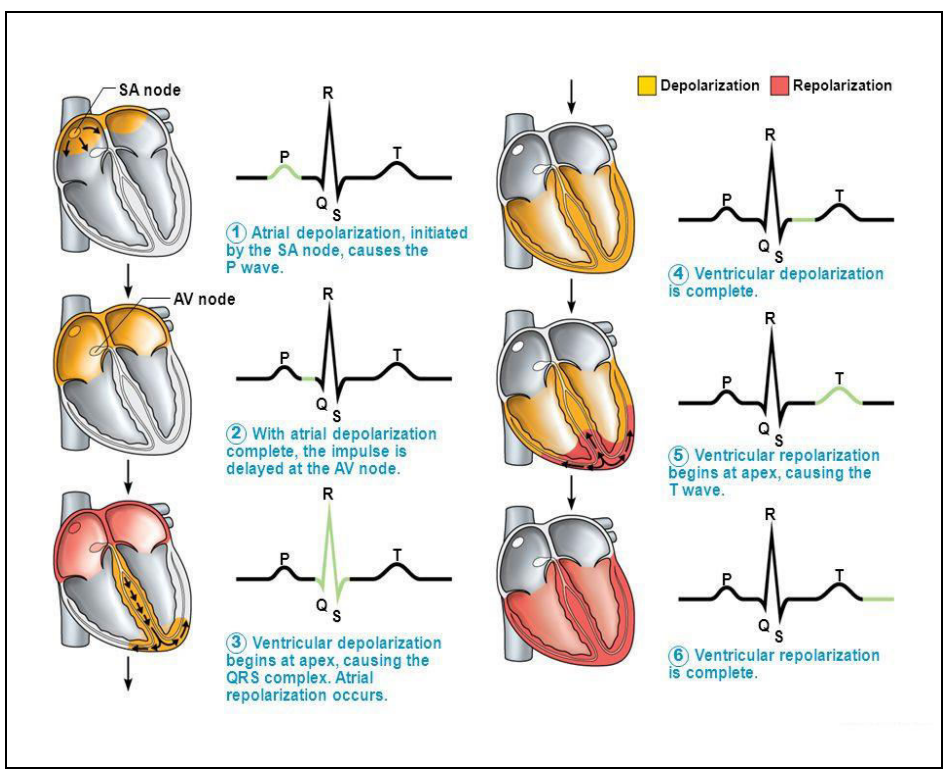

Figure 1. Generation of a Typical ECG Signal

Heart's activities **are** accurately represented by 12 lead ECG. It gives more accurate results in representing true state of the heart. A standard 12 lead ECG of a Ventricular Tachyarrhythmia (also called Ventricular Tachycardia) is shown in figure 2.

Figure 2. A typical 12 Lead ECG of VT

There are different forms of Ventricular Tachyarrhythmia, resulted from different abnormalities. Some of the common VTs are:

- Monomorphic- Monomorphic VT has regular rhythm in it. It is generated from a single focus point, so in each lead it creates uniform but identical QRS in the ventricles except the fusion and capture beats. It has broad QRS of approximately 200 ms.
- Polymorphic VT (PVT) - PVT have multiple QRS waves exists in ventricular focus. These waves are changing in axis, amplitude, and duration. Mostly myocardial ischemia causes PVT. TdP (Torsades de Pointes) and BVT (Bidirectional VT) are special cases of PVT.
- Torsades de Pointes(TdP)- TdP is a specialization of PVT having Polymorphic with QT prolongation property. QT prolongation occurs because of multiple drugs. In this type of PVT, QRS waves “twist” along the isoelectric line. It has very less life span and it terminates by itself.
- Right Ventricular Outflow Tract Tachycardia (RVOT)- The RVOT is the most familiar Tachycardia. These tachycardias have an identical characteristic property in ECG appearance. They have a left bundled branch, block appearance. They are also positive in the lower ECG leads.
- Fascicular Tachycardia- It is common form of IVT(Idiopathic ventricular Tachycardia) of left ventricle. The arrhymia mechanism appears to be macro reentry. It involves calcium dependent slow response fibers. These are part of purkinje network. Some tachycardia has been observed automatic. Mostly it occurs in young patients without structural symptoms of heart disease. It is a reentrance tachycardia.
- Bidirectional VT (BVT)- BVT is a rare ventricular dysrhythmia. Its frontal QRS axis is characterized by a beat to beat change. The QRS axis shifts by 180 degree from left to right with each changing beat.

- Ventricular Flutter(VF)- VF is an arrhythmia more specific type of tachycardia. The ventricles with a heartbeat rate in the range of 250-350 beats/minutes. The ECG shows sinusoidal waveform in this case, without exact definitions of the QRS and T waves.
- Ventricular Fibrillation(V-Fib)- VF is a heart rhythm problem. It occurs when patient have fast heart beats with erratically impulses. Due to this pumping chambers of heart vibrate unnecessarily, instead of pumping blood.

Re-entry of ventricular signal is one of the most common causes for VT. Triggered abnormality of either early or late depolarization may also be responsible for VT. Abnormal impulse generation by ventricular cells is third most common causes of VT.

Though it is difficult to classify different VT cases, even a single lead ECG has good traces of VT. A VT can be commonly detected by:

- It shows very broad bandwidth more than 160ms.
- Deviation on Extreme axis ("NW-axis") - QRS is +ve in a VR and –ve in I + a VF.
- Absence of typical RBBB (Right Bundle Branch Block) or LBBB (Left Bundle Branch Block) morphology.
- Atrio-ventricular (AV) dissociation (P and QRS complex waves at different rates).
- Positive or negative concordance throughout the chest leads, i.e. R shows all positive in leads V1-6 or QS shows entirely negative complexes, with no RS complexes.
- Fusion beats :Fusion beats occur when a ventricular and sinus beat overlap each other. It produces a hybrid complex of intermediate morphology.
- Brugada's sign : The distance from, QRS complex to the nadir of the S-wave is more than 100ms.
- Josephson's sign : Achieve near the nadir of the S-wave.

Though conventionally 12 lead signals are being preferred by doctors for VT diagnosis, it is possible to detect the traces of VT by analysis of Lead II (which is the major electrical axis of the heart) signal and looking for traces.

Single lead ECGs are easy to carry and operate. Therefore we present an easy and affordable option for heart diagnosis. As single lead ECGs does not give complete view of the heart, powerful analytics solution should be adopted to simulate the signal for the diagnosis rules. This is precisely the contribution of the proposed work. The research work intends a custom device to capture heart's electrical signal in Lead II configuration and analyze it through the aforementioned rules for detecting VT.

RTEPVA is an end to end system which has an affordable hardware upfront to acquire such signals and classify the signals using cloud platform. As connectivity remains a major challenge in rural India. RTEPVA offers algorithm which can efficiently tell if the person has any form of CVD (cardio vascular disease) or not and in particular ventricular Tachyarrhythmia or not, detecting such pathological abnormalities. Ventricular abnormalities can happen due to several reasons, for example shortening of the ventricular valves due to cholesterol deposition, re-entry of the current to the ventricular blocks due to improper functioning of the Parkinson's muscle and so on. Ventricular cycle of the ECG is determined by the ST segment and TP segment of an ECG signal.

Not only VT, but other cardio vascular problems too needs timely and continues monitoring. A whole new approach is needed to view and solve the clinical challenges of today. The basic needs are highlighted as follows:

Tracking parameters which matter & implementing meaningful Interventions

- Collecting human health data till now possible only with costly and cumbersome instruments. This needs to change and new instruments must be introduced that are easy to use, connected and that provides a means of remotely observing the patient by the clinician.

- Using minimum instrumentation and time thus enabling user to perform multiple recordings to track the changes with adverse or desirable interventions. Today medical tests are costly and therefore often user hesitates to go for periodic tests. This problem needs to be solved with devices and methods that enable multiple test takings.
- Simultaneous assessment of three major parameters of health (disease, origin and progression)- Autonomic Nervous System, Cardio-Respiratory Fitness & Endothelial Dysfunction. Modern ECG only reacts with the electrical activity of the heart and is unable to detect problems other than cardiomyopathy. However, proper prognosis requires other traits like autonomic neuropathy.
- Easy to understand analysis and interpretation. Plotting results against timeline (showing changes over short, medium and long term duration).
- Long term tracking of these dynamic parameters helps doctor to assess the impact of pharmacological & lifestyle interventions and adjust the treatment .
- Autonomic neuropathy detection.
- Psycho-physiological stress assessment.
- Arterial health(Endothelial Dysfunction) assessment.
- Psycho-physical readiness(fatigue) assessment for undertaking exercise.
- Biological age assessment (against the chronological age of an individual).
- Incorporation of all these parameters in a single 'Lyfas Health Score' – representing the impact of autonomic nervous system, cardio-respiratory fitness, endothelial function, body composition and stress on human health.

Even though the proposed work doesn't provide any framework for Arterial health assessment and endothelium dysfunction, but providing an easy, affordable and yet accurate system for continues and efficient cardio health check, we enable better diagnosis and monitoring solution. Further the proposed system can easily be used to build more robust mechanism for better psycho-physiological analysis along with current cardio-electrophysiology.

Tracking parameters conveniently & economically Immediate Feedback

Immediate feedback is another essential aspect of efficient detection of the cardio vascular disease. It is important to be remembered here that the cardio events are not sudden and are developed over a period.

- Any healthcare provider (physician, diabetologist, cardiologist, preventive medicine specialist, nutritionist, fitness trainer & psychologist) should be able to conduct a five minute assessment with proposed Lyfas app and gather unique and actionable information. In the absence of a trained physician the system must enable gathering and processing the data locally and providing users with the insight about whether they may require any medical intervention or not and to what degree of intervention is required.
- The app must be extremely easy to use. Even OPD non-technical staff can implement the Lyfas assessment. There is no recurring cost involved.
- The ease of access and the collaborative framework among different group and specialty of the care providers must be seamless to enable a better care structure.
- A doctor can get all these parameters without patient coming to the clinic/hospital on a regular basis thus allowing him to fine tune the interventions continuously & earn revenue.
- Patient can save on money and time as there is no need to go to the clinic/hospital but can send important health information to the doctor. Easy monitoring can show the changes in parameters after adverse or beneficial lifestyle interventions. This real time feedback helps in modulating health related behaviour.

In summary we can say that by building a simple IoT and edge analytics driven system that comprises of low cost hardware, high end data analysis and offering a great degree of connectivity to the system we can offer a better cardio care. Further by incorporating suitable detection mechanism we can extend the framework efficiently for detecting, monitoring and managing Ventricular Tachyarrhythmia.

2. Related Work

Y.H. Noh, et.al [1] worked on a convenience healthcare monitoring system and a real time arrhythmia or abnormal ECG detection algorithm is developed. M Hadjem, O Salem [2] proposed a new Cardio Vascular Disease detection system. Authors used the Wireless Body Area Network(WBAN) technology. In this system ECG is processed the captured using filtering. They used Un-decimated Wavelet Transform (UWT) techniques to remove noises and extract the required nine parameters, which are used in diagnosis. S Gradl, et.al. [3] discussed about an Android application for real time ECG monitoring and detect automated arrhythmia by analyzing patterns of ECG parameters. M Romano et. al. [4], explained the heart rate variability, They worked on a tool to study the auto cardiac control and better functioning of the autonomic nervous system. M Romano, et.al._[5], depicts that parameters integration, derived from the non-linear techniques, like symbolic dynamic analysis, and traditional ones derived from frequency domain analysis, could improve the complexity of cardiac regulation systems. A new ECG de-noising method was proposed by Binwei Weng, et.al. [6], It was based on the Empirical Mode Decomposition (EMD). The EMD based method was able to remove high frequency noise with minimum signal distortion.

Prof. Dr. S.M.Rajbhoj, et.al. [7], studied the stress monitoring of humans wearable sensors. They also discussed the issues to be noticed to tackle the challenges. Dedi Kurniadi et.al[8], presents signal processing technique and data analysis to suppress any noise in the recorded signal and classified it into two groups which are normal heart sounds and pathological heart sounds that contain Ventricular Septal Defect (VSD) inside. A.Mjahad, [9], worked on fiction approach to signal analysis. The main objective was to safely select the proper therapy for Ventricular Fibrillation(VF) that is required to identify it correctly from Ventricular Tachycardia (VT) and other rhythms. According to them the required therapy would not be the same in all cases, an erroneous detection might lead to serious injuries to the patients or even cause Ventricular Fibrillation (VF). In the paper “Support vector machine based expert system for reliable heartbeat recognition”, Osowski S, et.al.[10] worked on reliable heartbeat recognition system. They use SVM in classification mode to recognize the heartbeat in the system. They proved that this expert system gives average performance.

Kohler B.U et.al. [11], provides a review of advancement in the QRS detection using Artificial intelligence. Gokhale P.S[12], experimented the de-noising of the real noisy ECG signals with the help of wavelet transform. PLI noise is added to various ECG signals. They used MIT/BIH arrhythmia database to accomplish the task. Pahlm O et.al. [13], explained the one-channel QRS detectors. Authors explained the current detection scheme with its structure, evaluation of performance , features of QRS detectors, and the problem of multichannel detection. Demiao Ou et.al.[14], developed an electronic stethoscope for heart diseases. It is based on micro electro mechanical system microphone. This paper describes the design of this electronic stethoscope with its circuit that amplifies sound generated from heart beat. They also explained the background noise remove with a band-pass filter. Liu, Huang, and Weng [15], proposed a CKLM (cascaded kernel learning machine), EMG classifier. They used it to achieve the high accuracy recognition of EMG. First, G.O.Addio, el.al. [16]worked on Indices of Symbolic Dynamics in heart patients, Voss A, et.al. [17], studied and introduced the new methods of non-linear dynamics. They compare them with traditional methods of HRV (heart rate variability) and HRECG (high resolution ECG) analysis. That analysis was helpful to improve the reliability of high risk stratification.

Guzzetti S, el.al.[18] explained the variability of heart rate using symbolic dynamics. For this they worked on Cardiac Autonomic Modulation. In the paper "Cardiovascular and Cardio respiratory Coupling Analyses: A Review ", S. Schulz, et, al.[19], reviewed coupling analysis of cardiovascular and cardio respiratory. They explained the review work on controlling the heart rate from rapidly reacting systems. They also covered parasympathetic and sympathetic systems. Jose M. Sanchez et.al. [20], described the Optimal Ablation Techniques for Ventricular Tachycardia Management. Wilbur J et.al. [21] explained the diagnosis and management of heart failure in the outpatient setting. N. Paquette [22] et.al. worked on abnormalities in preterm neonates for ventricular shape and relative position.

3. Methodology

As we can see that even with advancement of technology, mobile ECG devices still relies on the analysis by doctors. This is one of the major drawbacks in the context of India where number of doctors are obviously very less. The proposed solution brings ML and AI into the context and offers a signal diagnosis through AI. But as there is a lack of internet connectivity in rural India, it offers a local cloud running in powerful PC like Gigabyte. This local cloud can be synced with a core cloud when sufficient connectivity is available. The present system and proposed system is as shown in Figure1.

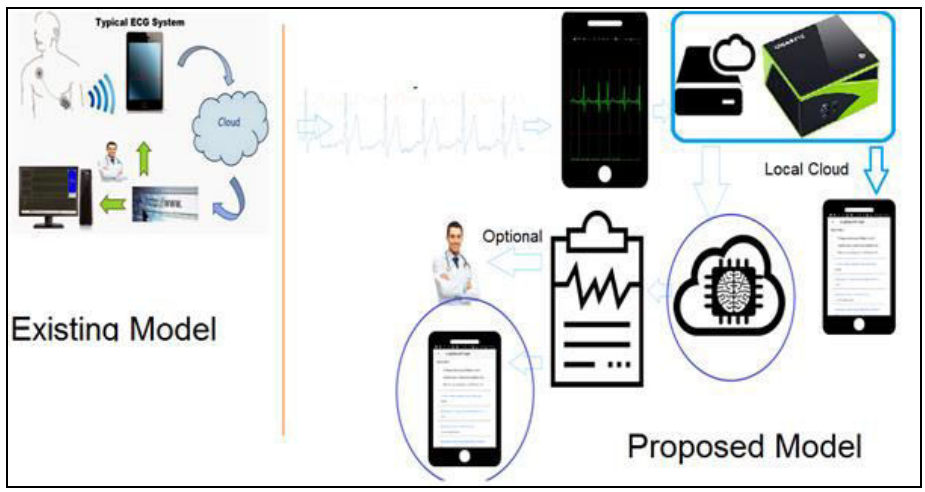

Figure 1. Present System v/s Proposed System

The user has to access the RTEPVA hardware device and data is transmitted via Bluetooth to the Mobile. The ECG signal, Pulse Signal is sent to the Local Server running ML and AI and Store Locally. Then the signals are Sync with Cloud. The Local Server running ML and AI, classify the signal normal or abnormal. If abnormal then it has to tell the type of abnormality.

The work is specifically focus on detection of Ventricular Tachyarrhythmia. The overall system architecture is presented in figure 2.

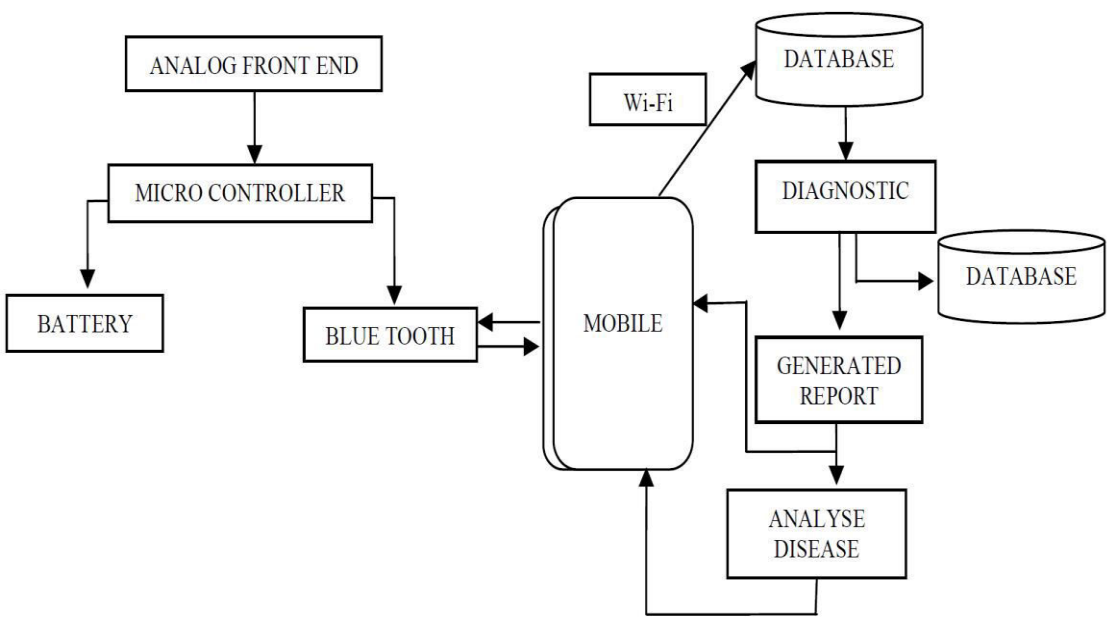

Figure 2. Block Diagram of the architecture

The proposed system leverages open source hardware and Arduino for writing firmware. This allows the user to acquire Single Lead ECG. However, one of the question that 12 Lead ECG is the standard norm, how can a single lead ECG provide comprehensive analysis of the heart? The best thing about our Single Lead ECG acquisition is that all the 12 leads can be acquired based on the three electrodes (one lead at a time). For non-axial leads, ground and -ve electrodes can be grounded together and signal can be measured with respect to the positive lead. Figure 3 Shows the Lead 1 and Lead 2 configuration.

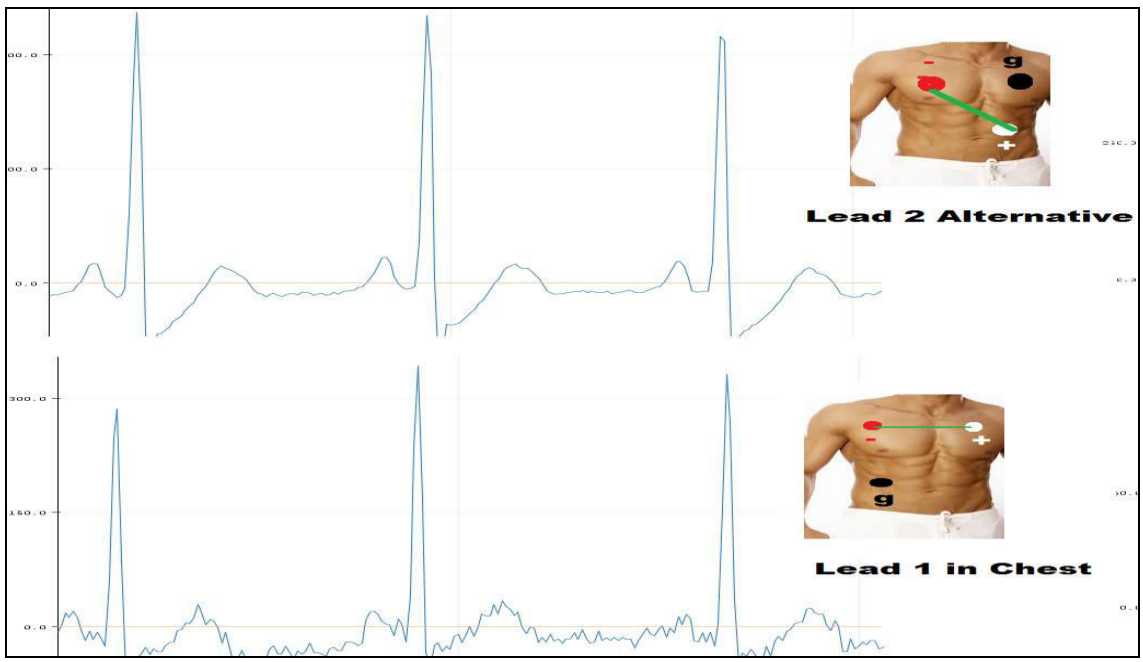

Figure 3. Lead I and Lead II Data Acquisition by Proposed Device

The proposed device also supports Lead I data acquisition through finger or wrist configuration as shown in figure 4.

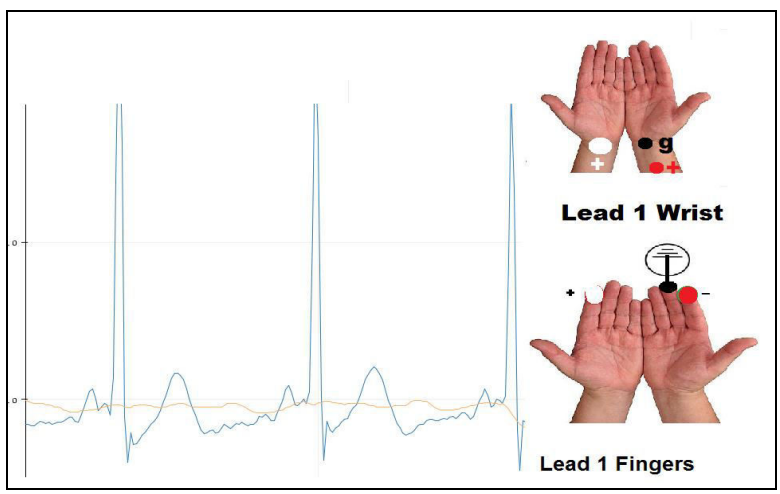

Figure 4. Lead I wrist and finger configuration.

It is also possible to acquire chest leads from the proposed device as shown in the figure 5 and 6.

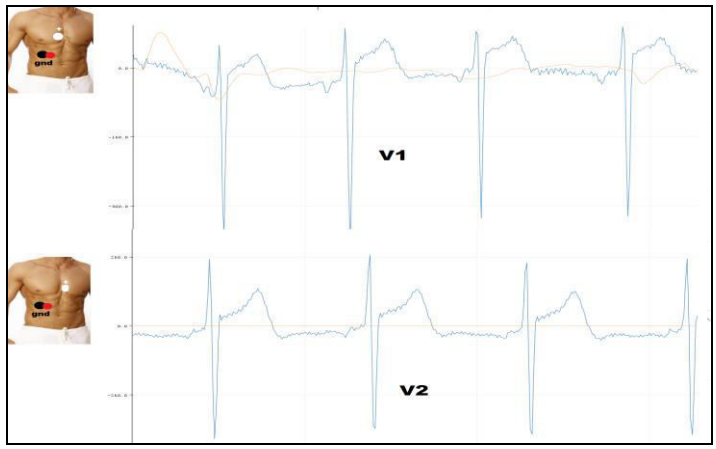

Figure 5. Lead V1 and V2 Acquisition from the proposed device.

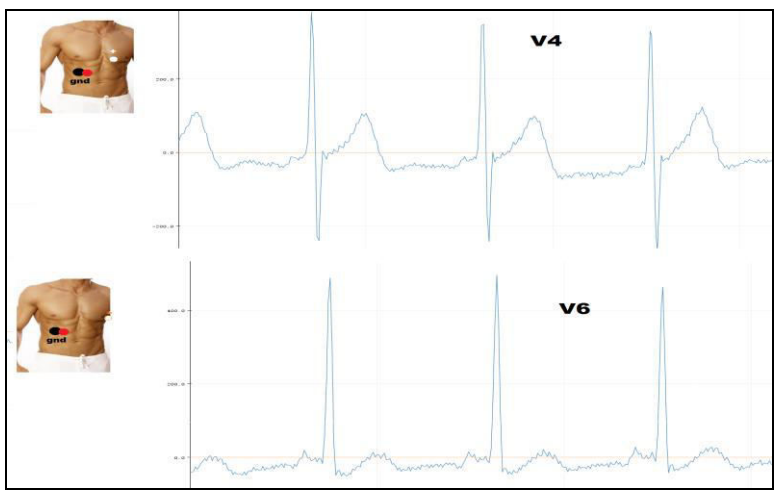

Figure 6. Acquisition of V4 and V6 through Proposed device.

Thus, this low budget device not only is capable of acquiring all 12 lead ECG, but at the same time it is mobile and affordable. The proposed work focuses on acquiring LEAD II configuration signal from the ECG and classifies the signal with a machine learning based classifier. In case the decision is not conclusive user can go for data acquisition of the chest leads.

3.1. Mathematical Model of Machine Learning

Phi(x0wk0+x1wk1...xn*wkn,Theta_k)->NA/A1/A2...An Where: x0,x1..xn are input parameters as specified above(RR, PTT, ST etc.) Wk0,Wk1..Wkn are the weights of the Neurons Phi is the activation function NA- No Abnormality, A1...An- Different abnormalities and Theta_k is the threshold.X0---Xn are called input NA, A1--An are called output layers Phi is the hidden layer.

For training the network, a vector V is given as input which is specified as V={ {x0 .. xn}1,{x0 .. xn}2...,{x0, xn}D} where notations 1,2...D of the set specifies the Signals stored in database (locally).

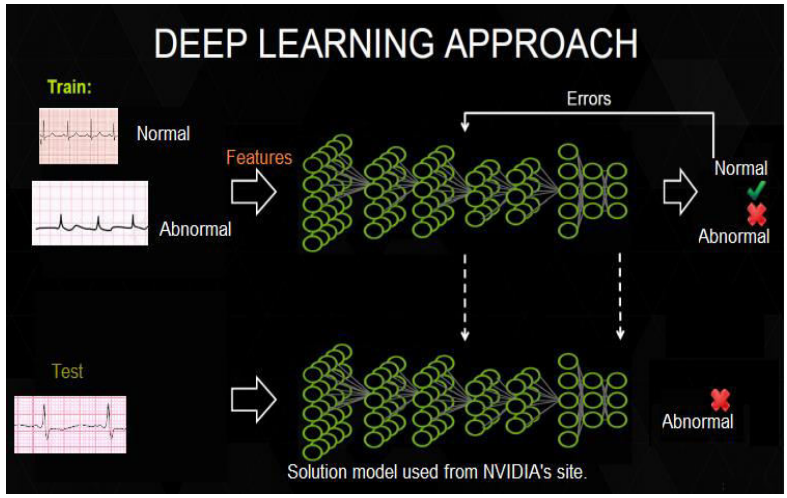

Figure 7. Deep Learning Neural Network for ECG classification

This database is updated and synced with cloud with enough Wi-Fi/Internet connectivity is available. A high level design is as presented in Figure 7. The overall steps in the proposed solution can be presented below:

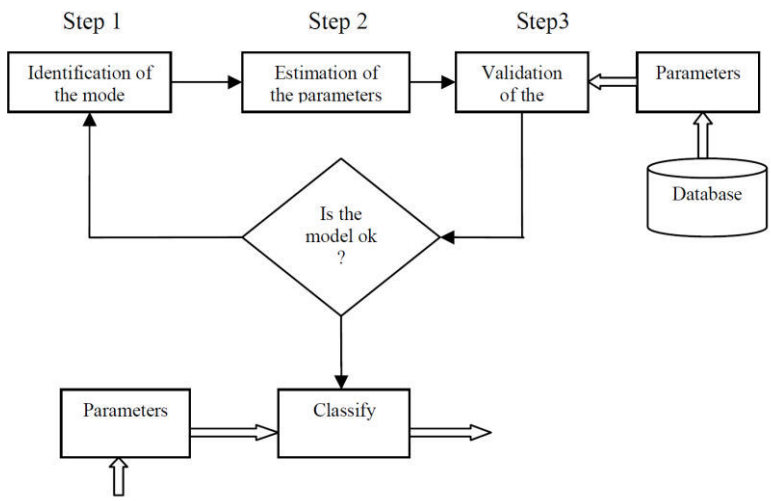

Figure 8. Proposed solution steps

It can be seen from above diagram that every local/Fog Server has set of above defined parameters. These parameters from existing and already classified records are downloaded from cloud storage when a data connection is available. MLP Neural Network (The AI Model) is updated. The process aims for an error rate of 1e-6 and maximum epochs of 4000. Once the model reaches steady state, it is saved and used for classifying new signal. The new signal is marked temporary file for a validation with doctor. Once the result is validated, it is also accommodated in the training dataset. It needs to be noticed that as the optimization of neural network model depends on the training data, at the initial phase, a doctor's manual classification of the signal is essential. However, as the model keeps learning, slowly the accuracy of classification improves and manual evaluation by a doctor starts reducing. The initial model is trained with PhysioNet's Ventricular Tachycardia and Normal Sinus Rhythm datasets.

4. Results

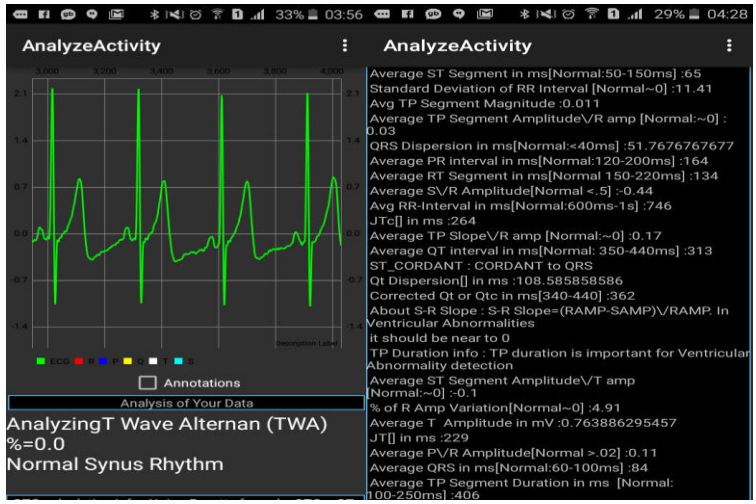

Figure 9. Mobile Screenshot of ECG Analysis

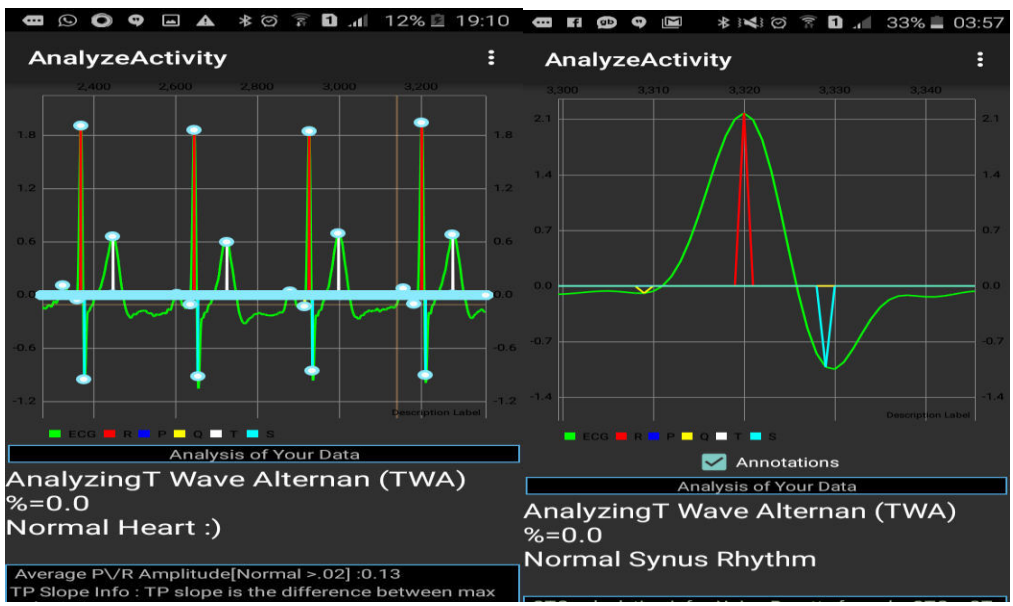

Figure 10. Detection and Annotation of Peaks

10-30 seconds of data is captured in mobile and is analyzed through the proposed system. Figure 9 and 10 shows the analysis result and detailed peak detection respectively.

Figure 11 shows the peak annotation of the analysis of VT and Normal signals. From the figure the morphological difference in Lead II of both the types of ECG can be seen. The average values of the parameters for both normal as well as VT signals are shown in Table 1. It can be clearly seen from the tables that many of the parameters for the two are linearly separable. For instance the R peak standard deviation is extremely high for the VT.

Table 1. Average Parameter Values of Normal and VT signals

Parameters	Normal Sinus Rhythm	Ventricular Tachyarrhythmia
Average RR-Interval [Normal:600ms-1s]	647	800
Standard Deviation of RR Interval[Normal~0]	1.68	165.37
% of R Amp Variation[Normal~0]	7.99	17.6
Average Heart Beat Rate[Normal:60-100 bpm]	92	74
Average QRS [Normal:60-100ms]	80	98.5
Average ST Segment[Normal:50-150ms]	88	2
Average T Amplitude(ms)	-0.030928286	0.0015002996059
Average S/R Amplitude[Normal <.5]	-0.5	0.82
Average S-R Slope [Normal ~1]	-1.5	0.17
Average RT Segment [Normal 150-220ms]	145	176

Parameters	Normal Sinus Rhythm	Ventricular Tachyarrhythmia
Average P/R Amplitude[Normal >.02]	0.1	2.01
Average QT interval [Normal: 350-440ms]	292	327
Average PR interval [Normal:120-200ms]	152	128
Average TP Segment Amplitude/R amp [Normal:~0]	0.01	0.76
Average TP Slope/R amp [Normal:~0]	0.02	1.04
Average TP Segment Duration [Normal:100-250ms]	248	401
Average ST Segment Amplitude/T amp [Normal:~0]	1.23	-5.95
QRS Dispersion[Normal:< 40ms]	23.4375	78.0
Qt Dispersion[]	125.0	196.0
Corrected Qt or Qtc [340-440]	362	
Uuing Bazetts formula: QTC = QT / sqrt(RR) JT[](ms)	212	228.5
JTc[](ms)	263	255
T Wave Alter nan (TWA) %	0.0	0.0

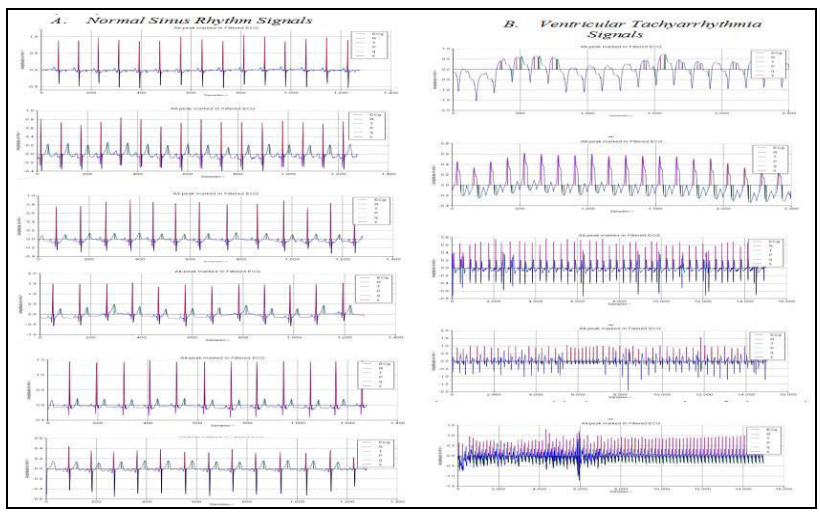

Figure 11. Analysis of Normal and VT Signals

5. Conclusion

India has a very low doctor/patient ratio than standard (as specified by WHO). With the increased stress and change in urban as well as rural lifestyle and food habits the chances of heart related diseases are being increasing. At the same time the average age of the heart abnormalities and heart failure is reducing in India. Hence we need more AI assisted solutions to tackle this problem. Through this work we have proposed a cost effective way of extracting ECG signals from human body and analyses them through cloud based machine learning techniques. This work was evaluated in two folds: firstly the live signal from the subjects were acquired, processed and checked through Lyfas device, secondly the algorithm and classification performance was evaluated with standard PhysioNet database. The access to real Ventricular Tachycardia patients were not high for us, we evaluated the performance using standard dataset. Results shows that the system is extremely efficient in detecting Ventricular Tachyarrhythmia and many related cardio vascular diseases. The system can improve further by incorporating other Models like support vector machine and self-organizing map with current machine learning context.

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How to Cite

Kalaskar, R., Harsoor, D. B., & Das, R. (2018). Forecasting Ventricular Deviation in Monitoring of Live ECG Signal. *International Journal of Machine Learning and Networked Collaborative Engineering*, *2*(03),pp. 95-109.
https://doi.org/10.30991/IJMLNCE.2018v02i03.002

IJMLNCE JOURNAL

International Journal of Machine Learning and Networked Collaborative Engineering

Journal Homepage: http://www.mlnce.net/home/index.html

DOI : https://doi.org/10.30991/IJMLNCE.2018v02i03.003

Cow Behavior Monitoring Using a Multidimensional Acceleration Sensor and Multiclass SVM

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Abstract

The daily behavior of dairy cows reflects the health status and well being. An automated monitoring system is needed for suitable management. It helps farmers to have a comprehensive view of the cattle healthy and manage large of cows. Acceleration sensors can be found in various kinds of applications. In this paper, we detect the cow's activities by using a multidimensional acceleration sensor and multiclass support vector machine (SVM). The acceleration sensor is attached to the cow's neck-collar in order to sense the movements in X, Y, and Z axes. The data is brought to a microprocessor for pre-processing, and join in a wireless sensor network (WSN) through a Zigbee module. After that, the data are transferred to the server. At the server, a suitable SVM algorithm is chosen and applied to classify four main behaviors: standing, lying, feeding and walking. A well know kernels, Radius Basic Function (RBF), is chosen. After that, a cross validation (k-fold) is used to measure the error and select the best fit model. The sensor is used to acquire experimental data from Vietnam Yellow cows in the cattle farm. The promising results with the average sensitivity of 87.51% and the average precision of 90.24% confirm the reliability of our solution. The classification results can be automatically uploaded to the cloud internet and the farmer can easily access to check the status of his cows.

Keywords

Classification,

SVM,

Monitoring,

Cow,

Acceleration,

Sensor,

3-DoF

1. Introduction

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Viet Nam is the Agriculture country and has a tropical monsoon climate so the cattle industry is very developed especially is cow farming. The cattle industry in our country has a great potential for development as the demand for meat and milk of people is increasing, natural conditions, customs, habits have advantages for development cow farming. Cattle are raised in all regions of our country. Cattle raise for meat and traction in our country have developed for a long time. Dairy farming has appeared in the 20th century, but by the beginning of the 21st century, it has become an important economic sector [2]. At present, the trend of using beef and cow products is increasing in our country so it motivates cow farming. In the limit of economic integration, large companies have continuously expanded their activities in beef and milk dairy farming, such as: TH True Milk, Vinamilk etc. Beside of the extend scale breed, they opposite with some difficulties as climate, economic etc. To develop the cattle industry, become a major livestock industry, we should apply the modern technique, some of the difficulties have been solved and the management of cattle gets much easier and easier [3]. In addition, they save the labor and the price of the product is also reduced. Some companies apply the technique to manage the cattle, for example they set up the camera on the farm to observe a herd of cattle through display. But it has some disadvantage as they only view in daytime in the night if they turn on light they do not observe the cattle.

An automated monitoring system is needed for suitable management [1]. There are many different types of sensors and methods which are used to classify the animal behavior. In [14], the authors applied a K-means classifier to classify the data of location of cows. Linear classification methods and decision tree were applied for the sheep behavior by using the pitch and roll tilt sensor data [15]. Fuzzy logic and neural network classifiers are also applied to classify the behavior of sheep [16]. This paper constructs an automatic system for classification behavior of animals typically on the cow. We developed the system based on the touch 3-axis accelerometer and 3-axis angle sensor (MPU-6050 sensor) help determine status more accurately. This system is designed to set on the collar of the cow and the data received from the sensor will process and classify behavior by using multi-support vector machine as: standing, feeding, lying, and walking. The work found that support vector machine classifiers can be classified with the highest classification success rate [17].

In the next section, we describe the working principles of the proposed system in section 2. In section 3, 4 we focus to cow's behavior classification and the data acquisition. Our experimental results are presented in section 5. Finally, the conclusion is given in section 6.

2. Working Principles

The system includes three main components: IMU6050 sensor [4], PIC18F45K20 [5], and Zigbee module (see Figure 1). Due to the strong growth of MEMS (Microelectromechanical systems) technology, the MEMS based sensors can be found in various kinds of applications [11] [13]. IMU6050 sensor is attached to the cow's neck-collar in order to sense the movements in X, Y, and Z axes. The sensor can be also attached to the cow's leg in some previous works. It can be seen that both positions are sensitive to the cow's movements. The working range of the acceleration sensor can be chosen among ± 2, 4, 8, or 16 g (1g =9.8 m/s2). In this paper, we choose the range of ± 4 g which is suitable for cows' movements. The acceleration in each axis is computed as

$$A_i = \frac{raw\_data_i}{scaling\_factor} \tag{1}$$

where i= X, Y, Z; and the scaling factor is 8192 LSB/g.

The data is brought to a microprocessor for pre-processing. In this work, we use the microcontroller (MCU) PIC 18F45K20 from Microchip INC [6] [7]. It is a strong processing unit to build any electronics projects. It is small, thin and high performance RISC CPU. It incorporates a range of features that can significantly reduce power consumption during operation as: alternate run modes, multiple idle modes, on-the-fly mode switching, and low consumption in key modules. Furthermore, it has the self-programmability as it can write to their own program memory spaces under internal software control, an Analog-to-Digital Converter (ADC) module with 10-bit resolution and 13 external channels.

After that, the electronic board joins in a wireless sensor network (WSN) through a Zigbee module. We use Zigbee module DRF1605 which is simple and stable for using, and it offers a large distance for transmitting and receiving data. This module can be also configured as a coordinator or a router. Other

characteristics of this module can be listed: operation voltage of DC 3.7V; the data rate of 9600bps, 19200bps, 38400bps; the working frequency of 2.4GHz, and the transmission distance of 400m. Consequently, the data are transferred to the server. At the server, a suitable SVM algorithm is chosen and applied to classify four main behaviors: standing, lying, feeding and walking. The sensor measure movement of a neck's cow in X, Y, Z axes, the MCU will receive the data, then process and send it to the server through a Zigbee module. The power source for these components is from a 3.7V-4000mAh rechargeable battery. The lifetime of the device is about one week. The photo of a real device is shown in Figure 2.

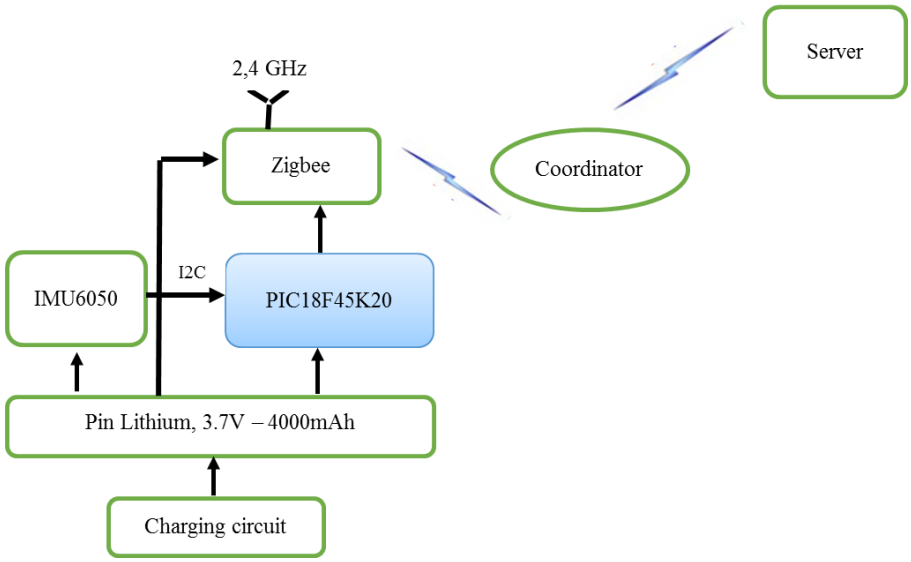

Figure 1. Block diagram of our proposed system

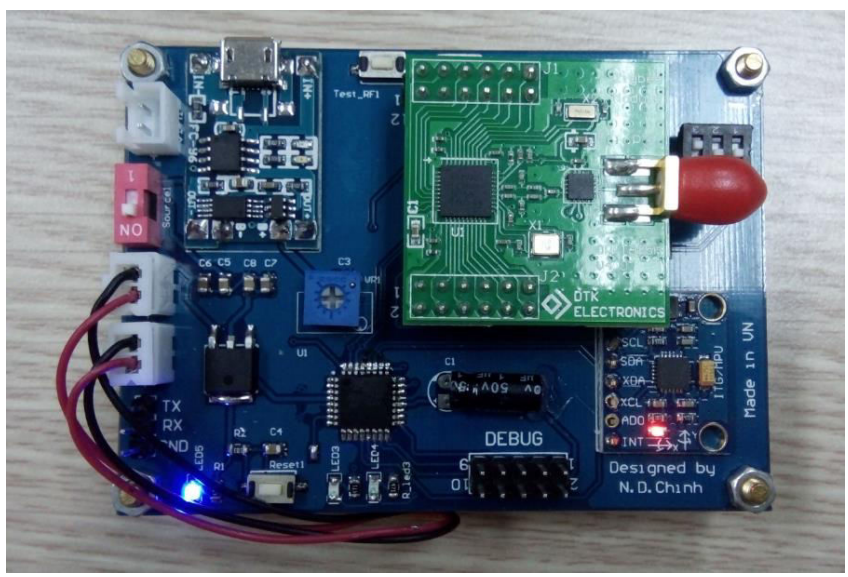

Figure 2. The photo of real device

3. Cow's Behavious Classification

The classification problem divides a data object to give classes owning to the model which is constructed based on a training set [9],[19]. The process of data classification includes two steps: 1) construct the model and 2) use the model for classifying the data.

Step1: The model will be constructed based on the analysis of pre_label data objects which include standing, lying, feeding, and walking. This data set has also known as the training data set. We define the class labels of training data sets, thus, this method has also known as supervised learning.

Step2: Classify new or unclassified objects and evaluate the accuracy of the model.

The classification can be made by a simple algorithm with a low computation: decision tree. However, it cannot offer good performance compared to other methods. In this work, the multi-class support vector machines (SVM) are used for data classification. The reason is that we have four different kinds of behavior need to classify: standing, lying, feeding and walking. There are four typical types of support vector machines that support the multi-class problems [10]: 1) One-against-all support vector machines; 2) Pair wise support vector machines, 3) Error-correcting output code (ECOC) support vector machines; and 4) All-at-once support vector machines. In this paper, we choose one-against-all support vector machine for the classification. To solve this problem they convert *n*-class into *n(n-1)/2* two-class problems each of them trains data from two classes. For the training data from the ith and jth classed, we solve the following two-class classification problem. We consider data points of the form: $x=\{x_i, i=1,\ldots,N\}$ R^m and x_i belong to one in four classes. If these data are linearly separable, we can determine the decision function:

$$D(x)=w^T x^i + b, \tag{2}$$

where *w* is an *m*-dimensional vector and *b* is a bias term.

$$\min_{w_{ij},b_{ij},\xi_{ij}} \quad \frac{1}{2}(w_{ij})^T w_{ij} + C\sum_t \xi_{ij} \qquad \xi_{ij}^t \geq 0 \tag{3}$$

where ξ_i slack variable and C is is the margin parameter that determines the trade-off between the maximization of the margin and the minimization of the classification error.

$$\begin{aligned} (w_{ij})^T \phi(x_t) + b_{ij} &\geq 1 - \xi_{ij}^t \qquad \text{if } x_t \text{ in the i}^{\text{th}} \text{ class} \\ (w_{ij})^T \phi(x_t) + b_{ij} &\leq -1 - \xi_{ij}^t \qquad \text{if } x_t \text{ in the j}^{\text{th}} \text{ class} \end{aligned} \tag{4}$$

where $\phi(x)$ is the function which is used for mapping input vector *x* from m-dimensional to l-dimensional feature space. We classify *x* into the class: $\arg \max_{t=1,\ldots,n} D_t(x)$ with $D_t(x) = (w_{ij})^T \phi(x_t) + b_{ij}$. After constructing *n(n-1)/2* classifiers, we used a voting strategy: each binary classification is considered to be a voting where votes can be cast for all data point *x*, finally a point is designated to be in a class with the maximum number of votes.

SVM used training data to build a model which is later used to classify the test data. The most important is that we can choose a suitable kernel and its parameters for the model. There are four common kernels, and we select Radius Basic Function (RBF). Cross validation is used to measure the generalization error and selecting the best fit one. There are also four types of cross-validation: k-fold, leave one out, boot trap and hold out. In this study, we use the k-fold to validation and choose the model selection. For k-fold cross-validation, we divide the data initial into *k* subset have approximately S_1, S_2,... S_k [10]. The learning process and the test are run *k* times. At the i^{th} time, S_i is the test data set, the remaining are the training data set. The meaning is S_1 is test data and S_2..., S_k are the training data; continue with S_2, S_3.... are the test data. From this we find the best cross-validation accuracy and the pairs (C, γ) for the final model. In this method growing sequence of C and γ is a practical method to identify good parameters. Consequently, we use the C and γ to train my data. LIBSVM provides a simple tool to check a grid of parameter [8][12].

4. Data Acquisition

Acceleration data in X, Y, and Z axes were recorded by using MPU-6050 sensors in the period of time with from Viet Nam Yellow. Figure 3 shows acceleration samples in four activities of cows. The sampling

frequency is 50 Hz. It is brought to an average filter in order to smooth the acceleration signals. Some abnormal samples are removed by setting a threshold. After collecting the data, we pre-process the noise and abnormal samples. Then, we stick the label for each status using recorded videos (see Figure 4). When observe the cow we can see that if the cow is lying or standing it less movement so the acceleration is less change and when it is feeding the collar move up and down so the acceleration change significantly. When they are walking the acceleration also changes dramatically because their neck also move as turns left or right. But in lying status, three axis accelerometer change quite strongly. We can see that in figure about lying above, it is quite similar to standing status. Why so? When we observed and received about lying status, we realized that when cow were lying their knelt down and the head was still up. So the head shaking and it affects to the sensor value. There are four main statuses of cows that we concern:

Standing: the cow stands without swinging its head.

Lying: the cow lies without chewing.

Feeding: the cow moves head up and down and chew grass.

Walking: the cow walks straight and the head shaking.

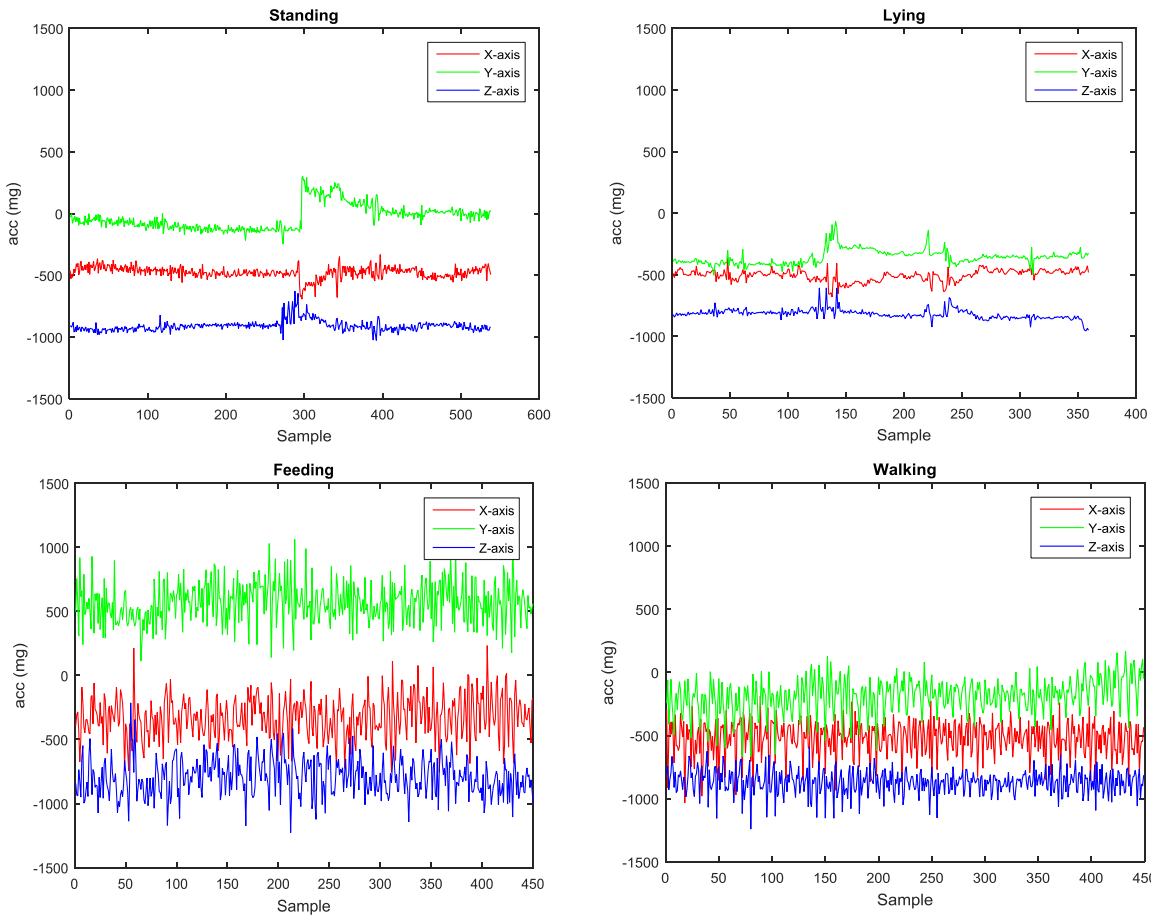

Figure 3. Acceleration samples in four activities of cows

Figure 4. Recording for building the labelled data objects. The videos are synchronized with the acceleration data in order stick labels to the acquired data.

5. Experimental Results

The acceleration values in X, Y, and Z axes are used for the inputs of SVM classifier. After recording the data and sticking the label (using video surveillance) we divide into two datasets: 50% as the training set, and 50% as a test set. The rule of selecting is random. Firstly, in the training data set we conducted the model. By using grid-search with the cross validation method (in LIBSVM) to compute the best CV accuracy with training data set and it equal 93.83% and then shows the optimization of C and γ (in this work C=8 and $\gamma = 2^{-15}$). We use these values of C and γ to train the whole the training data set to create the optimal classifier. Finally, we used it for classification the data set to evaluate the SVM model. Because it is a multi-class problem, we need a confusion matrix where the elements at the main diagonal show correct classifications and all other elements show incorrect classifications. Using this matrix, we can directly see which class is confused with which other class. For example, we have a confusion matrix for standing behavior as shown in Table 1.

Table 1: Confusion matrix for standing behavior

		Observed behavior	
		Standing	Non-standing (Lying/Feeding/Walking)
Predicted behavior pattern	Standing	TP (True positive)	FP (False positive,)
	Non-standing (Lying/Feeding/Walking)	FN (False Negatives)	TN (True Negatives)

We can calculate the sensitivity and precision of the classification using the following formulas:

$$\text{Sensitivity} \quad Sen = \frac{TP}{TP + FN} \tag{5}$$

$$\text{Precision:} \quad Pre = \frac{TP}{TP + FP} \tag{6}$$

Result of confusion matrix is shown in Table 2. We can see the occurred misclassification of each behavior as behavior within each column. Standing and feeding were classified with high accuracy. However, there are some misclassifications, for example the lying status was misclassified as standing status

(27%); walking was misclassified (20%) as standing.; standing was misclassified as walking (8.5%); the remaining was negligible.

Table 2: Results of confusion matrix

		Observed behavior				**Total**
		Standing	**Lying**	**Feeding**	**Walking**	
Predicted behavior pattern	Standing	**297**	0	0	20	317
	Lying	0	**137**	0	37	174
	Feeding	10	0	**341**	4	355
	Walking	52	2	2	**248**	304

The boldface text is the number of correctly classified samples for each behavior. We compare the reality observation and the classification to evaluate the performance. The classification performance is shown in Table 3. Average sensitivity and precision is computed from four behaviors' ones. Sensitivity of lying is not good as compared to the others. One of the reasons is that the number of observed events in lying is smallest among these behaviors. The highest sensitivity is 96.06% and the highest precision is 99.42% at feeding. It can be seen that, in the classification using SVM, one behavior categories may be confused with one or two other behaviors (e.g. lying and walking). The performance was good for feeding and lying, but the lower precisions are found in standing and walking. It means that these behavior patterns are easily confused with the others. On the other hand, the sensitivities were generally high. It means that not many negative cases were falsely classified as positive. With the similarities between certain behaviors bring to misclassification so we need to collect more data to improve the accuracy and sensitivity.

Table 3: Performance of classification using LIBSVM

Status	**Sensitivity (%)**	**Precision (%)**
Standing	93.69	82.73
Lying	78.74	98.56
Feeding	96.06	99.42
Walking	81.57	80.25
Average	87.51	90.24

6. Conclusions

This paper was successful to conduct the system by acquiring the three-dimensional accelerations from the neck's cows, pre-processing and classification of four behaviors using SVM. Four main behaviors of the cows: standing, lying, feeding and walking are detected successfully. Acceleration sensor is used to acquire experimental data from Vietnam Yellow cows in the cattle farm. The experiment results offer the average sensitivity of 87.51%, and the average precision of 90.24%, which can confirm the reliability of our system. The classification results can be automatically uploaded to the cloud internet and the farmer can easily access to check the status of his cows. In the future work, more data will be collected to provide more accurate analysis of each status. The pedometer will be attached to the leg's cow to detect precisely the cycle of estrus in cow by counting the number of steps per day. We will combine two devices to classify more behaviors and obtain the best classification results. It becomes easier to prevent cows from disease, and then improve the quality of milk and beef.

Acknowledgements

This work was supported by University of Information and Communication Technology (ICTU), Thai Nguyen University, code ĐH.2018–TN07-02. The analysis and write-up were carried out as a part of the first author's PhD study at Faculty of Electronics and Telecommunication, VNU University of Engineering and Technology, Hanoi, Vietnam.

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How to Cite

Hoang, Q.-T., Phi Khanh, P. C., Trung Ninh, B., Phuong Dung, C. T., & Tran, T. (2018). Cow Behavior Monitoring Using a Multidimensional Acceleration Sensor and Multiclass SVM. *International Journal of Machine Learning and Networked Collaborative Engineering*, *2*(03),pp. 110-118.

https://doi.org/10.30991/IJMLNCE.2018v02i03.003

IJMLNCE JOURNAL

International Journal of Machine Learning and Networked Collaborative Engineering

Journal Homepage: http://www.mlnce.net/home/index.html

DOI: https://doi.org/10.30991/IJMLNCE.2018v02i03.004

Machine Learning Approach for User Account Identification with Unwanted Information and Data

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Abstract

Machine Learning used for many real time issues in many organizations and for the purpose of social media analytics machine learning models is used most prominently and to identify the genuine accounts and the information in the social media we are her with a new pattern of identification. In this pattern of model we are proposing some words which are hidden to identify the accounts with fake data and the some of the steps we are proposing will be help to identify the fake and unwanted accounts in Facebook in an efficient manner. Clustering in machine learning will be used and in prior to that we are proposing an efficient architecture and the process flow which can identify the fake and suspicious accounts in the social media. This article will be on machine learning implementations and will be working on OSN (online social networks). Our work will be more on Facebook which is maintaining more amount of accounts and identifying which are over ruling the rules of privacy and protection of the user content. Machine learning supervised models will be used for text classification and the image classification is performed by CNN of unsupervised learning and the explanation will be given in the implementation phase. There are large numbers of algorithms we can consider for machine learning implementations in the social networking and here we considered mainly on CNN because of having the feasibility of implementation in different rules and we can eliminate the features we don't need. Feature extraction is quite simple using CNN.

Keywords

Machine Learning, Social Media, Analytics, CNN, Supervised Learning, Unsupervised Learning.

1. Introduction

Consider a person is maintaining his personal information in social media and time to time he is updating his information and capturing the society sight on him. Suppose if the person has a sponsored

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account in the platform, it is not an issue. Otherwise, it's a serious issue if the content is the adult and contains any pornography or nudity. To mention this words in the article is not a matter and the thing matters are spreading the adult content and maintaining the account which is against the rules of social media. Cyber threats are more nowadays and the teams which are appointed for the cybersecurity are being failed for a long time because of not identifying the correct pattern of these kinds of threats. In this article, we are highlighting the user accounts which are not following the hashtag concept of the social media. Facebook contains a hashtag dataset which is banned from using in the image tagging. In the text classification, we can identify this kind of things by using machine learning supervised model methods support vector machine model using the bag of words concept. Here we are extending the pattern and the workflow of the algorithm.

Big data is being created daily on social media, and the significant collection of data consists of images, and the tagging of images can be useful for identifying the accounts which are unauthorized [1]. As we are discussing social media, even Instagram and Twitter have the list of banned hashtags and the identification made easy by those firms for the fake and unwanted user profiles. But the users are more intelligent than the platform creators. They are identifying the new ways for the creation of the false and unwanted accounts with adult content for cyberbullying.

Cyberbullying is the process of stealing genuine information and saving those. Users will create a fake account exact to the original account and sell information for money. This content may be offensive in social media and the algorithm which the current versions are not tracking. Based on the information we collected in the past work done by various researchers we implemented our algorithm and the process flow and achieved success rate of 95% of the fake accounts using the CNN. Here this process is divided into two categories based on the primary requirement. First one is text classification. As discussed before we have the concept of banned keywords which should not be mentioned while tagging or posting. Second is images repetition in more than one account, and those pictures have to be identified in any other public website and have to conduct image classification using tensor flow library which is much used for such type problems. In the next section, we are explaining a few past operations or research done by few enthusiastic researchers and later with the proposed approach, next with architectural approach we are considering and finally concluding with explanation and references. We spoke lot about medical domains implementation in machine learning and deep learning and we don't know what to achieve in the medical domain using machine learning and deep learning. In this article we are discussing about the fake accounts detection in the Facebook as we can consider the same social networking as the platform for creating medical data in a large manner time to time. In this consideration we are focusing on the accounts which are posting the irrelevant information about the health care in the social media. Here we can get lot of pages, groups and the accounts which are sharing some health tips to the user and which are promoting their product which was not taken acceptance from the medical council. In those pages we can find the fake information on the health tips and we can consider those are the fake and unwanted accounts. Though they are real accounts but the rule here we are implementing is they are providing and projecting the fake information on the health standards.

Another situation we can remember through twitter tweets which are being poled fake votes in any hashtag competition. Whenever any hashtag is created as an event and consider some groups which are anti to that person related to hashtag then they will target to spread the fake and harmful information through fake accounts. For those kind of accounts they use abbreviation language to target the person in public. Consider a large group of people as conducting health camp in various cities and the other private hospital people may target them in the social media with fake information on that and try to spoil the camp. In those situations we are getting lot of information which is unwanted to be maintained in our servers.

CNN is the algorithms we are here mainly considered for the image classification. But also we can use for the text classification. **RULE** is the theory we are considering for the filtering of the accounts based on the keywords we are mentioning. Here we can consider some of the keywords like LOL, ROFL etc. Which widely used as the sarcastic words in the communication. We will group the combination of the words and list out the combination of those will work or not.

Support consider association rules in the data mining which will consider the group of rules which will take the user to the next level to understand the prediction model on which if the person purchases milk he tends to purchase diapers also. If the person purchased eggs then her tends to purchase bear. In this case we are considering the group of rules and the combinations and this could be the long process but it works. In the association rules are considering the probability of occurrence of the issue.

2. Literature Review

Many of the authors in the previous study mentioned few things related to the concepts in the social networking and few of the ideas we are going to explain here for better understanding of our theory.

Walt [2] explains the concept of identifying bots and human-managed accounts individually with his team member Jan and the idea is considering supervised learning for text classification using the bag of words for detecting spam messages in the report on the current trend topic on the internet [3]. They used Filtering [4][5] used for identifying accounts which are in the blacklist and comparing them with the current existing list of items.

Yongjun [6] Explains about their research regarding the content matching in the different social platforms related to the same user. Identification of the user is based on the shared content using the user-generated content (UGC) concept. Here they performed machine learning models based on the profiles access and the content displayed on the platform based on the individual user.

Ala M. Al-Zoubi [7] explains about the different identifying contents in the social media based on the spam profiles using support vector machines. Here they used whale optimization algorithm to identify the fake and spam accounts in the social media. Again here they focused on online social networks [2][3].

Julien Fontanarava* [8] explains the identification of the fake reviews in the online platforms. This will happen especially on Twitter on the trending topics. It might be a political or any personal all the illegal activities and the fake information will be passed in twitter. To identify those authors performed supervised learning classification model to analyze the fake reviews in the twitter especially.

Other researchers focused on different aspects of social media and in this article we are focusing on presenting you the basic ideas like fake accounts and unwanted accounts in Facebook based on the content published on their accounts and pages.

3. Proposed Approach:

3.1. Text Classification

There are most common banned text words in the privacy policy of the social networking. Here Facebook is the case. If we are identifying those words in the posts. There is a pattern we are following. The following algorithm will explain u in a clear manner.

```
START (HASHTAG,SPON,USERNAME)
{
Ht = hashtag is there or not (1/0)
Spon = Sponsored  account or not (1/0)
Username = username

HASHTAG [] = hashtag API query;

If (Ht == HASHTAG[])
        then
        username = blacklist[]
Else if
If( Ht.HASHTAG[] == true && spon == true)
        then
        username = truelist[]
Else
        username = blacklist[]
Print all the accounts
Create CSV file
END
}
```

The algorithm which we mentioned above is the sample, and the original type of algorithm will be different.

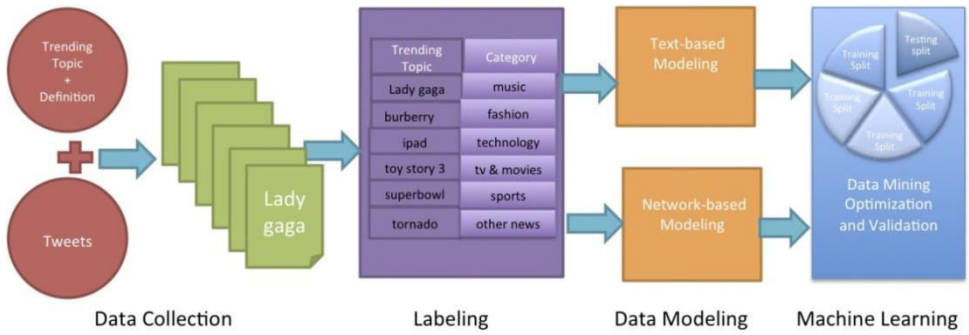

Figure 1 Text Classification Architecture

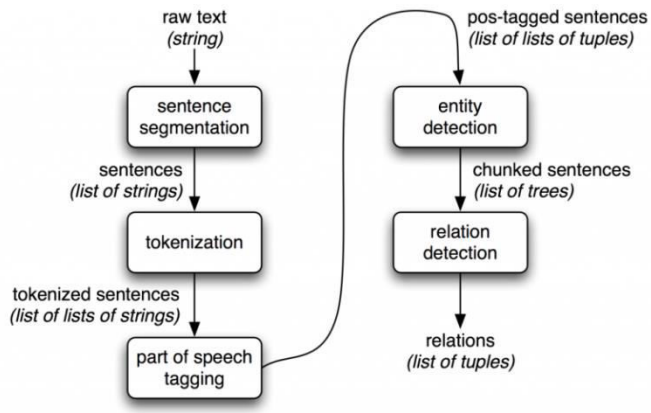

Figure 2 Tokenization in text classification

Text classification here done in two phases. One with normal NLP operation and other is tokenization. In this tokenization, we are separating the sentences into parts, and then we are matching the entity relations with the already existing entities. The chunks are separated and mapped to the test set data, and then we are identifying whether the account is genuine or not.

Figure 1 explains the NLP operation using machine learning model, and in that, we are considering sample tweets for example and then mapping them with the relevant user contents based on the natural language processing. Finally, we get the set based on the training and test set of the data. Based on that we need to perform tokenization, and then we have to implement the support vector machine model to identify the account trustworthiness. Whereas fig 2 explains the concept of tokenization.

In the text classification, we are using tokenizing to separate the text and the hashtag. Here we have some predefined hashtag words in the array, and we are correlating the array with the current words we identified. If the word is available in the array then send that account to block list otherwise that account is genuine.

3.2. Image classification

In the image classification, we are following the process of using tensor flow model for gathering information of images with the hashtag tagging and maintain them as a training set, and we need to analyze the same with the text data.

Fig 3 explains the concept of image classification in general and fig 4 explains the classification using sensor flow library

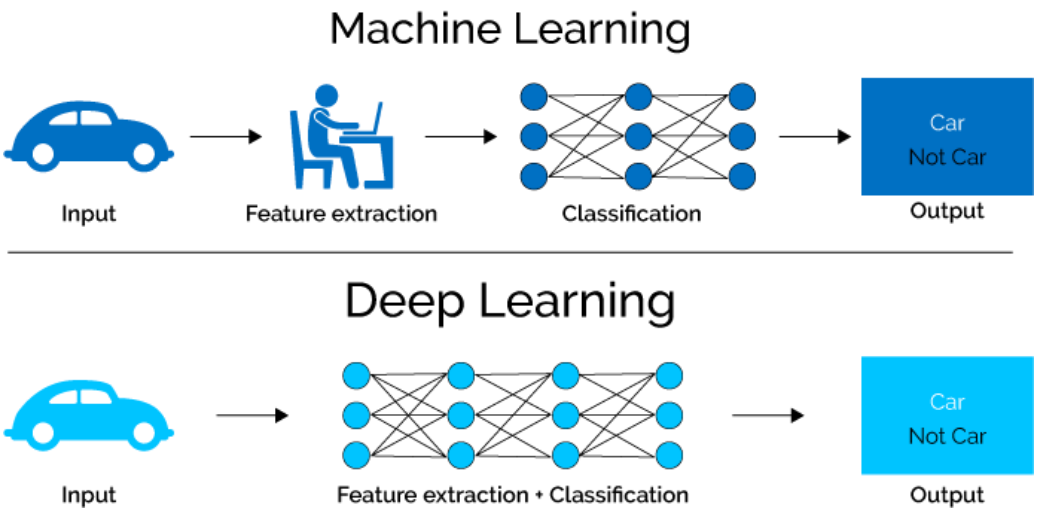

Figure 3 Image classification difference in Machine Learning and Deep Learning

In image classification the hidden layers will perform all the task and if the algorithm is considered then all the images which are collected as set will train the machine with the suitable method[9-10][16] and then there will be some combinations which the process which we are following has to consider while checking the account data. So that whenever the new account found with the same kind of inputs, then it must be regarded as the blacklist account and we have to block that permanently [13-14].

In this article, we contributed our time and ideology and considered this research would help social networking like facebook which is regarded as in this article to manage accounts in a right manner[17][15].

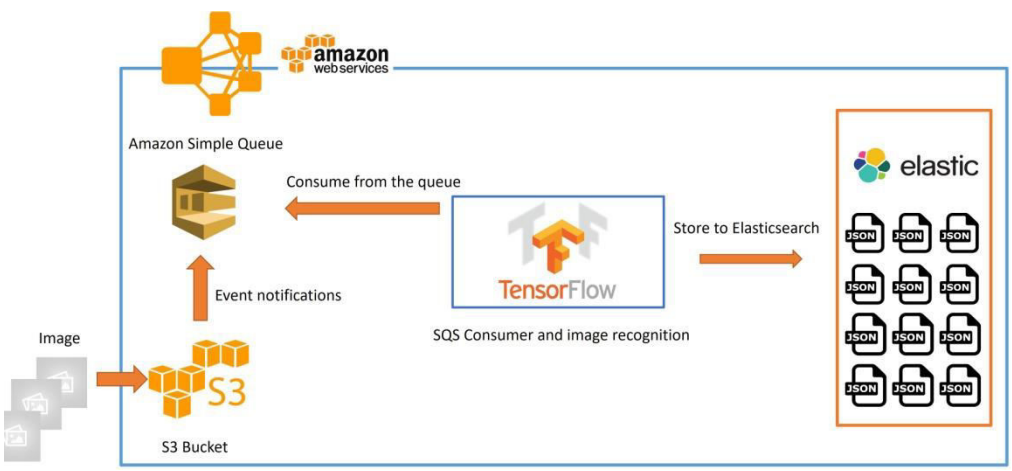

Figure 4 Image classification using sensor flow

In figure 5 we can show the concept of image classification using CNN. As we discussed previously, we can perform image classification using CNN. In CNN we are conducting more hidden layers and identifying the combinations of the rules are pose on the model. The sample architecture is mentioned below[14-15].

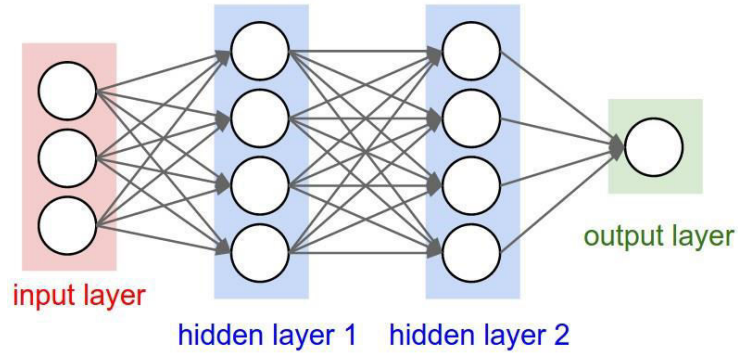

Figure 5: CNN implementation for image classification

```
START (HASHTAG,SPON,USERNAME,IMG)
{
Ht = hashtag is there or not (1/0)
Spon = Sponsored account or not (1/0)
Username = username

HASHTAG [] = hashtag API query;

If (Ht == HASHTAG[])
        then
        username = blacklist[]
Else if
If( Ht.HASHTAG[] == true && spon == true)
        then
        username = truelist[]
Else if
(ht.HASHTAG[] == true && spon == true && IMG.HASHTAG[] == true)
        then
        username = truelist[]
Else
        username = blacklist[]
Print all the accounts
Create CSV file
END
}
```

The above is the image classification algorithm model we are proposing and this is not precisely we present directly. Just for the sample, we present with sample notations.

Machine learning algorithms are more famous for implementation in prediction models, and here we are trying to implement the concept in social media analytics which is a major threat to the society and also for the people in the social media. These days kids are more frequently available in social media. Here kids mean teen. In this current situation, we are unable to stop them from using social media, but we can try to make that platform as a good for them with protecting them from unauthorized information. This kind of protection will be given using machine learning and deep learning models.

In the text classification, we are performing not with advanced models but with the basic idea of the machine learning models like support vector machines and the random forest methods. In these two cases, we found better and standard models implementation procedure and implemented text classification with these two. We may consider other machine learning models as well, but the case here is we need to perform text and image in the unsupervised learning methodology, and we have done that with CNN model which will be in different layer type implementation with layers 2 3 4 and those are the significant parts in the hidden layers. With this implementation, we found a better way to secure social media world with the teens.

4. Results and Output

Considering the work we have done, we would like to explain the worhttps://orcid.org/0000-0003-4161-508Xk with suitable outputs based on the algorithm we use.

4.1. Text Classification Results

We perform this with three algorithms. SVM, Random Forest, and CNB Classifier.

In SVM we consider the bag of words to match and identify the hashtag set. In the random forest, we would like to map the rules to determine the nature of account [8-13], in CNB we use WEKA tool for the classification of account.

The following table will explain the accuracy of each algorithm we consider

Table 1: Results of accuracy in Text Classification

Algorithm	**Tool**	**Accuracy**
SVM	Not Tool. Bag of Words	96%
CNB	WEKA	75%
Random Forest	NA	96%

Here if we observer we can find random forest and SVM will have equal accuracy rate compared to CNB classifier.

4.2. Image classification

We perform image classification based on the number of hidden layers we consider. In the first level, we find three hidden layers, second four layers and the final level we consider five hidden layers. And observe the accuracy of the identifying the fake and genuine account

Table 2: Image classification with CNN

CNN Implementation	3 Layers	75%
	4 Layers	80%
	5 Layers	85%

Here in this implementation based on the number of hidden layers we can get better accuracy. Based on increasing the rules, we get better accuracy.

5. Conclusion

The algorithm we are focusing in this architecture is having different levels to understand. In this method, Facebook is the main focus, and the thing here is we are analyzing facebook in tow levels. One is using text classification, and the other is image classification. In text classification, we are using support vector machine models which will develop the model based on the bag of words to identify the hashtag data. In the image classification, we are using CNN and sensor flow methods individually to identify the accuracy. And they performed equally. In the future implementation, we are focusing for more accuracy in identifying fake accounts and unwanted accounts.

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How to Cite

Kumar, A., & SAIRAM, T. (2018). Machine Learning Approach for User Accounts Identification with Unwanted Information and data. International Journal of Machine Learning and Networked Collaborative Engineering, 2(03), pp. 119-126. https://doi.org/10.30991/IJMLNCE.2018v02i03.004

Vol. 02, No.3 ,(2018), 128–142, **ISSN:2581-3242**

IJMLNCE JOURNAL

International Journal of Machine Learning and Networked Collaborative Engineering

Journal Homepage: http://www.mlnce.net/home/index.html

DOI : https://doi.org/10.30991/IJMLNCE.2018v02i03.05

Internet of Things and Healthcare Technologies: A Valuable Synergy from Design to Implementation

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Abstract

Internet of Things (IoT) promises to be a reliable technology for the future. Healthcare is one of the fields which are rapidly developing new solutions. The synergy between IoT and healthcare promises to be very beneficial for human healthcare and evolved into a new field of research and development: the Internet of Medical Things (IoMT). This paper presents a review on various enabling IoMT technologies based on the latest publications and technology available in the marketplace. This article also analyzes the various software platforms available in the field of IoMT and the current challenges faced by the industry.

Keywords

Internet of Things

Internet of Medical Things,

State of the art,

IoT, IoMT

Healthcare

1. Introduction

During the last years, the synergy between the fields of Internet of Things (IoT) and Healthcare - the Internet of Medical Things (IoMT) is becoming increasingly more apparent. Many researchers from disparate fields are working on smart Healthcare devices able to connect to the internet. IoT in combination with Cloud Computing are increasingly more getting the valuable support for the next generation eHealth [1] Services. By 2020, the Healthcare IoT market [2] is expected to grow to $330 billion, according to global market analyst Grand View Research (see figure 1). Many governments are aware of the potential of Smart

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Healthcare Devices and ready to invest and promote the use of eHealthcare Services. The cost and quality of existing Healthcare systems can be improved with the help of IoT Based Healthcare Systems. This paper gives an overview of the current State of the Art of the IoMT and it provides the background information to better understand the challenges and open issues in this field.

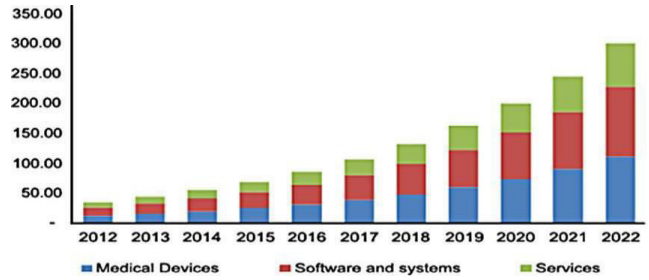

Figure 1. IoT in Healthcare market growth [2]

The architecture of an eHealthcare System [3] is divided into three components: 1. Device Layer, 2. Internet Connected Gateways Layer, and 3. Cloud Computing Layer (see figure 2). Medical data like heart rate and pulse rate can be directly assessed by the user, such as a medical doctor. The eHealthcare system can then take Intelligent Actions and propose the proper medical treatment.

A system that can support the operations in the office or company such as system to manage orders, is called a Backend System. Backend Systems work on the Cloud (Computing) Layer and consists of two parts: 1) Cloud based back-end infrastructure, which includes data storage and intelligent decision-making, and 2) User interface "dashboard" platform, which displays the user controls and data visualizations. Due to advanced intelligence systems and the Machine Learning technique, an IoMT health system is automatically set up as a duplex communication system which can predict patient health and take intelligent decisions if necessary, such as starting a treatment according to the diagnosis of the detected health problem.

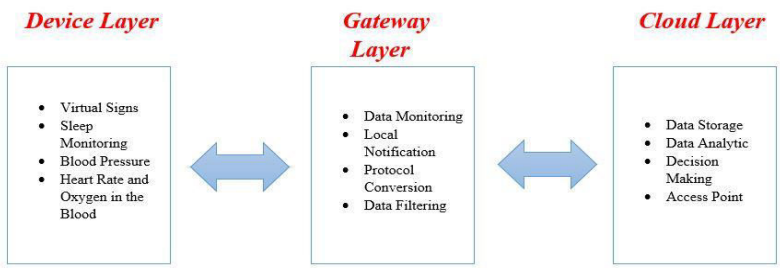

Figure 2. Architecture Block Diagram of IoMT

This next sections of this article are organized as follows: section 2 covers the IoMT based research studies, section 3 presents the IoMT enabling Technologies, and section 4 covers platform support for IoMT, section 5 presents the IoMT industrial market, and finally, section 6 presents the conclusions and future research areas are discussed.

2. Internet of Medical Things Studies

Many researchers are working on the IoMT, to make IoMT enabled medical devices smart and cost effective. Bui and Zorzi [4] proposed a framework for the healthcare applications. They developed an IoT stack protocol framework and measured the advantages of the protocol. Hassanalieragh, Page, Soyata, Sharma, Aktas, Mateos, Kantarci and Andreescu [5] reviewed Cloud based Health Monitoring system opportunities and challenges for future healthcare. They highlight the following challenges: sensing, and visualization for the design of the system, as the essential ways to improve healthcare and reducing cost. Rodrigues, Segundo, Junqueira, Sabino, Prince, Muhtadi and Albuquerque [3] present IoT based Healthcare techniques to analyze problems like Heart Rate, Oxygen saturation in the blood, and ECG and discusses enabling technologies for IoMT and the latest products available for IoMT service providers, researchers and

technology developers. Alansari, Soomro, Belgaum and Shamshirband [6] have reviewed usage of IoT in the health sector. They identified two criteria for achieving sustainable development for the IoT: 1) Economic prosperity and 2) Quality of life. Mahmud, Koch and Buyya [7] introduced a solution for healthcare called Fog-Based IoT Healthcare Solution. This HealthCare solution is analyzed with the use of iFog Simulator and in relation to Power Consumption and reduction of latency. The results of these simulations is helpful for the reduction of the price, network delay and power consumption. Sharma, Chen and Sheth [8] conducted a study called k-health – a platform is developed for monitoring diseases such as Diabetes, and Blood Pressure Problems.They built data mining algorithms for the preservation of privacy, which is relevant to the healthcare solution. These algorithms help to improve the privacy and cost. Maia, Batista, Cavalcante, Baffa, Delicato, Pires and Zomaya [9] developed an EcoHealth platform for sharing Real Time Data between doctor and patient. The main aim of this platform is to improve Health Monitoring and Medical Checkups for patients.

The studies discussed in this section illustrate how the synergy between the IoT and Healthcare is beneficial for improvements to the medical field and the challenges and open issues. We will examine the various enabling technologies and software platforms available to date, for IoMT research and development in further section.

3. Various IoMT Enabling Technologies

The IoMT system architecture, consisting of three layers (Device Layer, Internet connected gateway and Cloud Layer), allows a connection between a patient and their medical personnel, such as a medical doctor. It provides e-health facilities for continuous monitoring of heart rate, body temperature, blood pressure, blood sugar, electrocardiography, electromyography, skin problems and brain hemorrhage.

In the IoMT Architecture, data is collected from the human body via medical sensors. The output of the sensors is in electrical form and these signals are processed via Microprocessors or Microcontrollers and then this output is directly forwarded to the User Terminal. The User Terminal is connected to a layer which enables the end users' client or near user device to carry an amount of stored data, called Fog Layer with the help of Communication Protocols such as Wi-Fi, Bluetooth, NFC, nrf24l01, ZigBee, etc. This Fog Layer is connected with the cloud layer. The Cloud Layer is used for Data Storage and Data Processing. The Cloud Layer also makes a backup for the patient data or history like "The number of times the patient visits the clinic" or "Reasons for hospital visit".stem this will be the significant territory of concern. IOT worldview will have pass on user's request for the data validation & protocols such that its request can be assess against the policies so that they can give or deny access. There is a prerequisite for new protocols & definition because the accompanying requirements can't be expressed from this present scenario [3].

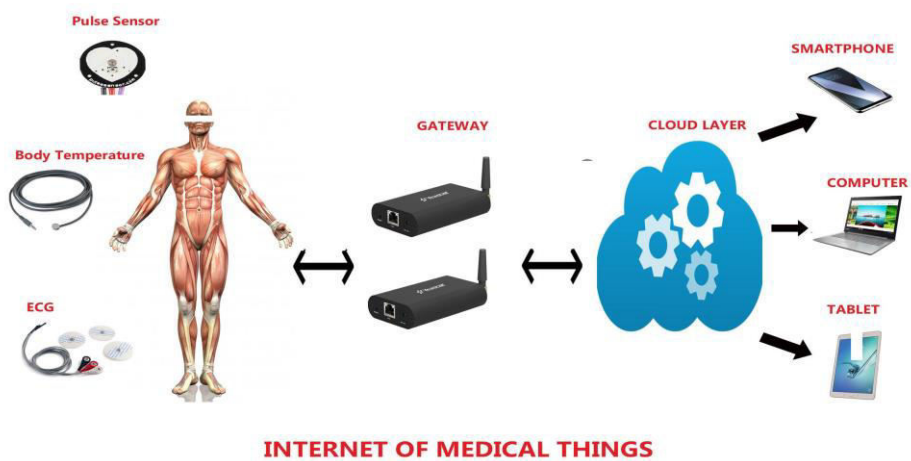

Figure 3. Architecture of IoMT

The IoMT are categorized into many enabling technologies but for the purpose of our review, we are focused on those technologies which are mostly used by the Universities and Industries for research of: 1) Remote Patient Monitoring, 2) Telehealth, 3) Wearable Devices for the IoMT Solution, 4) Software Platform for the Smartphones. We discuss these technologies one by one below, in sections 3.1 - 3.4 respectively.

3.1. Remote Patient Monitoring

Remote Patient Monitoring Systems are IoMT systems via which patients can be monitored at any place at any point in time. Remote Health Monitoring systems are beneficial for care homes, hospitals, healthcare centers and clinics. They can easily communicate and monitor health problems, in real time. It can potentially help reduce hospital waiting time and treatment time, decrease clinical treatment costs and improve the quality of care for the patients. Remote Health Monitoring Systems can be operated via Android or iOS applications and these applications are then directly connected via the Cloud Layer to the user terminal on smartphones, tablets or smart watches. Medical sensors will send data like oxygen saturation in the blood, heart rate, or pulse rate directly to the user's smart device in the emergency situation (see figure 4).

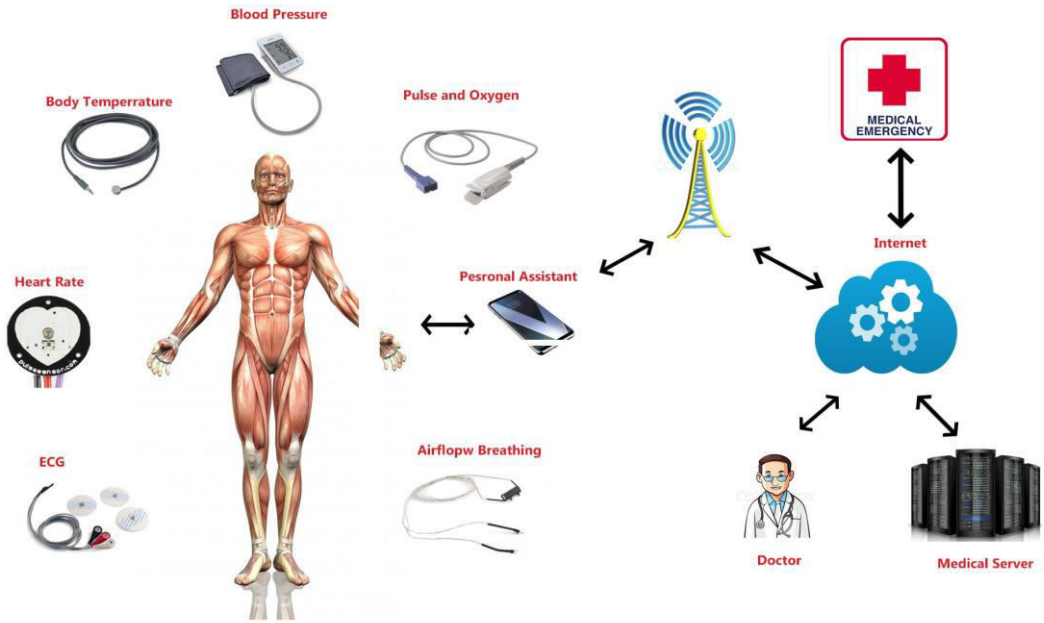

Figure 4.Illustration Architecture of Remote Patient Monitoring System

The Remote Monitoring Healthcare System is divided into three tiers: 1) Wearable Sensors, 2) Cloud Layer, 3) User Terminals (such as tablets, smartphones, web portal, smart watches). The first tier in this system consisting of Wearable Sensors, is used to collect data like Pulse and Heart Rate, which is transmitted directly to the second tier. There the data is processed and stored in the Cloud Layer. The Cloud Layer receives data with the help of various communication modules such as Wi-Fi, Bluetooth or a 2.4 GHz Wireless. In the third tier of the system, hospital or clinical faculties access the data on smartphones or web portal. The Remote Monitoring Healthcare System uses multiple sensors to acquire health data and provides this real time processed information to the medical doctor as well as patients' smartwatch. Based on these results, the medical doctor can provide guidance to patients, for instance: "What to do to recover from the diagnosed disease" or "Which diet is better". The User Terminal consists of four modules of operations: 1) Storage data for the patient or about the patient, 2) Management system, 3) Patients view their stored data number of times, 4) Provide treatment advice according to requirements. Every Remote Monitoring Healthcare System has two parameters to make it a Real Time Health Monitoring System: a. Energy efficiency b. No delay between data transmission and reception.

3.2. Telehealth

Telehealth is a bidirectional audio-video communication between Healthcare Service provider and a patient in their place of residence (see figure 5). Telehealthcare facilities provide a virtual physical presence of the medical doctor to the Patient's home for the medical treatment and monitoring of the patient and their vital signs. Due to the two-way communication, diseases can be detected by the medical doctors through monitoring their vital signs and providing medical assessments via the Telehealthcare system

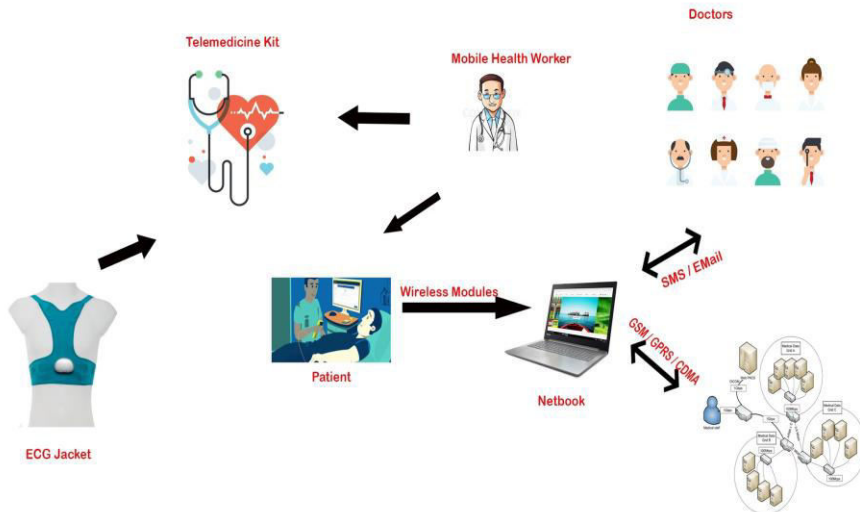

Figure 5. Illustration Architecture of Telemedicine

Telemedicine applications consist of three modes: 1) Save and Forward 2) Tele-meeting, 3) Video-meeting. Save and forward, stores a patient's medical history and diagnosis report in a file with the help of Electronic Medical Record (EMR) [13]. The EMR software sends the report to the medical doctor for advice. Telemedicine can help reduce or bypass the typical problems of waiting-times and travel time, when taking an appointment with a medical consultant. However, this technique is not suitable in case of health problems that require immediate treatment. Tele-meeting is a consultation between different parties' discussions regarding the patient's health through audio via Internet. It is also suitable as a medium for a discussion between patient and doctor about the medical treatment. Video-meetings have so far been found to be the most beneficial and appropriate method for a long-distance medical discussion [21]. It uses both audio and video, and requires high bandwidth and the cost of the equipment can be high if they using Radio Frequency (RF) components for audio and video.

Telehealth is categorized into different domains: 1) Synchronous and Asynchronous Transmission and Reception of Data, 2) Remotely Monitored Medical Data

3.3. Wearable Devices for IoMT Solutions

Wearable Devices are smart devices that can be worn by the user or patient and collect medical data like Heart Rate, Pulse Rate, Body Temperature and transmit this data directly to the Cloud Service Provider Via Gateway. In a Wearable Device, the sensor and processor should have small in size and power efficient. Wearable devices - such as Smart Glasses, Smart Watch, Smart Shirt, Wireless key tracker, Smart Shoes, Smart Shirts and Pants, Smart Belt and Smart Bracelets - can be beneficial for elderly people, for the monitoring of vital signs during physicals activities.

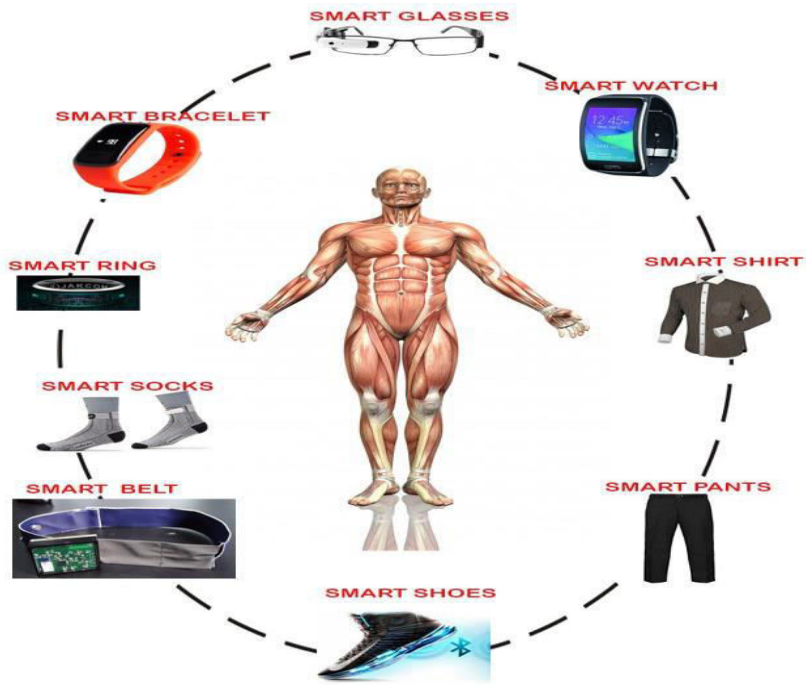

Figure 6. Illustration Architecture of Wearable Technology

Wearable devices are rapidly becoming more popular and the main motivation behind using wearable technology is that the user can monitor their own physical response to exercise more effectively and they can adapt their exercise routine accordingly, during their daily workout. This wearable technology is directly connected to the smartphone or tablet, for processing of the daily collected activity information. The following two problem areas for Wearable devices have been identified that are different compared to other kind of Wireless Networks [15]:

1. Power Consumption: preferred batteries are small in size and operate on a very low voltage and current. Bluetooth and Wi-Fi are not suitable because they have up to ten times more power consumption.
2. Interaction between two or more signals: Signal interaction between wearable devices and wireless networks is creating a challenge. Cybersecurity experts have warned that wireless data from wearable devices is a gold-mine for computer hackers. This problem is eliminated only if an up-to-date security infrastructure is in place.

3.4. Software Platform for the Smartphones

With the advances in technology development, the adoption of self-monitoring devices also increases. Self-monitoring devices [16] provide a health analyses and suggest how to treat heart diseases, diabetes, blood pressure, cancer or other health related problems. Many healthcare companies provide and integrate these medical technologies into a daily medical routine. For instance, healthcare companies have developed unique “apps”[20], for patients who are unable to go to the clinic for their routine checkups.

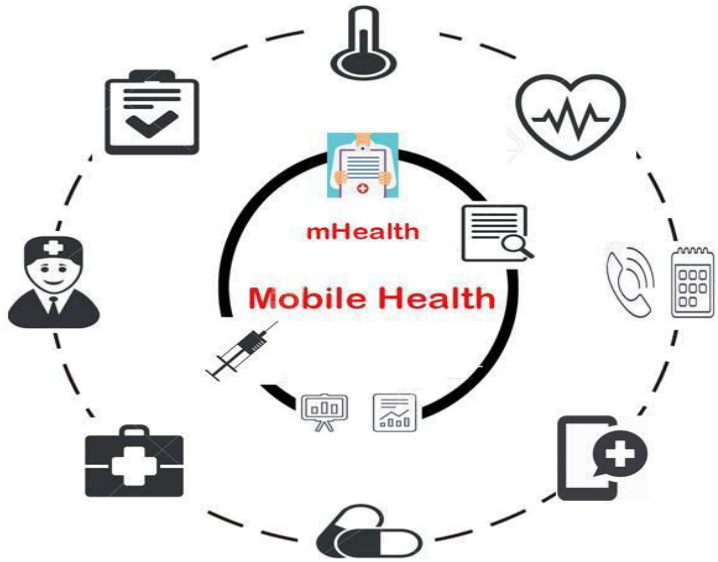

Figure 7. Illustration Architecture of Smart Devices

These apps are directly connected to the clinician's or doctor's user terminal. These app will be useful in the following ways.

3. Digital Health Records : Digital health records are being integrated by many hospitals and private clinics, via their servers, for access to patient records via smartphones apps. With the help of this integration users can access their data anytime from anywhere. For instance, a patient can see available appointments of the doctor and this can potentially save time and resources.
4. Management of Diseases: Disease management [18] apps are the most convenient and beneficial way to improve the efficiency of Healthcare. With the use of this kind of app, the career can stay directly involved with the patient and monitor progress and treatment of the diseases in real time.
5. Socially Active :Patients are connected to other patients via social media and can discuss and compare their experiences with the treatments they receive. Hospitals always encourage the patients to use social media and compare their experiences with others. Patients can significantly benefit from using mHealth apps. These mHealth apps can help patients review their health statistics and records, in real-time, provide guidance for the effective management of their illness or diet and help connect them with other patients via social media type chat-groups related to their illness and health goals.

We analysed that Remote Monitoring system for healthcare system plays a important role in the Medical Field. It helps to reduce the waiting and treatment time and provide a better treatment with low cost. Telehealth provides the audio-video facility between patient and doctor. It reduces the travel time or cost and send the patient medical records directly to the doctor for the advice but this technique is not beneficial in the emergency situation. Usage of the Wearable devices are increasing day by day and help to collect medical data like heart rate, pulse rate , body temperature and send to the Users terminal but still consumes more power and not energy efficient devices. mHealth app is used for health analysis and suggest how to treat with the diseases. It helps to store the digitally health records but this mHealth APPs are only working in the online mode if it gets offline no storage of data.

4. Platform support for IoMT

Currently every big company is trying to improve their services to increase their presence on the medical market. Specifically, every big provider of Cloud Services is enhancing their services to

accommodate IoMT Devices. They are providing and developing intelligent services for the businesses, including hospitals. Most of the available platforms consider the same IoMT architecture and follows the end to end solutions. The main components of the IoMT architecture are :

1. IoMT Sensors: Medical sensors helps to fetch the data toward Cloud Section
2. Gateway: Gateway is used to collect and filter data. It provides Internet Connectivity to all data centers.
3. Storage: Data is analyzed with the help of gateway and send to the storage section which help us to maintain, configuration, and control of data.
4. User Terminal Applications: At the user terminal, there is a software compatibility app like Android or iOS, to display the analyzed data in the proper manner.

The worlds' main IoMT vendors and companies provide services for healthcare applications as follows:

4.1. Amazon Web Services (AWS) IoT

AWS IoT provides dual communication between IoMT sensors and the Amazon Web Services Cloud. Medical Companies are developing framework for healthcare with the use of the AWS Cloud Service.

Figure 8. Components of the AWS IoT Platform

AWS has developed AWS Green glass software, which allows industries to securely process messaging and synchronizing for the connected devices. According to the AWS Services [17], AWS clouds can be connected with millions of devices and supports billions of messages from end to end points with high security and reliability.

4.2. Qualcomm Life Platform for Healthcare

Qualcomm Life is another platform used for the Healthcare applications. It provides end to end solutions for the Healthcare Clinics, patients and doctors. Qualcomm Life is based on a Cloud Platform that allows or connects with a huge number of medical devices and helps to collect, analyse and store the medical data. This data is transferred with the help of short range communication modules like Bluetooth, Wi-Fi.

Figure 9. Qualcomm Life Ecosystem

The main components in the Qualcomm 2net are:

1. 2net Hub: Device in which installed at User Home to communicate with the medical devices and collect data with the help of radio. It is a Plug & Play device.
2. 2net Mobile: Mobile software app which is installed at the user's home to collect the transmitting data via gateway.
3. 2net Platform: Cloud-based system that enables point to point exchange of the medical information transmission, and connection with the medical devices.

4.3. Microsoft Azure IoT Suite

Azure IoT is a Microsoft IoT solution in Cloud Computing, capable of sending and receiving millions of messages every second. Azure IoT manages communication of device to cloud and cloud to device. It can communicate with millions of medical devices simultaneously and supports HTTP and MQTT (Message Queuing Telemetry Transport) for sending data from device to cloud and cloud to device.

Figure 10: Azure IoT Suite

One of the main challenges in the development of IoT platforms, is the Cloud Connectivity to the medical devices. Azure IoT overcomes this challenge as follows:

1. Device Twin: A JSON document that can help to store the metadata for configuration of the device. It helps to synchronize the sharing of data between the app and the backend database.
2. Secure Connectivity: Durability is a very important factor in the IoT service. The Azure IoT Suite provides durability between the cloud and device through feedback or acknowledgement with every message. It also provides secured communication using the Transport Layer Security and X.509 protocol.

3. Secure Processing: With the help of Azure Active Directory, the Azure IoT Suite provides an authentication to access and manage Cloud Data. It enables this level of security via the Azure Cosmo Database.

4.4. Intel IoT Connecting Medical Devices to the Cloud

The Intel IoT has developed the end to end model architecture and its environment is combined with the third party to provide solutions for the medical devices to securely connect with the cloud. Intel has developed a platform which can support connectivity for millions of medical devices with Intel Cloud and the architecture is deployed with few key point:

1. It helps to autonomously setup the device connections from device to cloud and cloud to device.
2. It facilitates the simplification of protocols and format of data.
3. It secures the IoMT platform at both hardware level as well as software level.
4. It provides real time monitoring and real time analysing from device to cloud and cloud to device.

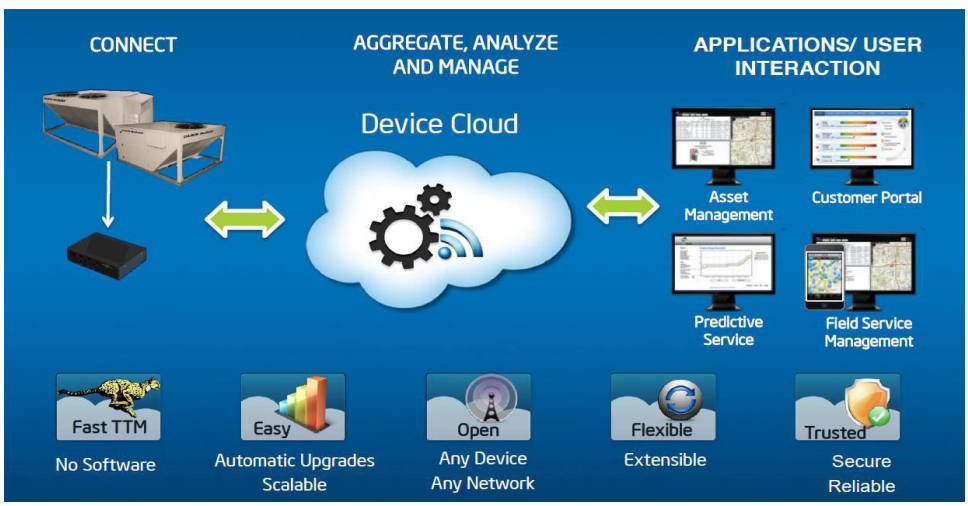

Figure 11: Intel IoT

Intel IoT provides a solution for addressing some challenges, such as high cost due to using of outdated equipment's, and the fact that technology used for remote monitoring may not be properly compatible with the needs and abilities of an aging population.

We analysed that many big companies are trying and launching the IoT services for the HealthCare. AWS has launched the software called Green glass which help to process and synchronize messages very securely. It provides very high security and reliability. Qualcomm life allows to connect the millions of medical devices and it helps to store and analyse the data of connected devices. Microsoft Azure IoT suite is another platform for the IoMT. It helps to support the millions sending and receiving messages in every second and provides the highly secure connectivity and secure processing with the help of Azure Cosmo Database. Intel has also launched one IoT platform for the medical devices which is autonomously setup the bidirectional connection between cloud and devices. It provides high security and real-time analysing between the cloud and devices. It also helps to replace the outdated medical equipment's and reduce the cost.

5. IoMT Industrial Market

With the increasing adoption of IoT technology, the research rapidly goes to a new direction. IoT is continuously growing to the Medical Sector and enhance the opportunities for the industry to reduce the cost.

The IoMT industry is rapidly growing and it is generating many discussions and explorations of novel application areas. Start-ups, university research labs and (multinational) companies are developing new

products and moving onto the market to implement the IoMT devices. The IoMT market will reach $136 billion by 2021 according to the Allied Market Report [19].

At present, the IoMT industry is mainly focused on the healthcare technologies like Wearables and Smart Technology. Mobile devices are already equipped with Near Field Communication (NFC) and Radio Frequency Identification (RFID), so they can easily communicate with medical devices through the cloud. Table 1. Presents a IoT companies supports HealthCare. High speed Internet and sponsorship from the government, also help grow the IoMT industry.

Recently, Ericson presents a report [22][23] called “Role of 5G in the Healthcare Sector”. In this report, Ericson says that in remote monitoring system, there is a requirement of updations of data at very high frequency rate existing technologies cannot fulfil the requirement while connecting with millions of devices.

Table 1: IoT companies and products support IoMT

Company	Product	Product Type	Brief Description
Naya	Naya Smart Breast Pump	Device	Naya Breast pump is a hydraulic suction pump used for baby feeding. It embed with app to display the session data for pumping and milk volume.
Orbita	Orbita Voice	App	Orbita Voice is a app which creates a virtual assistant and connect with clinical person to capture feedback from the smart devices like google home.
Trulnject	Trulnject	Kit -Model and Software Application	It is IoT connected injection training system which includes model and software system for the practice on injectable medication
Carré Technologies	Hexoskin - Wearable Body Metrics	Device - Smart wearable shirts	Hexoskin is a IoT enabled shirts to measure the ECG , Heart rate , breathing rate and sleep cycle.
Breathometer	mint	Device	Mint is a device which enabled with the IoT to monitor the oral health.It analyze the oral bacteria and send the immediate feedback to the mint app.
Keriton	Keriton Kare Nurse	APP	This app provides the IoT based platform to reduce the NICU nurses workload and help to care the children's.It can save more than 10000 NICU nurses data.
Meru Health	Meru Health Ascent	APP	Meru Health Ascent is a mobile program that gives the Precision treatment for the burn out.

6. Conclusion and Future Scope

The IoMT is playing an important role in enhancing the healthcare industry. One of the fastest growing industries in the medical field is the IoMT, which is why we did this review of IoMT enabling technologies. Furthermore, we analyzed the recent publications about the IoMT and presented the enabling technologies that are used by the healthcare industry and presented the top IoMT platforms developed by

industry for healthcare technologies. These solutions are essential for society because to demonstrate further insights into the latest IoMT developments, we also provided a broad overview of the latest trends, technologies, industrial platforms, challenges and open issues like Wearable Technologies. Basically wearable technologies

Wearable technologies face the following challenges:

1. Wireless Modules like bluetooth consumes more power,
2. Pattern recognition and machine learning require more storage.
3. Government support needed for Healthcare governance, user and manufacturer rights.

This overview does not provide in-depth information about IoMT security, but recognizes it as an essential element of success for the IoMT and further research is needed to address these issues. However, it has provided and overview of the security challenges, topologies and architectures. The Latest technologies like electronics patches, Big data , virtualization are very important in the Medical Sector and it should be considered in the future research.

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How to Cite

Gautam, K., Puri, V., Tromp, J., Le, C., & Nguyen, N. (2018). Internet of Things and Healthcare Technologies: A Valuable Synergy from Design to Implementation. *International Journal of Machine Learning and Networked Collaborative Engineering*, *2*(03) pp 128-142.

https://doi.org/10.30991/IJMLNCE.2018v02i03.05