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Internet of Things based Physical Activity Monitoring (PAMIoT): An Architectural Framework to Monitor Human Physical Activity

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***Abstract*—Internet of Things (IoT) has gain huge popularity in science community in last few years. Due its prospect in future internet domain many applications area have emerged. Health care is the most vital zone where IoT could play important role. For sake of well being of health, physical activity has become a keen part of modern life. Monitoring physical activity has most of time been under clinical supervision though recent literatures have shown development of few devices in digital domain. They lack in standardized design architecture, hence not applicable to get acquainted with network which has become a mandate to mankind. This paper studies the architectural framework for monitoring physical activity based on IoT in structured way. We propose a novel framework for Internet of Things based Physical Activity Monitoring (PAMIoT) to visualize measure and analyze the physical activities of human in daily life. PAMIoT is envisaged to be promising for physical activity monitoring purposes by complying technology enabled smart living in near future.**

***Index Terms*—Internet of Things, framework, pervasive health monitoring.**

I. Introduction

THE Internet of Things (IoT) is defined as "The Internet of Things allows people and things to be connected Anytime, Anyplace, with Anything and Anyone, ideally using Any path/network and Any service. [1]" From the advent of IoT in Auto-ID Centre at MIT at the beginning of 2000 many technological growths have been accomplished by scientific researches. According to Gartner [2] around 26 billion devices will be connected to Internet in 2020 [3]. Due to the development of sensor technologies in all degrees of life such as industrial, bio, chemical etc., microcontroller [4] based platforms and networking protocols development of embedded systems [5] have been easier.

Healthcare has always been a serious issue in all time for mankind. With the rapid development in internet technologies in last decade, smart healthcare has become evident in our livelihood. Smart phones and hand held digital devices have changed the world and the way of thinking. Physical activity is the basic job of our normal lifestyle which is becoming more narrative to the consciousness of the stress full livings. Many technologies and devices have been developed and marketed in last few years to counter the gap between the human and the monitoring of their physical activities. All the developments done so far lack in common environmental communication or platform hence provide vertical silos in tackling this gap in a structured way. This motivates to author an architectural framework to cater the need of bridging the missing link between man and its activity monitoring based on IoT.

Internet of Things based Physical Activity Monitoring (PAMIoT) is the novel and first ever designs of monitoring physical activity through the usefulness of IoT in form of framework. PAMIoT advocates the handy use of access to the applications made to measure, analyze and visualize the data gathered from various biosensors while busy in physical activities. The information processed by microcontroller or open source platform is then transferred either Andriod, and/or IOS based smart devices or could be stored at Cloud for further analyzing. PAMIoT is so designed that it could be implemented in and out door locations with help of number of communication protocols and microcontroller support. PAMIoT is envisaged to perform successful monitoring activities deploying less connectivity issues, cheaper cost, and plug n play support. The application of this framework could be in the fields like sports, gymnasium, clinical, and personal.

The rest of paper is as follow. Section II deals with related work. Section III describes details of PAMIoT. Section IV concludes the work.

II. Related Work

Very few researchers have pointed out the frameworks for health monitoring using IoT. Assisted living has been given priority to facilitate the elderly people. But, normal aged (14-55 years) people should be equipped with the flavor of smart health care management while performing physical tasks either at home or outside and any time at ease.

In [6] authors design a sensing model springs from the reference structure tomography (RST) paradigm [7], which in turn permits scan-free multidimensional imaging, data-efficient, and computation-efficient source analysis. The reference structure plays the role of modulating the visibility between the object space and the measurement space. Thus, after object space segmentation, the spatial awareness of the PIR sensors in the measurement space is enhanced, and spatio-temporal feature of the fall could be captured by the PIR. Several PIR sensors with their own masks are multiplexing in one sensor node to modulate the visibility pattern of the object

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space. [8] presents a literature survey of state-of-the-art Ambient Assisted Living frameworks, systems and platforms to identify the essential aspects of AAL systems and investigate the critical issues from the design, technology, quality-of-service, and user experience perspectives. [9] has proposed Home Health Hub Internet of Things (H^3IoT), an architectural framework for monitoring health of elderly people which is developed for preventive health, proactive monitoring, follow-up care and chronic care disease management.

III. PAMIOT

Internet of Things based Physical Activity Monitoring (PAMIoT) is a 5-layered framework to visualize and analyze physical activity of a person. The PAMIoT (Fig. 1.) is a concrete layered approach towards the solution of long awaited problem of activity monitoring of physiological performance. The architecture comprises of biosensors, microcontroller, communication technologies, gateway, applications, and internet as backbone. When in practice, PAMIoT provides a novel way of inter conjugation of various modules either in software or hardware, resulting effective, portable, and plug n play based framework. User wearing (stand alone model will also work) a device compensated with PAMIoT would be capable enough to validate the daily calorie consumption, and heart rate detection. All of the information collected would help user get a real measurement of his/her physical activity. Whether he/she wants to get fitter or even if they want to see improvement in their preferred sport the more he/she can know about his/her body, the better.

A. Physiological Sensing Layer (PSL)

This is the bottom most layer of PAMIoT comprises of biosensors (devices). Example includes Electrocardiogram (ECG) –measures heart activity, Pedometer– measures vertical acceleration to count steps and accumulate total time spent at certain activity intensity. When positioned correctly, this device could record each step and can also measure common activities like going up and down the stairs, bending to tie your shoes, etc. They are normally worn on the user's hips or on the wrist, and Pulse Oxymeter– measures SpO2 (dissolved oxygen in blood) along with pulse. The data collected from PSL is elevated to upper layer for necessary action to be taken

B. Local Communication Layer (LCL)

LCL is 2nd most bottom layer of PAMIoT architecture. LCL plays a vital role by transferring the sensed data at PSL to upper layers. The communication technologies reside in PSL basically act in low geographical range (0.3 – 3 meter) to facilitate the intrabody communication. BTLE (Blue Tooth Low Energy), BT HDP (Blue Tooth Health Device Profile), BT SSP (Blue Tooth Secure Simple Paring), and IEEE 802.15.4 (Low Rate Wireless Personal Area Network – WPAN) are various technologies which perform best in such scenario. Data from LCL is elevated next higher level for further work.

C. Information Processing Layer (IPL)

IPL is the soul of PAMIoT. Microcontroller or open source hardware platforms might be in place in order to process the data obtained from LCL to information for further actions in higher layers. Proprietary platforms such as MicaZ [10], Libelium[11] etc. and open source initiatives as Arduino [12], Raspberry Pi [13] are now being used plenty in similar type of researches. Gateway (a network point that acts as an entrance to another network) links its information at IPL to upper layers implying 2G, 3G, 4G or WiFi connectivity.

One important thing worth noting is that LCL could by pass through IAL (Internet Application Layer) (described later) for direct processing at UAL (User Application Layer, see later). This would help user out in offline mode.

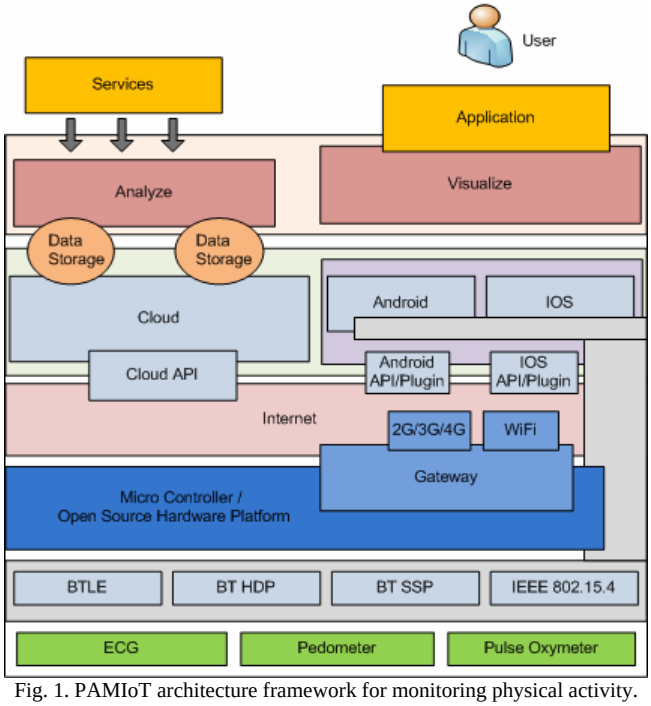

Fig. 1. PAMIoT architecture framework for monitoring physical activity.

D. Internet Application Layer (IAL)

IAL is the backbone of the system – e.g., Internet. Information received from IPL is conveyed to Andriod [22], IOS [23], or Cloud [24] (xively [14], Ayla [15], Axeda [16], Exosite [17], Open Source IoT Cloud [18] etc.) platforms for visualization and or storage and analyze at later stage. API (Application Programming Interface) [19], APP (Mobile App) (A mobile app is a computer program designed to run on smart phones, tablet computers and other mobile devices.) [20], Plug in (a software component that adds a specific feature to an existing software application) [21] are various software which increase accessibility of internet in Andriod, IOS devices as well as Clouds. Android API, IOS API, Cloud API are used to enact with internet for sake of information required by user in UAL. Cloud is made basically for data storage (age and weight of user, various foods and their calorie) which might be used by analyzing applications run at UAL to provide accurate status of user's health condition.

E. User Application Layer (UAL)

UAL is the top most unit of PAMIoT. UAL can be said as the nearest touch point of PAMIoT to the user whom the real time information about physical activity and status of health should be made for. Mostly visualization of received and processed information from IAL is done in UAL. Recently, *Journal of Sports Sciences* has published the following formula which could correctly make out the status statement of health of user. Equation (1) and (2) states the calories burned for long Time activity for men and women respectively. Theses equations might be incorporated at visualization application and/or analyzing application.

Men:

Calories Burned = [(**Age** x 0.2017) - (**Weight** x 0.09036) + (**Heart Rate** x 0.6309) - 55.0969] x **Time**/4.184 (1)

Women:

Calories Burned = [(**Age** x 0.074) - (**Weight** x 0.05741) + (**Heart Rate** x 0.4472) - 20.4022] x **Time**/4.184 (2)

IV. CONCLUSION

Internet of Things has become a real life changer in recent past through its virtue of applicability in many zones from logistics to environment monitoring and retails to agriculture. Health care is one of these which demands a motivational support by us that can only be accomplished by IoT in compact and handy way.

This research work has developed PAMIoT to monitor physical activity in all spheres of life especially in daily life. This approach is capable to solve the problem of healthy mankind for sure.

Talking about pros, PAMIoT has low energy communication technologies along with open source hardware platform which hold the key of durability of the system as well as cheap and easy maintenance. Simple architecture makes PAMIoT efficient to perform in less constraint environment. Where as PAMIoT is for general purpose monitoring only but could not be justified for monitoring critical physiological aspects. In future implementation of PAMIoT in a chain of devices and related security issues should be investigated.

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