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A Novel System Design for Intravenous Infusion System Monitoring for Betterment of Health Monitoring System using ML- AI

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Abstract : In the upswing of contemporary science we can monitor and regulate the saline flow rate. Scrupulous flow has to be retained so that risks of fore shortening the threshold level of patient's heart rate, blood pressure and oxygen level in blood level. Intravenous infusion used intermittently in hospital has to be checked for is purity. For the change in threshold level of patient's body condition, saline flow has to be adjusted. The assessments obtained from the patients is proceed to the centralizer controller which is connected to the cloud is updated periodically to avoid loss of reports. The updated data sets shared to the chemist and CPU so that flow rate of saline is controlled automatically in accordance to the data received. The machine learning based algorithm (SVM) is used to predict the more accurate changes on data which is obtained from patients so that the controller can act agilie. This work gives better results based on the accuracy level calculation and efficiency improvement in terms of more fast response.

Keywords:- IVF, SVM, ML & AI.

I. INTRODUCTION

In the era of digital world, every field requires intelligent of operation as the population of the world follows the growing exponential curve, The people where suffering from different chronicle and non chronicle disease at the rate directly proportional to growth rate of population, also the availability of hospital and medico to help people is not adequate, as per the survey by AYUSH on doctor required in a village is 1:1000, ie., one doctor can serve the population of 1000 and its also in align with recommendation made by WHO [7]. But the support from the clinical assistant, is not defined exactly anywhere which makes a tough situation where a medico have to maintain a records of minimum 1000 patient and more or less the requirement of maintain large data which is observed from different patient is getting more difficult in the growing population rate. Here is the point where we required support from technology to support health care domain.

The two different vertical fields which has different strength on different scale operation should be combined. The harmony between these two vertical sectors will strengthen the effect greater than the effects created by individual vector sectors. This novelty should support the code of conduct of medicine, such as efficient, effective & safety. So reediting the name of health monitoring might be redesign the medical application and devices with enabled wireless communication and artificial intelligence (AI) [14,15] which is also one of the fast rapidly growing fields. The applications which is designed to support the medical system or medical diagnosis should be adopted to base code of medical, such as safety, agility and versatile on decision making. So the system should maintain those principles to make an effective and efficient system. The most common issue happen at the medical is injection and following the fluid therapy [4]. Most of the time identifying the exact fluid and inject it to the veins is taken care with caution and it should be monitored continuously. The entire process which is known as intravenous Infusion (IVs) in medical field [6]. The observation from the physical parameters during this infusion gives the support in understanding the response from the human body and also leads for continuously monitoring if required it gives an caution to the medico. The drug which is penetrated to the veins through this IVs is effective and it passes all the nutrient content to the entire physical system as it is connected to the centralized veins. However the IVs has a certain drawbacks such as problem with drip changer, dust particles in fluid and reused infusion needle etc., so the monitoring of patient reaction during the period of IVs could help to avoid the issues related to air embolism, venous reflux and reverse osmosis of blood. The most used fluid in IVs is saline, iyile and atah. The major objective on focusing IVs is through the automated system and decision making system which helps to reduce the complexity [10] such as when to remove the IVs, Time alert when the trip is completed to avoid reverse osmosis and to make a proper therapeutic intervention also the inadequate knowledge of IVs and fluid therapy is force caution of mortality and sickness. This paper brings out the decision on imparting the [12] AI to the medical field and modifies classic practice present now and this design mainly focusing on effective usage of IVs through how to uphold the fluid levels such as blood, drug, metabolic and electrolytes.

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This paper organized as survey followed by working principle and the importance of implementation of monitoring system and analysis results based on machine learning algorithm to take decision.

II. LITERATURE SURVEY & TRADITIONAL METHODOLOGY

A. Methods of Drip calculation

There are different types IV Modes are there such as Peripheral IV lines which is to be injected to a peripheral vein, PIV-central-line which is injected through peripheral-vasculature. The flow rate value of IVs is calculated based on the specific rate which may neither fast nor too slow [5]. This flow rate measurement is carried as "ml/hour" or L/hour or drops/min, so controlling the flow or adjustment on the flow rate only depends on number of drops per minute. The drop factor indicates the number of drops in one ml

Table I : Drip Calculation

$FR = \frac{Vol * DF}{Time}$ FR- Flow rate (drops/min) Volume (ml) DF- Drip factor (gtts/ml) Time (sec)	1-10 drops/ml(with equal Volume) (blood set)
	12-15 drops/ml 3(with equal Volume) (regular set)
	3-60 drop/ml (micro drop, burette)

Similar to the flow rate calculation the drug usage is calculated as follows

$$Drug\ Usage = \frac{D * V}{H}$$

D- Dosages ordered or desired dose
H- dose on container label or dose on hand
V –form and amount in which drug comes (tablet, capsule, liquid)

In general the improper IV leads to infiltration problems where the catheter enters to the tissues which are surrounded by body vessel. Due to the improper IV, it leads to the IV fluid directly enter into tissue which cause the phlebitis, hypothermia and local infection. The simple phenomenon behind the IVs generates the severe attention to its purity and drop rate monitoring.

B. Using WSN

The paper title "intravenous infusion monitoring system based on WSN by yang zhang presents the design and implementation of a WSN (wireless sensor network) for intravenous infusion monitoring based on slot-coupled infrared emitting diode as sensors and Zigbee communication [1]. This paper describes how the IVs monitoring is done using LED sensor, through the usage of LED sensors failed to improve the sensing accuracy if there is a variation in flow so it could lead to misidentification and alert systems.

C. Design materials

The Article [2] Design, Fabrication, and Testing of an Internet Connected Intravenous Drip Monitoring Device" presents the retro based monitoring system on IVs and the data is updated to medico thorough WSN. The pros and corns of this paper is defining the material to fabricate and unreliable measurements for the changes on drip chambers also the setting of manual drip values each time. This is position where the automation plays a key role [9]. The implementation of artificial intelligence to the clinical solutions monitoring will give more optimized results.

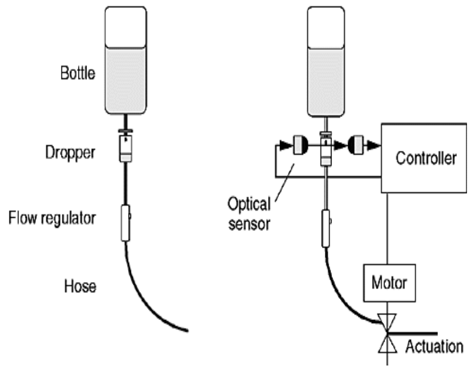

Fig.1. Flow control mechanism

The automation at the flow control [10] of drip chamber or controlling the motor which pushes the change of saline or clinical water was failed due to its functionality and controlling the flow through fault deduction of clinical water level & the motor connected and controlled by wireless. It is showing that the motor controls do not change its flow rate as described in table I. The other system which uses PPM techniques to implement the high accuracy on monitoring does not check for the purity of saline and patients response after consuming the saline. The paper [2] illustrates the RI sensing with high percentage of accuracy to measure the purity of saline. According to [4] an ideal device to automated method for saline flow monitor and keeps the track of patients heart rate and body pressure level frequently. This article also describes the control of flow rate or fluid level to the medico who can control the process from the control room. Another article [7] describes about the strain created by IV fluid due to continuous infusion. Transducers detect such a variation in resistance and final receiver node receives the electrical signals which cause a buzzer to trigger an alarm. Through the different mechanism for monitoring auto rate using Mobile communication [11], load cell sensor [4], fabricated PWM IC [2] failed to measure the parameters like saline purity level, the nutrients level to be added to saline, the response from the human, so the AI based machine learning algorithm[14] is implemented to overcome the drawbacks mentioned here. This AI based systems generally maintains the different response recorded by the sensory unit and also the data's were processed as image or extended data. This network forms posses the natural language processing unit and it is connected to machine learning part where output is produced as reference set of database [13].

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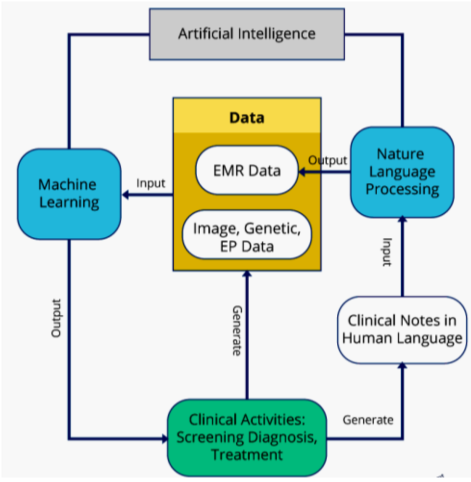

Fig 2: General block diagram of ML in Health care

The AI analyzes the purity of clinical water and reports shared to the control section. The Machine learning (ML) algorithm is used to check [15] out the threshold conditions as mentioned by medico for the particular patient to improve the response of recording with high reliability and also updates the reports to the controller via cloud networks. The upcoming sections will describes about the function operations behind it.

III. FUNCTIONAL DIAGRAM & WORKING PRINCIPLE

A. Working Principle

The base architecture of this system is divided into 3 sections namely centralized controllers, control room and observation section. The centralized section is designed to have access with controlling all the signals associated with monitoring and control sections. The control room have access to pass the specific comments to the controller accordingly feedback received from centralized controller via the observation room. It is mandate to define precisely the parameter to be observed from the human interface parts and these sections gave adequate information to the controllers for each second. Before proceeding to the physical parameters, the quality of saline is checked through the optical sensors. The sensors with source light transmitting the optical information to receiver through the saline bottles. The optical signal analyzer works under the principle of refractometry [16].

The refractometry is used to measure how much the light refraction is occurred and measures the refractive index when the light from the optical source unit passed through the saline bottles, it creates a bending illusion due to refraction of solid particles present in the saline bottles and hence the refraction & refractive index changes the wavelength of light refracted. From the refraction and wavelength variation of light is measured at the primary level and the database is updated at the centralized controller. So the saline level and purity of clinical water is measured using the automated optical analyzer where snells's law is implied to change over the level to the controllers. Now the controller has a reference value and the testing sample values. Both wavelength and refractive index are compared to identify the purity and level of saline used in the particular clinical water. Through this device we can measure the variation of refractive light with the accuracy level of 0.00002 and the bandwidth of refractometer bandwidth to +/- 0.2 nm [16] . If the testing values is greater than the prescribed level then the controller alert the control section about the saline quality and suggest for the change of clinical bottles at the particular moment. Next to the quality analyses of saline the droplet calculation is taken place. According to the medical code of conduct which is explained in previous sections, the level of saline with or without nutrients should maintained constantly and droplet or drop level is calculated as per the requirement and to the level of liquid flow accepted by the centralized veins of patient. The droplet is counted by the UV lights which are kept at the bottom of the droplet. The drops entering to the veins monitored and its effects are measured from the response from the human.

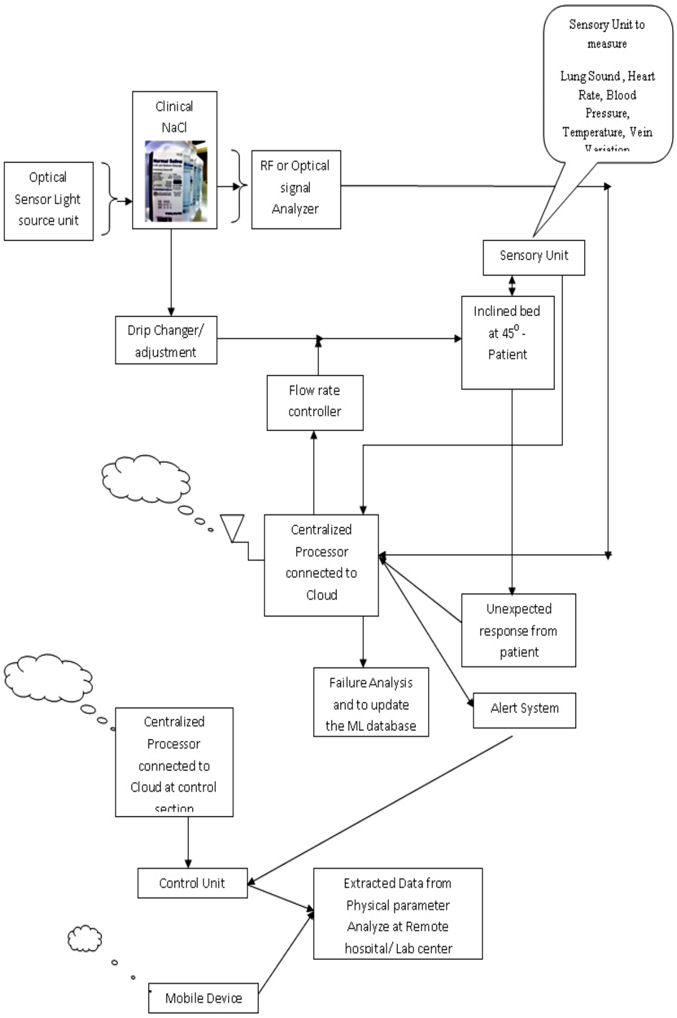

Fig 3:Block Diagram

The drops is neither too slow nor too tempo, the drip rate changer is connected at the flow level, so according to the response from the patient the centralized processor changes the drop count entering it to the vein. Based on the case it will increase of decrease rate of flow however the flow rate cannot be change its bandwidth of +/- 10%. Beyond the controlling mechanism of drip changer the drip unit calculator is reside. Whenever the saline or any form of nutrients passed with saline is injected to the body, the response from the patients are monitored regularly and also the sensory unit which is connected with the centralized processor, updates the physical parameters obtained for the patient to the control room through wireless sensor networks, that is data is stored and accessed via the cloud. The sensory unit mainly measures the lung sound using respiration mechanism that is the level of oxygen in blood by the inhale and exhale of air via nozzle and also the body temperature is measured using temperature sensor (LM 77) as temperature of the body adequately varying with the level of drops consumed. Among to this parameters the heart rate of patient is observed by the pulse sensor (AD8232) and the pulse response from the heart is monitored. So creating the environment which is used for the sensory and monitoring is important, as defined to the previous sections the data which is obtained from the patient will be recorded at the control room. The variation from the threshold level is measured and it will be update to the control room or medico for agility of functionality. The main process behind the monitoring is setting the threshold limit. Every human being is different in nature and having the different systems of response. To understand this different scenario, the data extracted from the patients is given as data sets to Artificial intelligence systems. The extracted data sets are given to the machine learning platform to predict the level of threshold at the particular time of monitoring.

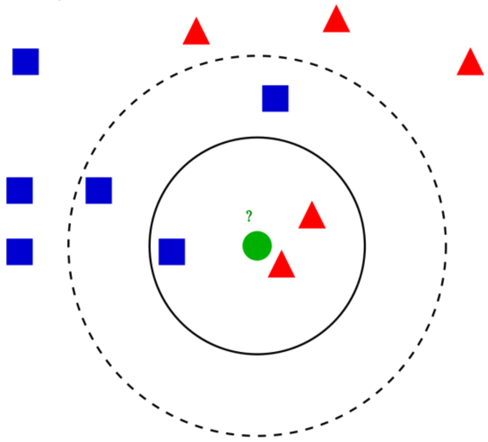

Fig 4: K Nearest Neighboring Algorithm

The logic behind the monitoring is build using datasets (extracted data from the patients), this machine learning based AI environment simplify the decision by analyzing large no of data sets received from the patient. So the data obtained from the monitoring unit should be divided based on the any type of classifier such as adaboost, SVM (support vector machine) and KNN classifier [14] and so on. These classifiers will build the models based on the datasets for simple vector generalization with large capability When the classifier is based on K nearest neighbor algorithm, it will not create any kind of assumption and can be classified based on regression but the drawback is high need of memory for storing the training set due to the ineffectiveness on datasets assumption tats why it's also called as lazy algorithm.

The prediction is based on the nearest neighbor value of K from the given set of training sets and the obtained results are summarized from the K values. So the K means algorithm and k nearest neighbor is having a controversy in segregation and generating of data sets. The classifier SVM is used here. That support vector machine algorithm is based on separating the data as two wide extreme corners as max ad min mode where the entire health care data is separated as invasive and non invasive parameters. The main objective of SVM is identifying the highest possible margin from any point with in the data set extracted from the patients. Here by the data points closed to the margins and farer to the margins are removed in order to alter the position with improvement on accuracy. This SVM machine sets optimization of data choosing and also does not over fit the data.

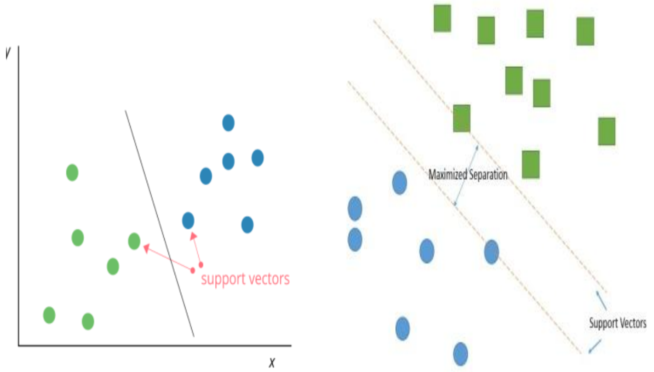

Fig 5: Support vector machine classifier models

B. Flow of operation

With the brief operation discussed on the previous section, the entire flow operation is defined here as algorithm.

Algorithm :

a) check for the purity of saline change if its impure

b) measurement of blood parameters

c) check for the previous records go to step "i" else go to next step "e"

d) extract the physical parameters

e) generate the first data sets

f) pass the nutrient level to the control room

g) maintain the flow level of liquid with or without additional nutrient based on step "b".

h) generate the data sets for tiny variations on physical structure.

i)compare the reference value and obtained data with reconstruction of pattern vector

j) monitor the flow rate and adjust the flow level based on changes from step "e".

k) update the changes or flow and response from human to the control room

l) update to the devices connected to the specified cloud.

m) apply SVM to take decision on abnormal

n) adjust the saline as per the decisions and stop the flow of saline and alert the control section if abnormality is high than threshold

o) alert the entire process and check with previously data and generate the diagnosis report.

p) repeat the steps "d" until the improvement on health

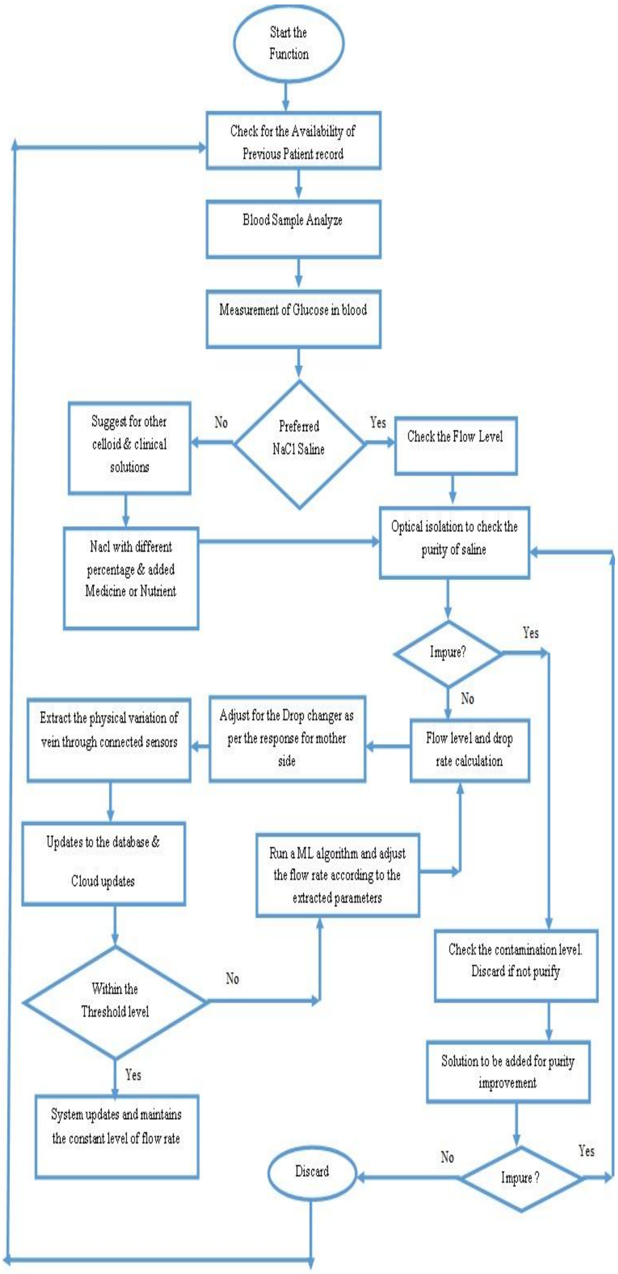

Fig 6: Flow diagram

IV. RESULTS & DISCUSSIONS

The Saline level and flow rate for drip chambers are calculated as per the table prescribed in section II. The various data sets are obtained from the sensory unit for the analysis using SVM based machine learning.

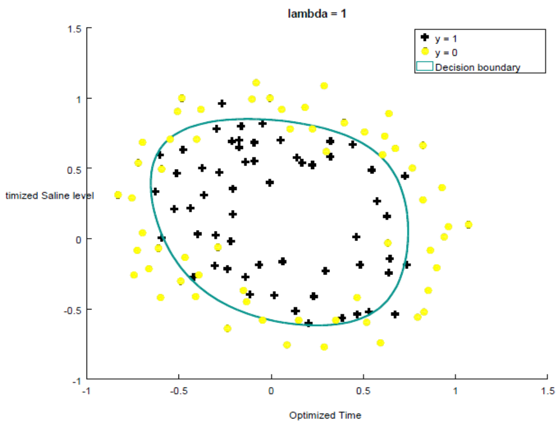

Fig 7: Optimization of Saline level vs Time

The various plots are given below based on the data sets obtained from the patients. It is clear that figure 8 shows how the saline level are calculated to the control of flow on different time scale with the help of sensory unit.
The various parameters such as blood pressure level, absolute temperature of the body, heart rate, lung capacity also taken into the account for analysis with saline level at different time stamps and its tabulated as follows.

Table II : Datasets obtained from the user

Patient	Time	Saline Level	Lung Capacity	Respory system level (volume per intake)	Heart rate	BP	Body temperature
A	1	20	6	2400	71	130	97.5
A	1.2	20	6	2350	71	130	97.6
A	6.1	20	6	2190	71	129	97.2
A	6.2	20	6	2200	71	130	97.2
A	6.3	20	6	2109	71	124	97.3
B	2	20	6	2350	71	130	97.2
B	2.2	20	6	2200	71	130	97.4
B	2.4	18	6	2500	74	140	97.3
B	3	18	6	2450	73	140	97.3
B	3.2	18	6	2450	73	140	98.1
B	3.4	18	6	2445	73	140	97.8
C	3	18	6	2450	73	140	97.3
C	3.2	18	6	2450	73	140	98.1
C	3.4	18	6	2445	73	140	97.8
C	4	18	6	2300	72	130	97.9
C	4.2	18	6	2300	72	130	97.2
D	4	18	6	2300	72	130	97.9
D	4.2	18	6	2300	72	130	97.2
D	4.4	18	6	2300	72	120	97.3
D	5	18	6	2100	71	125	97.3

The data sets obtained from the four different patients namely A,B,C & D are included for the updating of saline level based on various parameters obtained at different time periods. As this data sets were used as inputs to the SVM based Machine learning to take a decision on the alert system and flow control Figure 8 & 9 describes about the regression model implementation on the particular datasets with different parameters like hear rate, temperature, blood pressure.

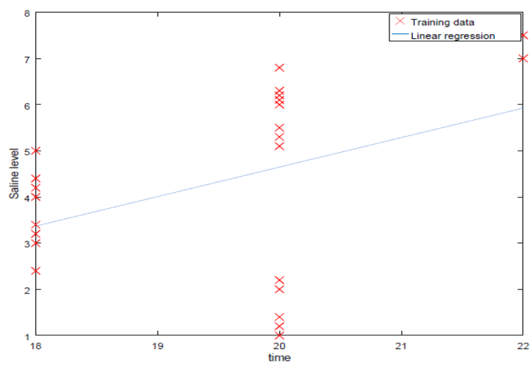

Fig 8: Saline level vs Time based on regression Model

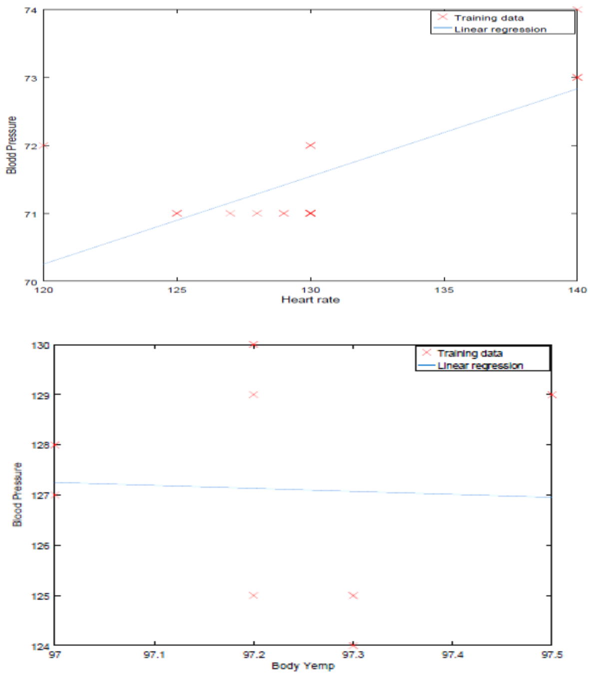

Fig 9: Linear analysis Heart rate Vs Temp Vs blood pressure

Figure 10, describes the data sets obtained from the 4 different patients whose are under the monitoring for 24 hours.

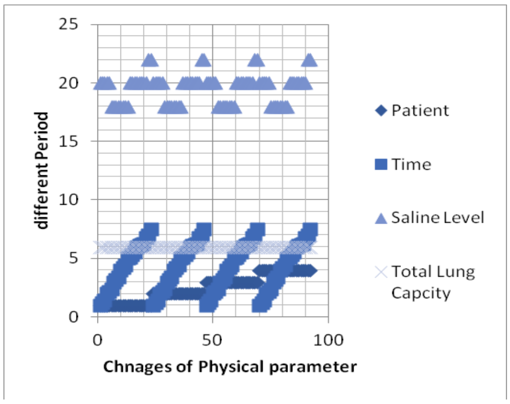

Fig 10: Over all Dataset graph for a day.

V. CONCLUSION & FUTURISTIC IMPROVEMENT

The system describes is highly recommended at the healthcare unit for 24*7 monitoring. The intravenous Infusion system (IVs) with automated control on saline level and AI based machine level calculation supports for the flow control helps the medico to monitor the saline level with high accuracy in terms of low rate, purity and observing points of patients. The sensory unit designed here has interfaced with the centralized server so that the data can be uploaded directly to the clouds so that it can be easily accessed by the end user such as medico, patient's relative. The different datasets obtained from the patients has been tabulated and the results were plotted to check the efficiency with traditional methods. So obviously this device has improved the efficiency in monitoring and alert systems compared to other systems defined previously. So the upcoming field of AI based health care unit helps to analyze and diagnosis the different disease associated with patients.

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