Integrated Autonomous Emergency Detection and Warning Systems

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***Abstract*—Technology has been able to provide the tools for swift and rapid treatment but is our human counterpart equally tuned. As the growing need of doctors is unable to compete with ever prolific population growth, the development of stand-alone systems for providing immediate health care or First Aid has become a dire need. To add to this dilemma, acute shortage of health care professionals in this field has led to major outsourcing of human resources from villages, slums and rural areas. This massive inflow of partially or completely untrained health care assistants has only added oil to this growing flame of unresponsive and crude immediate health care competence. The solution we propose in this paper is the development and integration of unique case-based statistical data collection with autonomous emergency alerts and temporary preventive measures. Thus restricting the patient's dependence on doctors or nurses might not be in the position to provide the best treatment due to sudden escalating unforeseen conditions.**

***Index Terms*—first aid, healthcare, case-based statistical data, emergency care**

I. Introduction

Despite being a pioneer in public health management and disease prevention since the Vedic period, India has only one doctor for every 1,700 people; a surprising 2.6 folds lesser than global standards. This however is not constituted as a symptom of being a developing country; it has been shown through multiple surveys that the attributing factors lay beyond the economics of countries [1].

It is speculated that by 2020, there will be an acute shortage of approximately 230,000 doctors, 150,000 dentists, pharmacists and physiotherapists and 590,000 nurses [2], [3]. Currently, in India, there is a shortage of about 6 lakh doctors, 10 lakh nurses and two lakh dental surgeons [2].

The rising advancements and research in Healthcare Technology and Pharmaceutical companies have reached their pinnacle in the 21st century with ongoing unprecedented methodologies concerning drug delivery and Nano devices. Without doubt there is an ongoing relentless effort being put into the electronics end of this industry but what about the human end. The statistics involving the total population and death rates in India from the beginning of the 21st century are shown in Table I.

TABLE I. Indian Demography Statistics [1]

Year	Total Population	Death rate per 1000
2000	1,014,004,000	8.88
2001	1,029,991,000	8.74
2002	1,045,845,000	8.62
2003	1,049,700,000	8.49
2004	1,065,071,000	8.38
2005	1,080,264,000	8.28
2006	1,095,352,000	8.18
2007	1,129,866,000	6.58
2008	1,147,996,000	6.4
2009	1,166,079,000	6.23
2010	1,173,108,000	7.53
2011	1,189,173,000	7.48
2012	1,205,074,000	7.43

The following graph as shown in Fig. 1 is obtained from the above data and highlights the change in the number of deceased people over the years during which major progress in Healthcare has been established.

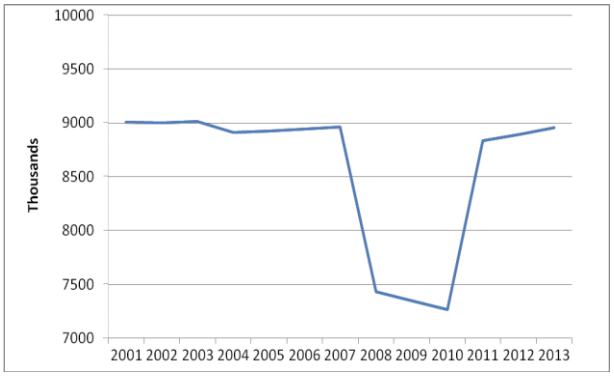

Figure 1. Number of deceased in India

It is clear from the above data that our Healthcare System has reached a stage where we need to improve the Human end of the system to raise the standards and improve the system. It is not that the technology is not efficient, the lack of trained faculty and human resources have constricted its progress.

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II. System Design and Architecture

In this paper, we propose an Integrated Autonomous System incorporated with sensors, alarms and preventive measures which allow us the ability to predict, control and address the patient's situation instantaneously. We have also incorporated in this system an immediate communication link to his/her corresponding or nearest doctor for further aid.

The proposed design is subdivided into multiple subsystems so as to address the various limitations faced in the conventionally used methods. The following subsystems along with their characteristic features and the drawbacks they are designed to overcome are elaborated below.

A. Electrochemical Actuator

Electrochemical actuators as shown in Fig. 2 are portable electronic devices which are used to control a mechanism in a system in response to a stimulated ambient change. They are mostly designed to react to change in temperature but recent ones have been re-equipped to respond to stimuli like motion, pressure and Wi-Fi signal [4].

Figure 2. Electrochemical actuator used in drug delivery [5]

Electrochemically-driven mechanical pumps possess multiple advantages including minimal power consumption, low heat generation, accurate flow control, and large driving force for in vivo drug delivery [4]. These factors, augmented with the potential for biocompatible construction and wireless actuation, enable many interesting biological and medical applications [4].

B. On Board Statistical Analysis System

Dissolved Oxygen levels in the blood, temperature, blood pressure, pulse rate: these are all factors which play a major role in all metabolic activities or mechanisms taking place in our body.

Thorough research into these parameters and their variations has shown a direct link to the patient's condition [6]-[8]. If we can incorporate a memory device into these parameter sensing systems to keep track of the patient's data [6] or allow statistical inferences to be conducted on this data in the form of graphs like histograms and data properties like mean or median; we can achieve more insight on the patient's condition. For example temperature curves are used for correlation of the Sequential Organ Failure Assessment (SOFA) Score [7]. The temperature logged over a period of time can also assess inherent thermoregulatory dynamics during systemic inflammation as in the case of Systemic Inflammation Response Syndrome (SIRS) [8].

C. Sensing and Threshold Units

After obtaining and concluding statistical inferences from the data, we can setup a particular threshold for emergency detection. It has been shown that there is usually a range of values in which normal metabolic conditions of the patient lie as shown in Fig. 3.

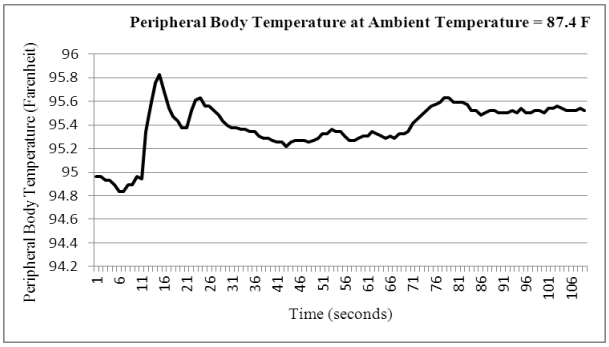

Figure 3. Peripheral body temperature variation recorded at ambient temperature of 87.4 F [6]

To obtain these conditions, it will be required to study the patients, as these conditions have shown to vary from person to person. Studying the patient's unique parameter signature, we will be able to predict any drastic change in the patient's health.

D. Emergency Speed Dial System

It has been shown through multiple data analysis of various parameters that after the detection of a significant statistical change in the patient's condition there is an interval of couple of minutes before any major heart attack or trauma is experienced as shown in Fig. 4.

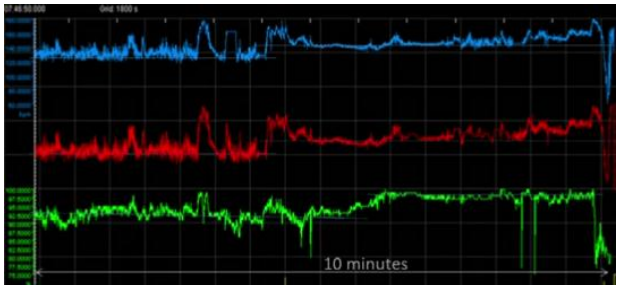

Figure 4. Statistically derived interval before cardiac event.

If we can setup an immediate warning system to inform the concerned authorities beforehand, we can effectively counter this trauma before it could further cause damage to the patient.

III. Approach

There have been multiple individual developments to improve healthcare conditions. However, the implementation of these developments has been impeded due to limitation in budget of most hospitals or due to misguidance towards adopting such a system.

Instead of focusing on integration of existing systems there has been a shift in focus to either develop more

accurate components like heart rate monitors or the more preferred solution being assimilation of a large number of medium-skilled nurses or staff that can relieve skilled doctors from relatively menial duties. Keeping in mind the ever increasing demand for qualified technicians as well as health experts, this emerges as the only feasible solution for the lower-end hospitals. Thus, more reliability is placed on the performance of untrained, inexperienced faculty.

IV. Procedure

The uniqueness of the proposal lies in the feedback mechanism which is augmented, to device a patient-specific threshold which will be able to manipulate predictions about the patient's progressing condition. To develop this threshold we would need the system to have a set of data from the patient for the system to develop a statistically significant value like mean or variance calculation. Then as the patient's data approaches this threshold (such as 95% of the true threshold value), the system will immediately detect and activate the electrochemical actuator to help assist the patient by performing a drug delivery to control the situation. The following procedure is illustrated in Fig. 5.

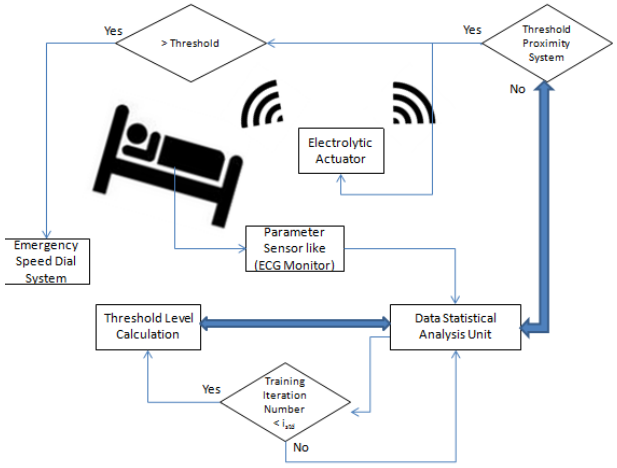

Figure 5. Process flow diagram

If the condition does not improve and once the threshold is crossed or after a specified period the condition remains unchanged, an emergency notification message will be sent to the patient's corresponding doctor and the nearest duty doctor of the hospital.

V. Implementation

The core of implementation of this system lies in the requirement of the system to remain integrated to the remaining components as a whole.

A. Hardware Implementation

As most devices already store the information in presently available formats or external devices, the incorporation of a central desktop in the ward which could perform the processing of the data for individual patients. This desktop could have a continuous connection with the stat monitors to refresh the data coming in and process the current parameter status of the patient. This coupled with an alarm system and an emergency contact service would be enough to complete the arrangement. There have been recent developments in the healthcare devices that are not only portable [6] but can also automatically send data to smart phones or the hospital's network. These devices can be used to introduce a home based Autonomous Emergency system.

B. Software Implementation

The software required to integrate this system includes a data statistical application or plug-in which is mostly found in the basic office system or one may even opt for more in depth analysis by using analysis softwares like Origin 8. The next major hurdle would be to incorporate a control system and an emergency contacts system which would need to be designed.

VI. Conclusion

The proposed system, we have illustrated above has shown the tendency and versatility to overcome the various inadequate and aggravating complications that have been hindering the efficiency of healthcare treatment in India.

The introduction of integrating Wi-Fi stimulated electrolytic actuators along with the patient-specific parameter signatures allows us to take necessary measures in dire healthcare situations like insulin overdose complexities that develop in diabetic patients which result in sudden dehydration of the body. There are similar such cases which can be addressed with this system like in case of cardiac related disabilities wherein each patient has different pulse rates, blood pressure and dissolved oxygen content in blood.

Appendix A Healthcare Statistics

Let us now shift our focus from the number of professionals to the statistics on facilities. We have drawn the following conclusions to account for the need of the development of the proposed system and its requirement in the current scenario; after carrying out necessary calculations, considering the relevant scenarios and rational assumptions.

The scenarios we have considered are the following:

1) Road accidents

To calculate the total number of injured or admitted cases occurring due to road accident, we will utilize relevant and approved statistics of conditions in 2009 [2].

Number of Road Accidents per Hour = 14

Number of Injured per road accident = 4.1

Number of admitted days in a hospital = 3

(Based on Accident severity, 28.6 people die for every 100 accidents and that most accidents involve fractures, traumas and even concussions)

Thus accordingly;

Total Number of Injured people per Day = 1,377.6

Total Number of Occupied beds per Day = 4,132.8

2) Birth rate

Considering the birth rate for 2009 [2] and the fact that an average delivery will result in occupying a bed for 4 days.
The Birth Rate per Thousand people = 21.76 [2],
The Total Indian population = 1,166,079,000
Thus accordingly;
Total Number of Births = 25,373,879.04
Total Number of Births per day = 69,517.48
Total Number of Occupied beds per Day = 278,069.91

3) Death rate

Considering the death rate for 2009 [2] and the fact that everyone when in a serious condition is reported and admitted in a hospital for surgery or treatment,
Number of Days a person is Admitted = 10
(Considering treatments like Chemotherapy, transplants or heart attack)
The Death Rate per Thousand people = 6.23 [2],
The Total Indian population = 1,166,079,000
Thus accordingly;
Total Number of Deaths = 7,264,672.17
Total Number of Deaths per day = 19,903.21
Total Number of Occupied beds per Day = 199,032.1

Now, considering the above mentioned situations the potential requirement of beds to be provided to adds up to the following:
Total Number of beds required per day = 481,234.81

But sadly the Total number of Beds available in the below tabulated data is 508,000.

Thus at any moment of time there are 26,765.19 beds available.

Thus at any moment of time in a hospital only 5.27 beds per 100 beds are available for immediate Health Care treatment for routine or any emergency cases not including road accidents. The following data has been referred form the statistics of Healthcare facilities in India which is mentioned in Table II.

TABLE II. INDIAN HEALTHCARE STATISTICS [1], [2]

State	Number Of Govt. Hospitals	Number Of Beds In Govt. Hospital	Population 2011 (% Indian Population)	Ratio of beds to population (100%)
Andhra Pradesh	359	34000	84,655,533 (7.00%)	0.0402
Arunachal Pradesh	161	2000	1,382,611 (0.11%)	0.1450
Assam	153	8000	31,169,272 (2.58%)	0.0256
Bihar	1717	22000	103,804,637 (8.58%)	0.0212
Chattisgarh	218	9000	25,540,196 (2.11%)	0.0352
Goa	20	3000	1,457,723 (0.12%)	0.2058
Gujarat	373	29000	60,383,628 (5.00%)	0.0480
Haryana	154	8000	25,353,081 (2.09%)	0.0316
Himachal Pradesh	142	8000	6,856,509 (0.57%)	0.1167
Jammu & Kashmir	92	4000	12,548,926 (1.04%)	0.0319
Jharkhand	500	5000	32,966,238 (2.72%)	0.0152
Karnataka	919	64000	61,130,704 (5.05%)	0.1047
Kerala	386	31000	33,387,677 (2.76%)	0.0928
Madhya Pradesh	377	20000	72,597,565 (6.00%)	0.0275
Maharashtra	765	50000	112,372,972 (9.28%)	0.0445
Manipur	28	2000	2,721,756 (0.22%)	0.0735
Meghalaya	38	3000	2,964,007 (0.24%)	0.1012
Mizoram	20	1000	1,091,014 (0.09%)	0.0917
Nagaland	48	2000	1,980,602 (0.16%)	0.1010
Orissa	1709	15000	41,947,358 (3.47%)	0.0358
Punjab	231	11000	27,704,236 (2.30%)	0.0397
Rajasthan	475	32000	68,621,012 (5.67%)	0.0466
Sikkim	30	1000	607,688 (0.05%)	0.1646
Tamil Nadu	581	47000	72,138,958 (5.96%)	0.0634
Tripura	31	2000	3,671,032 (0.30%)	0.0545
Uttar Pradesh	925	32000	199,581,477 (16.49%)	0.0160
Uttarakhand	695	8000	10,116,752 (0.84%)	0.0791
West Bengal	294	55000	91,347,736 (7.55%)	0.0602

APPENDIX B DRUG OVERDOSE

One of the many obstacles that the system proposed in this paper is designed to overcome the emerging and lurking problem of Drug Overdose (OD). The primal factors that result in this situation are mostly concealed from the eyes of the system. Factors like consumption of drugs with alcohol, over consumption above prescription values and even unintentional drug delivery during treatment go unnoticed.

In 2010, the United States Center for Disease Control and Prevention reported that there were 38,329 drug overdose deaths nationwide. Of that 60 percent (22,134) of overdose deaths were prescription drugs, contrary to the notion that majority are illicit narcotics [3].

One of the key features of electrochemical actuators is that they are not only portable but they are secure. They can carry a limited dose which can be used over a short period of time. With a characterized flow and control over the actuators design, it will only give a metered dose under the required stimulus like hypoglycemia. Also they can give the medicine under a supervised flow to prevent other side effects like addiction or overdose.

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