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Modelling and Simulation of Wireless Machine to Machine (M2M) Based E-Health Care System

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Abstract:

The emerging technology of Machine-to-Machine (M2M) communications is bringing a paradigm shift in healthcare delivery. A broad range of e-Health applications can be conceived, with considerable benefits for both patients and healthcare providers. Many technological challenges have to be met, to ensure the widespread adoption of e-Health solutions in the future. In this context, this work is aimed at providing a comprehensive overview on M2M systems for e-Health applications from a wireless communication perspective. An overview of the candidate wireless technologies that are suitable for different parts of the M2M system architecture and then show how these technologies are seamlessly integrated to provide an end-to-end e-Health solution. The system was designed to take into consideration the psychological issues related to all actors in the e-Healthcare society such as: stress due to high workload, anxiety, and loneliness. The system is capable of performing most of the tasks in an autonomous and intelligent manner, which minimizes the workload of medical staffs, and consequently minimizes the associated psychological stress and improves the quality of patient care as well as the system performance. With these results obtained, it shows that modelling and simulation of wireless machine to machine (M2M) based E-health care system is better than the conventional approach in terms of health symptom diagnosis. From the result obtained, it can be concluded that this machine to machine (M2M) based E-health care system gave an impressive result with 75% improvement.

***Keywords* — ANN, WBANs, FUZZY, Machine to Machine (M2M)**

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I. INTRODUCTION

Machine-to-Machine (M2M) communication is an emerging technology that envisions the interconnection of machines without the need of human intervention. Machine to Machine (M2M) communication is a new and emerging paradigm under telecommunication (Chen, et al 2012). In M2M, the devices communicate and share information with each other autonomously without or with limited human intervention. M2M communication is used in a wide range of applications such as: smart home, smart e-Health, modified realm Kerberos while handling dynamic assignment of doctors to specific patient.

Information and communications technologies continue to transform social interactions, lifestyles and workplaces. One of the promising applications of information technology is healthcare and wellness management. Healthcare is moving from reactive responses to acute conditions to approach characterized by early detection, prevention and long-term healthcare management. Health condition monitoring is particularly important in chronic conditions such as where treatment of cardiovascular diseases is involved. Continues monitoring and recording of biomedical signals, such as Electrocardiogram (ECG) & Photoplethysmogram (PPG) gives realistic view of patient’s heart condition. On the other hand, Machine to Machine (M2M) technology, help doctor's patient's information (such as pulse rates, temperature, HRR etc.). These applications involve the use of sensors for communication to servers via M2M networks. This work presents:

1) Problem Statement

There is need to have proper medical equipment to diagnose health status of patients before medication. This saves lives and provides medical help to citizens. This can be done wirelessly with the application of wireless machine to machine (M2M) communication which based e-Health care system. This work is projecting.

2) Aim of the Study

The aim of this research is modelling and simulation of wireless machine to machine (m2m) based e-health care system

3) Research Objectives

The main objectives of this project are:

I. To characterize the health status of the patient.
II. To design M2M rule base that will monitor and diagnose health situation of the patient at a faster rate.
III. To design a MATLAB SIMULINK modeling and simulation of wireless machine to machine (m2m) based e-health care system.
IV. To validate and justify the percentage effectiveness of diagnosing the patient symptom fast with and without wireless M2M.

4) Significance of the Study

It enhances the healthcare system of a nation

I. It enables widespread access to smart healthcare services.
II. It enables health care service providers to have immediate health information about patient.
III. It will help caregivers and doctors to securely share and exchange patient's information.

5) Scope and Limitation of the Study

The scope of this work is to develop a Simulink Model of wireless machine to machine (m2m) based e-health care system. It is limited to software application only.

6) Conceptual Framework

The main concept lies in seamlessly connecting an autonomous and self-organizing network of M2M-capable devices to a remote client, through heterogeneous wired or wireless communication networks. An intelligent software application is usually employed at the remote client to process the collected data and provide the end user with a set of smart services and a practical interface. Although the idea of telematics and telemetry applications is not new, the widespread use of Internet, along with the trend for ubiquitous connectivity, especially via wireless communication systems, have placed M2M systems on the spotlight of attention for both academia and industry (Kartsakli et al, 2014).
Health care are used as a life-saver by monitoring the patient's condition in real-time. When the condition of patient becomes acute, the messages from sensor must arrive to the hospital immediately. Follow the warning messages; the doctor does some emergency measures for patient. The patient mobility will be improved, and that it will provide the opportunity for monitoring patients outside the health institutions. Patients' well-being and retention of health care has also influenced the recovery time. A transition to wireless systems will therefore help to improve patients' wellbeing and reduce recovery time.

7) Theoretical Framework

The increasing interest on M2M communications poses significant challenges that need to be met. A key issue to be handled is the large number of devices that must be supported in an M2M network, since market predictions estimate that the number of M2M-enabled devices with Internet connectivity will reach up to 50 billion by the end of 2020 (OECD Report, 2014). Regardless of the exact figures, the growth rate is impressive, and major efforts are required to provide scalable solutions that support the increasing number of devices with diverse characteristics and requirements.

In July of 2012, ETSI and six other major standards development organizations (ARIB and TTC of Japan, ATIS and the TIA of the USA, CCSA of China, and TTA of Korea) joined their efforts in the one M2M initiative, under the goal of creating a single universal standard for M2M communications (Kartsakli et al, 2014). This global standardization effort is crucial to enable the integration of heterogeneous technologies in order to achieve seamless end-to-end connectivity, removing potential barriers to market growth. The penetration of M2M solutions for monitoring and remote control in a wide range of markets, including industrial automation, security and surveillance, smart metering, energy management, and transportation, generates great business opportunities. The application of M2M enabling technologies to the healthcare sector, in particular, is expected to be one of the major M2M market drivers: market projections forecast that more than 774 million health-related devices with M2M connectivity will be available by 2020, yielding a total revenue of 69 billion euros in that year (Ullah et al, 2009).

II. DESIGN METHODOLOGY

The concept of the Internet of Things (IoT) in relation to technology from one device to another is an M2M that present the process of connecting two or more internet connections to transmit data. This improves reliability with link redundancies, and covers load balancing or failover modes, gathering bandwidth results which also vary in terms of cost

Materials Used

The materials used to achieve this project are

i. Laptop,

ii. MATLAB, and

iii. Visual basic software.

Method

The method used is Sample Selection Method: Sampling method is a process for obtaining sample from a population. The sample here must truly reflect the population, meaning that the conclusions to be drawn from the sample are conclusions on the population. The problem here is the process for sampling and how many units of analysis that will be taken.

Characteristic health status of the patient

Table .1 To Characterize the Health Status of the Patient

SYMPTOMS	VIRUS	TYPE OF ILLNESS	TIME OF IDENTIFICATION	IDENTIFICATION RANGE
HIGH FEVER, HIGH VOMITING AND NAUSEA	PLASMODIUM FALAPARUN, PLASMODIUM ORALE, PLASMODIUM MALARIAE	MALARIA	4 SECONDS	20 TO 40
LOSS OF APPETITE, ENLARGE LEVER, DIZZNESS AND JAUNDICE	HEPATITIS A, HEPATITIS B, HEPATITIS C, HEPATITIS D, HEPATITIS E	HEPATITIS	5 SECONDS	41 TO 70
DIZZNESS ,FEVER,HEADACHE	SERIOUS ILLMENT	SERIOUS ILLMENT	6 SECONDS	71 TO 100

The Mathematical Model: simulation of wireless machine to machine (m2m) based e-health care system becomes.

$$4x + 5y + 6z = 40 \quad (3.1)$$
$$5x + 4y - 6z = 70 \quad (3.2)$$
$$6x - 4y + 5z = 100 \quad (3.3)$$

Where

X is time of identification of malaria.

Y is time of identification of hepatitis.

Z is time of identification of other complex illness.

Then, solving equations 3.1 and 3.2 simultaneously to eliminate z

Recall equations 3.1 and 3.2

$$4x + 5y + 6z = 40 \quad (3.1) \times 1$$
$$5x + 4y - 6z = 70 \quad (3.2) \times 1$$
$$9x + 9y = 110$$

Similarly, solving equations 3.2 and 3.3 simultaneously to eliminate z

Recall equations 3.2 and 3.3

$$5x + 4y - 6z = 70 \quad (3.2) \times 5$$
$$6x - 4y + 5z = 100 \quad (3.3) \times 6$$
$$25x + 20x - 30z = 350 \quad (3.5)$$
$$36x - 24y + 30z = 600 \quad (3.6)$$
$$61x - 4y = 950 \quad (3.7)$$

Then, solving equations 3.4 and 3.7 simultaneously to eliminate y

Recall equations 3.4 and 3.7

$9x + 9y = 110 \quad (3.4) \times 4$

$61x - 4y = 950 \quad (3.7) \times 9$

$36x + 36y = 440 \quad (3.8)$

$549x - 36y = 8550 \quad (3.9)$

$585x = 8990$

$X = 8990/585$

$X = 15.37$

To find the value of y recall equation 3.4 and substitute 15.37 for x

Recall equation 3.4

$9x + 9y = 110 \quad (3.4)$

$9 \times 15.37 + 9y = 110$

$9y = 110 - 138.33$

$9y = -28.33$

$Y = -28.33/9$

$Y = -3.15$

Then, to find the value of z recall equation 3.1 and substitute, 15.37 for x and -3.15 for y

Recall equation 3.1

$4x + 5y + 6z = 40 \quad (3.1)$

$4 \times 15.73 + 5 \times -3.15 + 6z = 40$

$62.92 – 15.75 + 6z = 40$

$47.17 + 6z = 40$

$6z = 40 – 47.17$

$6z = -7.17$

$Z = -7.17/6$

$Z = -1.195$

From the results obtained it shows that time of identification of malaria is 15.37seconds while that of hepatitis is -3.15seconds and that of other complex illness is -1.195seconds.

These obtained results will be used to design M2M rule base that will monitor and diagnose the health situation of the patient at a shorter time interval than the conventional time of diagnosing.

III. DESIGN CHALLENGES FOR MHEALTH APPLICATION

The previously described M2M system architecture can be employed in the context of wireless mHealth applications, aiming to form a communication bridge between the patients and the healthcare providers. At the patient's side, we consider WBANs, defined as low-power short-range networks deployed in the vicinity of the human body, as the prevalent technology for the M2M area (or capillary) network. The nature of WBANs poses inherent limitations not present in regular sensor networks, due to the specific characteristics and requirements of the employed M2M sensor devices.

Furthermore, to provide end-to-end connectivity, the integration of different medium and long range technologies must be ensured, guaranteeing reliable and secure communication. The key design characteristics and challenges that must be taken into account at different stages of the M2M system, in order to design efficient techniques and communication protocols are summarized next. (Latré B, 2011)

i. *Heterogeneous devices and traffic*: In mHealth applications, the M2M devices are usually medical sensors that can be either attached on (wearable or on-body), or placed inside (implantable or in-body) the human body. These devices are capable of establishing wireless communication links, in order to enable continuous patient monitoring and provide real-time feedback to the responsible healthcare provider. Based on their operation, they can be classified as sensors or actuators. Sensors are used to measure external (e.g., motion, location, environmental temperature, *etc.*) or internal (e.g., hear-tbeat, body temperature, muscle movement, brain activity, *etc.*) parameters of the human body. Actuators perform specific actions according to data received from the sensors or inserted by the end user (e.g., a pump for the administration of insulin based on blood glucose measurements). Unlike typical sensor networks, the number of devices in a WBAN is relatively small (*i.e.*, usually restricted within the range of 20–50), with each device having a unique function.

Table 2: Technical characteristics of selected Wireless Body Area Networks (WBAN) sensors for mHealth applications

Sensor	Battery Lifetime	Data Rate	Criticality	Application
Deep brain stimulation	>3 years	1 Mbps	High	Therapeutic benefits for Parkinson's disease, chronic

				pain, tremor, and dystonia
Hearing aid	>40 h	200 kbps	High	Sound amplification
Accelerometers/Gyroscopes	>1 week	1 Mbps	Low	Measurements on motion detection, acceleration and angular velocity
Pulse oximeter (SpO_2)	>1 week	2 kbps	Low	Measurement of hemoglobin oxygen saturation
Capsule endoscope	>24 h	1 Mbps	High	Imaging of the digestive tract
Temperature	>1 week	2.4 bps	Low	Body or environmental temperature measurements
Electrocardiogram (ECG)	>1 week	9.6 kbps	Medium	Heart waveform characteristics
Electromyograph (EMG)	>1 week	100 kbps	Medium	Muscle movement
Gate/Falls	>1 week	250 kbps	High	Fall detection
Electroencephalo-gram (EEG)	>1 week	100 kbps	High	Brainwave activity
Video/Medical imaging	> 12 h	<10 Mbps	High	Digital video transmission

Table 2: contains a list of commonly employed sensors, emphasizing their diverse communication characteristics and requirements. As observed from the table, different types of data must be supported, ranging from plain messages to real-time audio and video content and continuous waveform signals, such as Electrocardiogram (ECG), Electromyography (EMG), *etc.* Consequently, WBANs must be able to handle heterogeneous traffic and support a diverse range of transmission rates. Scalability is also a key feature, enabling the seamless addition or removal of nodes without affecting the network's operation.

ii. *Wireless propagation characteristics*: The propagation characteristics for most well established wireless technologies (e.g., cellular, WLANs, *etc.*) have been extensively studied. In the context of sensor networks, several studies have been made with respect to the signal propagation in different communication media. Nevertheless, wireless communication close or inside the human body introduces new challenges due to the different propagation characteristics of the body area environment. Even though the distances between the nodes are small, WBAN links suffer from high propagation losses, mainly due to user activity, in the case on on-body communications, and power absorption by the human tissue, in the case of implants. In addition, patient mobility and frequent changes in body posture can affect the quality of the wireless link.

iii. *Technology integration*: The wireless technologies employed in the different stages of the M2M system architecture have diverse characteristics and challenges that are often studied separately. Nevertheless, the integration of these technologies into a unified mHealth application is an open issue that must be considered carefully. Therefore, in order to guarantee end-to-end QoS, scalability and ubiquitous connectivity, it is important to adapt the access communication technologies, such as LTE, WiMAX and IEEE 802.11 WLAN, to the characteristics of WBANs, taking into account the requirements of pervasive mHealth applications.

iv. *Reliability*: Closely connected to QoS guarantees, reliability is another important issue in mHealth applications. We define reliability as the guaranteed end-to-end delivery of the transmitted data, from the patient to the medical personnel, or vice versa. The most vulnerable part of the M2M architecture in terms of reliability is the patient-side WBAN, due to the error-prone WBAN channels, which must take into account the particular propagation characteristics of implanted and on-body wireless links and patient mobility.

IV. RESULTS AND DISCUSSION

Table 3: Result the health status of the patient

Symptoms	**Virus**	**Type of illness**	**Time of identification**	**Identification range**
High Fever, High Vomiting And Nausea	Plasmodium Falaparun, plasmodium Orale, plasmodium Malaria	Malaria	4 seconds	20 to 40
Loss of appetite, Enlarge lever, Dizziness and	Hepatitis a, hepatitis b, hepatitis c, hepatitis d, hepatitis e	Hepatitis	5 seconds	41 to 70

Jaundice				
Dizziness, Fever, Headache	Serious Illment	Serious Illment	6seconds	71 to 100

Table 4 Comparing ANN Trainings In Malaria

Months	ANN Training 1 For Malaria	ANN Training 2 For Malaria	ANN Training 3 For Malaria
1	20	10	6.667
2	21	10.5	7
3	25	12.5	8.33
4	30	15	10
5	31	15.5	10.33
6	35	17.5	11.67
7	40	20	13.33

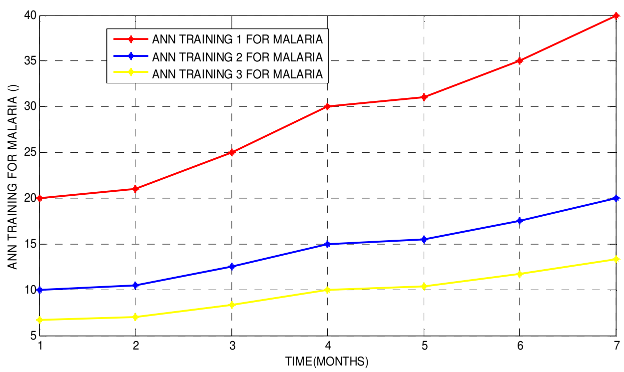

Figure 1: comparing ANN trainings in malaria.

Figure 1 shows comparing ANN trainings in malaria. The ANN training in malaria are done three times, training 1, training 2 and training three. The fastest rate of identification of malaria occurred at month seven when training one identifies malaria at a rate of 40, training two identifies malaria at a rate of 20 and training three identifies malaria at a rate of 13.33. With these results it shows that the fastest rate of malaria identification occurred at training three.

Table 5: comparing ANN trainings in hepatitis

Months	ANN Training 1 for Hepatitis	ANN Training 2 for Hepatitis	ANN Training 3 for Hepatitis
1	41	20.5	13.67
2	45	22.5	15
3	50	25	16.67
4	55	27.5	18.33
5	60	30	20
6	65	32.5	21.67
7	70	35	23.33

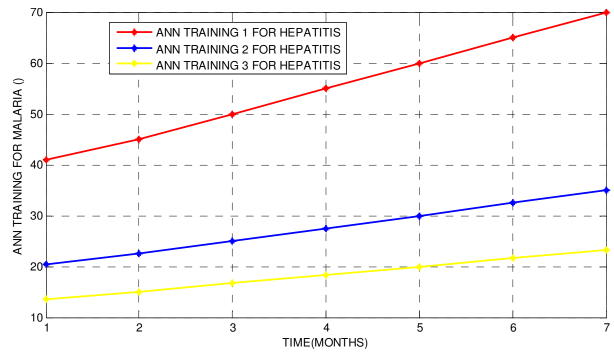

Figure 2: comparing ANN trainings in hepatitis

Fig 2 shows comparing ANN trainings in hepatitis. The highest rate of hepatitis identification occurs at a coordination of ANN training for hepatitis and time coordinates of (70, 7), for the first training of hepatitis, (35, 7) for the second training of hepatitis and (23.33, 7) for the third training respectively. With these results it shows that the training with third training gives the best result in terms of identifying hepatitis fastest than the other two trainings.

Table 6: comparing ANN trainings in complex illness

Months	ANN Training 1 For Complex Illness	ANN Training 2 For Complex Illness	ANN Training 3 For Complex Illness
1	71	35.5	23.67
2	75	37.5	25
3	80	40	26.67
4	85	42.5	28.33
5	90	45	30
6	95	47.5	31.67
7	100	50	33.33

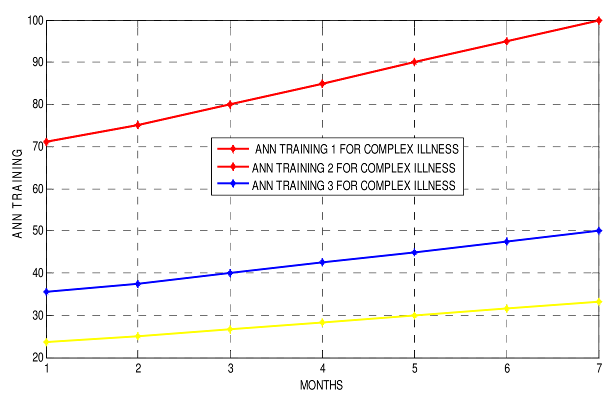

Figure 3: comparing ANN trainings in complex illness

Figure 3 shows comparing ANN trainings in complex illness. The lowest rate of identification in the first, second and third training of complex illness are 71, 35.5 and 23.67 respectively. With these results, it shows that the more the training the faster the identification of complex illness.

Table 7: Comparing Period OF Illness Identification AT Different ANN Trainings

Time	ANN training 1 for period of illness identification	ANN training 2 for period of illness identification	ANN training 3 for period of illness identification
0	0	0	0
1	5.5	2.6	1.8
2	3.5	1.7	1.2
3	4.2	2.2	1.4
4	4	2	1.33
10	4	2	1.33

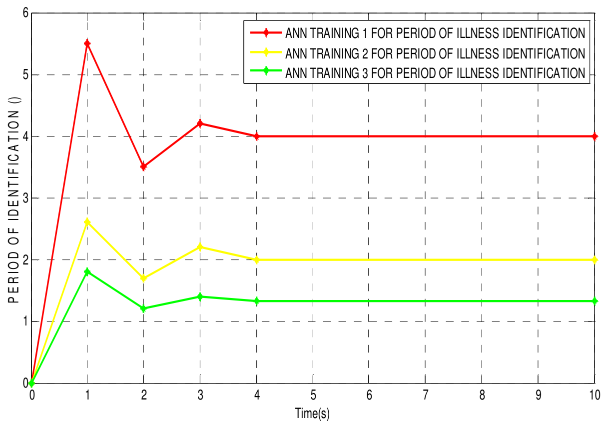

Figure 4: comparing period of illness identification at different ANN trainings.

Figure 4 shows comparing period of illness identification at different ANN trainings, The stability ANN training for the first, second and third trainings are (4, 4) through (4,10) for first ANN training (2, 4) through (2, 10) for second ANN training and (1.33, 4) through (1.33, 10) for third training. With these results, it shows that the third training identifies malaria fastest when compared to the other two ANN trains.

TABLE 8 comparing conventional malaria detection, fuzzy malaria detection, ANN malaria detection and wireless malaria detection

Months	CONVENTIONAL Malaria Detection	FUZZY Malaria Detection	ANN Malaria Detection	WIRELESS Malaria Detection
1	20	12	6.667	4.286
2	21	12.6	7	4.5
3	25	15	8.33	5.357
4	30	18	10	6.429
5	31	18.6	10.33	6.643
6	35	21	11.67	7.5
7	40	24	13.33	8.571

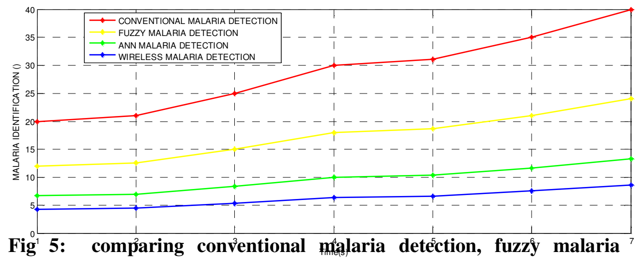

Fig 5: comparing conventional malaria detection, fuzzy malaria detection, ANN malaria detection and wireless malaria detection.

Fig 5 shows comparing conventional malaria detection, fuzzy malaria detection, ANN malaria detection and wireless malaria detection. The result obtained is conventional malaria detection of 40, fuzzy malaria detection of 24, ANN malaria detection of 13.33 and wireless malaria detection of 8.571. With these results, it shows that wireless malaria detection gives the best among them all in terms of fast detection.

V. CONCLUSIONS AND RECOMMENDATION

Summary of Finding

The rate of death experienced in the society this time around has arisen as a result of not having proper medical facilities that can detect illness before it escalates. This can be controlled with the application of the developed wireless machine to machine (m2m) based e-health care system. Characterizing the health status of the patient, designing M2M rule base that will monitor and diagnose the health situation of the patient at a faster rate, training ANN in M2M rule base for an effective monitoring and diagnosing of the patient health condition at a faster rate are the basic results. Designing a visual basic modeling and simulation of wireless machine to machine (M2M) based e-health care system, designing a MATAB SIMULINK modeling and simulation of wireless machine to machine (M2M) based e-health care system, validating and justifying the percentage effectiveness of diagnosing the patient symptom fast with and without wireless M2M was also achieved. The results obtained are The fastest rate of identification of malaria occurred at month seven when training one identifies malaria at a rate of 40, training two identifies malaria at a rate of 20 and training three identifies malaria at a rate of 13.33. With these results it shows that the fastest rate of malaria identification occurred at training three, the highest rate of hepatitis identification occurs at a coordination of ANN training for hepatitis and time coordinates of (70, 7), for the first training of hepatitis, (35, 7) for the second training of hepatitis and (23.33, 7) for the third training respectively. With these results it shows that the training with third training gives the best result in terms of identifying hepatitis fastest than the other two trainings, the stability ANN training for the first, second and third trainings are (4, 4) through (4,10) for first ANN training (2, 4) through (2, 10) for second ANN training and (1.33, 4) through (1.33, 10) for third training. With these results, it shows that the third training identifies malaria fastest when compared to the other two ANN trains. The result obtained is conventional malaria detection of 40, fuzzy malaria detection of 24, ANN malaria detection of 13.33 and wireless malaria detection of 8.571. With these results, it shows that wireless malaria detection gives the best among them all in terms of fast detection.

Contribution to knowledge

The MATLAB design of e health care using wireless machine to machine would enhance the rapid identification of the type of symptom a patient is suffering from by the doctor.

Conclusion

Concluding, despite the considerable amount of work conducted in the rapidly growing area of M2M communications for mHealth, there are still many open issues to be addressed. Apart from the specific challenges in each aspect of the mHealth systems, efforts must be concentrated on standardization activities that will enable the market exploitation of the scientific contributions in this field by paving the road for the development of interoperable M2M mHealth solutions.

Recommendations

In near future intelligence should be incorporated in the wireless machine to machine based e – health care system to enhance the efficiency of detecting early symptom of an illness before it becomes worst.

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SIMULATION CODES

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A = [ 1 2 3 4 5 6 7 ];
B = [20 21 25 30 31 35 40];
C = [10 10.5 12.5 15 15.5 17.5 20];
D = [6.667 7 8.33 10 10.33 11.67 13.33 ];

plot(A,B,'-
Sr','MarkerFaceColor','r','MarkerSize',1
2,'Linewidth',3);
hold on
plot(A,C,'-
Pb','MarkerFaceColor','b','MarkerSize',1
2,'Linewidth',3);
 hold on
plot(A,D,'-
Py','MarkerFaceColor','y','MarkerSize',1
2,'Linewidth',3);


grid on
Ylabel(' MALARIA');Xlabel('Time
(MONTHS)')
Legend('ANN TRAINING 1 FOR
MALARIA)','ANN TRAINING 2 FOR MALARIA
','ANN TRAINING 3 FOR MALARIA')
```

```
A = [ 1 2 3 4 5 6 7 ];
B = [41 45 50 55 60 65 70];
C = [20.5 22.5 25 27.5 30 32.5 35];
D = [13.67 15 16.67 18.33 20 21.67
23.33 ];

plot(A,B,'-
Sr','MarkerFaceColor','r','MarkerSize',1
2,'Linewidth',3);
hold on
plot(A,C,'-
Pb','MarkerFaceColor','b','MarkerSize',1
2,'Linewidth',3);
 hold on
plot(A,D,'-
Py','MarkerFaceColor','y','MarkerSize',1
2,'Linewidth',3);

grid on
Ylabel(' HEPATITIS');Xlabel('Time
(MONTHS)')
Legend('ANN TRAINING 1 FOR
HEPATITIS)','ANN TRAINING 2 FOR
HEPATITIS ','ANN TRAINING 3 FOR
HEPATITIS')
```

```
A = [ 1 2 3 4 5 6 7 ];
B = [20 21 25 30 31 35 40];
C = [12 12.6 15 18 18.6 21 24];
D = [6.667 7 8.33 10 10.33 11.67 13.33 ];
E = [4.286 4.5 5.357 6.429 6.643 7.5
8.571 ];

plot(A,B,'-
Sr','MarkerFaceColor','r','MarkerSize',1
2,'Linewidth',3);
hold on
plot(A,C,'-
Py','MarkerFaceColor','y','MarkerSize',1
2,'Linewidth',3);
 hold on
plot(A,D,'-
Pg','MarkerFaceColor','g','MarkerSize',1
2,'Linewidth',3);

 hold on
plot(A,E,'-
b','MarkerFaceColor','b','MarkerSize',12
,'Linewidth',3);

grid on
Ylabel(' MALARIA');Xlabel('Time
(MONTHS)')
Legend('CONVENTIONAL MALARIA
DETECTION)','FUZZY MALARIA DETECTION
','ANN MALARIA DETECTION','WIRELESS
MALARIA DETECTION')
```