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# Fuzzy Logic Based IOT Devices for Human Health Care

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## ABSTRACT

In the last few years of modern science in health care, the process of monitoring people health status has grown in interest in the researcher community and led to develop of new devices able to detect and analyse information gathered from many kind of sensors to sense the human health in terms of Blood pressure, heart beats etc.

These devices are commonly designed to monitor or diagnose disease in the medical field. Those people who want to monitor their health status by using low cost devices, in such case it is very important. In this work we propose a fuzzy logic approach in which the device tries to learn and fit customer habits in order to discover outlier warning signals. The real-time monitoring and analysis of gathered data from body sensors is accomplished. User status is carried out using a Fuzzy Logic based network. To implement the fuzzy logic, we need to have two stage filters where, the first stage will give us the current activity of the user while second stage will provide information about health status in terms of heart rate.

***Keywords:-*** IoT, Fitness, E-Health, Health Care

## I. INTRODUCTION

During last decade, the attention on keeping a good health status through the use of monitoring devices has been grown in interest. These interests regard not only medicine goals but also monitoring performances during the other aspect of health care like heart beats, blood pressure, diabetes etc. Moreover, a lot of money is spent on expensive devices able to gather data about health performances with the main goal of keeping a good health and

improving life quality [1]. Here we are going to put attention on the realization of a low cost wearable device to collect, analyse and classify data in order to monitor user health status. The device is connected with a cloud system to make a further investigation on collected data as well as analyse them to better fit device parameters to the specific user. In this way there is a continuous parameters customization that adapts the device to the user. In our proposed system a low-power wireless access device is used to give the possibility to send data towards the cloud system. Received data are analysed in real-time on-board, classified, clustered, and then sent to the cloud. In such system, the data exchange is ensured by Zigbee and Bluetooth networks. The data are not pre-processed for the real-time analysis but are aggregated before the transmission to the cloud storage.

## II. SMART DEVICE AND COMMON ISSUES

In this proposed work we are going to classify person health behaviour in terms of activities. Human body consist of many organs and each organ has its own functionality. So measuring the activity of organs is a typical task and thus through this we can easily predict the health status of a person [2]. Here the classifier has to identify in the most accurate way the activity of the user wearing the device. In this way is possible to map the current heart rate value with reference values previously acquired. In order to achieve these goals we introduce a set of sensors and a micro-controller in the device able to create a Body Area Network (BAN).

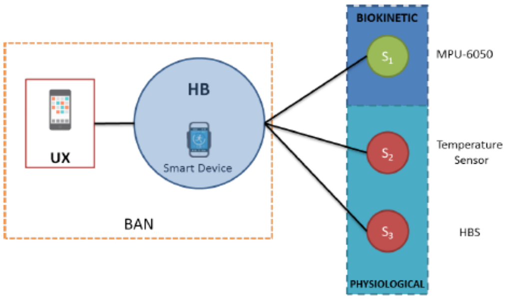



Fig.1. BAN example where several sensors are connected between them and to a base station that is commonly represented by a Smartphone

A human system is basically consist of following activity phases and through this we can classify the stages as follows.

### Stage- A. Human System

One of the most important function is the possibility to run several tasks in background avoiding users to interact directly with other software or hardware. Often, the Human Computer Interface (HCI) is considered as a resultant of two separates components, human and computer, but the main goal in this field is to have a joined entity where the human and the machine are strictly connected. The main reason is that we are looking for technologies that help us to make multiple actions in a shorter time.

**Stage- B. Sensors**

A Body Sensor Network (BSN) is composed by sensors and actuators. Some are less complex like heart-beat monitor sensors others instead could be more sophisticated like auto-injecting syringes able to administer medicine remotely.
Several ”sensor nodes” are placed on the user body and it is possible to define a general architecture for all of them. These Sensors can be divided in three main groups:

1. Physiological Sensors: they measure personal physiologic values like : heartbeat , blood pressure or the electrical brain activity Electroencephalography (EEG)
2. Biokinetic Sensors: they measure movements making the architecture space-aware
3. Environment Sensors : they measure values from the environment like temperature and humidity

**Stage- C**.

Heart Beat Rate (HBR) Unit in fitness applications During physical activities the heart beat rate increase to ensure the energies that are necessary to the body to support the strain. HBR monitoring represents a very important parameter in physical activities. Measuring HBR during physical activities allow to gather important information about energy consumed and about the exercise quality. It also allows monitoring in real time the health status of the person notifying the user if something is wrong.

## III. HUMAN ACTIVITY RECOGNITION (HAR)

To perform this activity we need to take under consideration how the human body move into the environment. Several techniques could be used some of them are more complex and invasive than others. The main categories of these systems are herein summarized:
The optoelectronic systems are based on the video analysis of markers positioned on the human body [4].
Electromyography (EMG) system evaluates muscles activities monitoring the Muscle Action Potential (MAP).
This method offers good performances and low errors but it is invasive and not easy to wear.

## IV. PHYSICAL ACTIVITY RECOGNITION

In this work we consider several activities as input for the fuzzy logic. Considered input for the logic block are:

- Resting (R)
- Light Walking (CL)
- Fast Walking (CV)
- Running (C)

As output the fuzzy logic block shall give the following results:

- Resting
- Walking
- Running

The Fuzzy Logic (FL) challenges and changes the concept of binary logic (only two states): in the real world everything is a matter of measure, not only white or black, but also shades [14]. Unlike the binary logic, to allow a greater relationship with the natural language, the fuzzy sets do not provide ”hard” boundaries but include a landmark change in the considered values. The Membership Degree (MD) of an object referred to a fuzzy set can assume any value in the range [0,1], unlike a traditional set, which is restricted to the values 0 and 1 (false and true): in FL, the MD is to be intended as indicating ”how much” a property is true. Through some inputoutput relationships it is possible to approximate any function or system to describe or control. One of the most usual inference method is the Mamdani approach [1, 4], divided into four main steps:

- Input fuzzyfication,
- Inference rule evaluation,
- Aggregation and
- Defuzzyfication.

### A. Algorithms:

```
while True do
gather data from Sensors;
filter data;
aggregate data;
analyze data;
if is connected to device then prepare data for REST service;
send data to REST service;
if data sent then
start from the beginning;
else
try to send data again;
end
else
try to peer device;
end
end
```

Algorithm 1: Smart Device main function

### B. Using sensors to recognize activity

By using the sensor, we can also recognize the activity of Human organs and we can predict the health status. To make this feasible, we use a fuzzy logic schema to infer info about status of the person that is wearing the device [1, 4]. Main Flow is shown in algorithm algo.1. During the first stage of the main loop device starts to gather data from sensors exploiting the BAN connections. These data are sampled, filtered, aggregated and partially analysed on board. After the device checks connection with the Smartphone and if everything is ok it prepares data and sends it remotely.

### C. Data sampling in IoT on-line service

When we are going for non- real time approach, at this stage the more complex actions are performed on the cloud-assisted platform initialized on the thingspeak.com services [1, 3]. Since data transfer is based on a wireless transmission one of the main issue is represented by the power consumption, in fact sending data continuously is not a good idea. Therefore, it is important to find the right trade-off between power consumption and data reliability.

## V. REAL CASE MEASUREMENTS

In the real time analysis, we need to monitor the person in various aspects. This pool was heterogeneous and it was composed of young people that presented good health status. Measurements have been compared with reference values carried out from medical instrumentations for HBR; regarding activity recognition we had a direct feedback by knowing user activities.

### A. First Stage : HAR

In the reference block of fig.3 the activity recognition classifier is shown. As it is possible to see this block is built taking into account only acceleration along X and Z axis. In fact, after several observation it has been carried out that the Y-axis is useless for the recognition step.

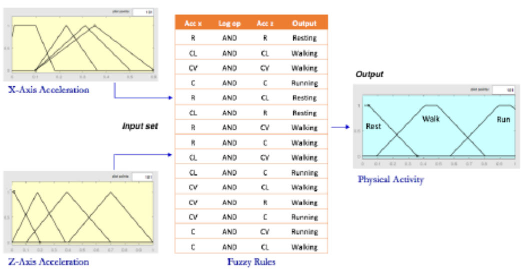
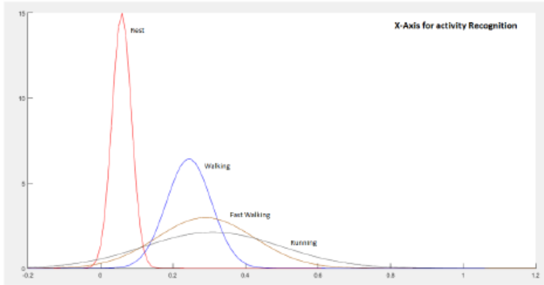



Fig. 3. Fuzzy Physical Activities Recognition Block

it is also possible to note the importance of the acceleration along the 3-axis in the

In this reference data we are going to compare the health status using HAR . In this case the graph obtained as follows.




Here in the diagram, the red graph is the standard reference we need to have for a good health person. And the blue one is the result obtained on the consider list parameter.

### B. Second Stage : Monitoring

The device performs a continuous monitoring of the customer acquiring its HBS, and Bo-kinetic data coming from sensors; these data are used to perform a real-time monitoring. It is important to recall that the device can fit reference data by adjusting parameters during its use.

### C. Warning rising

In this section we focused on warning recognition and how to report it to users. First of all the device recognizes individual activity; once the activity is known the right reference data set is considered and used to identify the range of the HBR. This step is performed in a real-time manner using a second step of fuzzy logic that takes into account following status, which are :

_ Resting
_ Walking
_ Running

### D. Reference Heart Rate Values

Form the above reference analysis, we can compute the value of MHRF with the help of two equation such as eq.1, which is possible to identify the MHRF, instead by using the eq.2 the feasible range for the HBR can be found. In eq.1 and eq.2 the term represents the Resting Heart Beat Rate (RHBR) and the term is the HBR actually measured.

$$MHRF = 208 - (0{:}7 * age) \quad (1)$$

$$MHRF_{Range} = (\beta - \alpha) * \%V\ O2max + \alpha \quad (2)$$

For testing scope a deep analysis has been performed with the main goal of finding the right configuration for the system. Once this step has been ended several data set have been created.
A classifier has been developed taking into consideration equations eq.1 and eq.2 and using the same Matlab tool already shown for the first stage. Making a join among data achieved by the eq.1 and the data obtained by real observation a model for detecting anomalies has been obtained.
HBR is recognized by dedicated sensor and exploiting the BAN this data reaches the smart device. Applying eq.1 the related activity in a normal status can be recognized. Moreover, by using the model that is based on a fuzzy logic block it is possible to raise alarm if data do not match a normal status.

## VI. CONCLUSION

In this work we present a smart device in the IoT domain able to recognize users activities and rises warnings when some outliers are discovered. This mechanism is based on a two stage classifier that uses fuzzy logic approach to perform activities recognition and anomalies detection. The core of the device is composed of an Arduino based architecture that is connected with several sensors by creating a BAN.

## REFERENCES


[1] Fritz, Thomas and Huang, Elaine M. and Murphy, Gail C. and Zimmermann, Thomas Persuasive technology in the real world: a study of long-term use of activity sensing devices for fitness Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, CHI '14, 2014, Toronto, Ontario, Canada, pp. 487–496 10.1145/2556288.2557383

[2] Oscar D, Labrador L, Labrador M, A Survey on Human Activity Recognition using Wereable Sensors in IEEE Communication Surveys & Tutorials Vol 15 No.3 Third Quarter 2013

[3] Cleland, I.; Kikhia, B.; Nugent, C.; Boytsov, A.; Hallberg, J.; Synnes, K.; McClean, S.; Finlay, D. Optimal Placement of Accelerometers for the Detection of Everyday Activities Sensors 2013, 13, 9183-9200

[4] L. Atallah, B. Lo, R. King and G. Z. Yang Sensor Placement for Activity Detection Using Wearable Accelerometers Body Sensor Networks (BSN), 2010 International Conference on, Singapore, 2010, pp. 24-29. doi: 10.1109/BSN.2010.23