Intelligent Private Fitness System Based on ARM and Hybrid Internet of Things

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Abstract. With the purpose of being fit, slim and active, a popular trend of gym culture is sweeping the whole current society. However, some drawbacks have gradually surfaced. On top of that, facing some of the common barriers, those new styles of different body-building activities could even do more harm then good to the individuals where these negative effect on the long-time training is not visible until the individual is facing physical injuries. For those reasons, this paper proposed a novel personal fitness system based on the ARM which attempts to match the requests of environmental friendly. Specifically, inventing a more scientific option of body building than the traditional gym to prevent incorrect ways of training and guide the individuals to do healthy exercises by utilizing visual personal training system and internet to design a distributed mobile application.

Keywords: Private fitness system · ARM · Energy conservation · IoT system

1 Introduction

The gym culture is affecting our daily life with pros and cons. Firstly, exercising in poor ventilated gym will lead to the inhaling of hazardous particles such as carbon dioxide which could cause damage to the respiratory system [1]. Secondly, the demand of equipment and coaches enlarge the usage of fake and inferior supply. Some poorly-funded gyms choose equipment with safety problems. For common people, weekends are their only time of going to the gym while they tend to get no chance of doing proper exercise since these gyms are already full of people. Last but not the least, commercials in the public media and

F. Chen and Y. Luo (Eds.): Industrial IoT 2017, LNICST 202, pp. 91–101, 2017.
DOI: 10.1007/978-3-319-60753-5_10

commercialize operational system lure consumers to go to the gyms with a low cost performance but a high threshold [2]. As a result, some of them are not qualified as a high standard gym.

This idea is inspired by the research we conduct about smart home. Since a lot of research is poured in improving the environment of gymnasiums such as "The new public gymnasium air purification intelligent control system" [3] and "Unhealthy factors in the gym" [4], we began to wonder if there is an alternative way of working out. Combined IoT technology, we present a personal fitness system which is highly innovative, because the latest paper we can find that is similar to our project is "Virtual intelligent fitness system based on embedded ARM" [5] from 9 years ago. Meanwhile, scattered research achievements like Heart Rate Monitoring Systems in Groups for Assessment of Cardiorespiratory Fitness Analysis or "Smart shoes design with embedded monitoring electronics system for health-care and fitness applications" [6] and "Healthy Together: exploring social incentives for mobile fitness applications" [7] have enabled us to build a multi-functional integrated fitness system as a substitute which has not been taken into account of by sales market despite of such sophisticated R&D environment.

This paper proposes the idea of personalizing the fitness activities so that each person could exercise with the guidance of the 'personal coach' and tailor-made equipment in the form of applications. As a result, the quality of the equipment and coaches, exercising environment, scientific methods of exercising and a low cost performance could be ensured. According to the feedbacks collected by the sensors of pressure, visual, gravity and so on by the equipment to the consumers, those processed information could guide consumers intelligently to do healthy exercise. Individuals do not have to stand in the lines for the treadmills, bench press equipment and exercise bicycles. Apart from that, the lack of resources and misleading problem could be settled.

2 System Designation

The core part of our proposed system is based on the ARM (Acorn RISC Machine) which presents a high cost performance, code density, excellent real-time interrupt response and low electricity consuming with a small piece of silicon chip. Specifically, ARM is an ideal option for the embedded system that could assume more significant functions other simple SCM (Single Chip Micyoco) cannot, for instance, micro control system 51 Series and Arduino. It also has enough pins of GPIO and ADC (Digital Analog Conversion) that can be connected to the number of sensors. Additionally, its external RAM and ROM could strengthen the ability of algorithms and memories. External screens have the ability of making the operations more humanized. Built-in value-set registers enable the system to update the data from the cloud. All those advantages make the ARM the best choice of completing the fitness system.

The basic design is built on the entire integral fitness equipment. As Fig. 1 shows, energy conversion and storage system on the bottom layer of the fitness

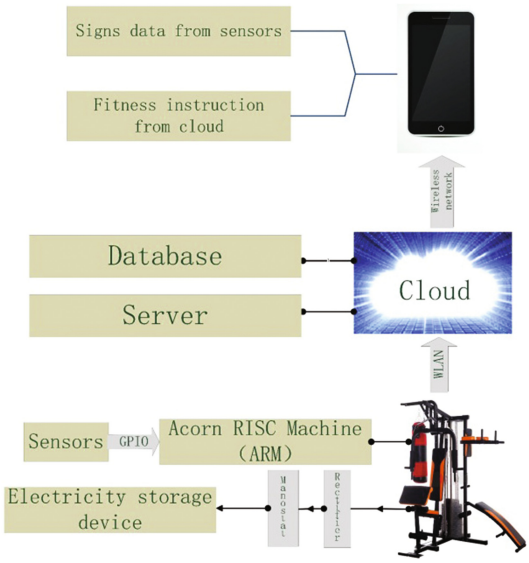

Fig. 1. System structure.

equipment is an innovation of this project. First of all, small-scale generators are installed on each body-building module and stored in the storage devices after adjustment to reduce or even avoid the power loss. Secondly, several sensors (the processor is ARM) are embedded to construct the base of the feedbacks to the mobile terminal. Moreover, data are sent by the ARM through Wi-Fi to Cloud services and database to be integrated with those are already in the cloud before sending to the mobile terminal app. Eventually the consumers are able to gain intuitive results of exercising with processed data from sensors.

3 System Realization

3.1 Energy-Saving System

Considering energy-saving and emission reduction, several small-scale generators with a common output are installed on the bottom layer of the highly integrated fitness equipment. Since different means of exercises would generate various kinds and scales of currents, the rectified module is added to transform all the DC (directive current) and AC (alternative current) into DC output. To protect the energy storage module from breaking down by the high voltage and ensure a stable output, a module of adjusting voltage is designed by choosing capacitors as a snuffer in the energy storage module. After this adjustment, the time of charging and discharging is reduced and the circuits of charging is becoming more simple by the use of capacitance which is more suitable for the centralized fitness system with proper control circuit rather than battery.

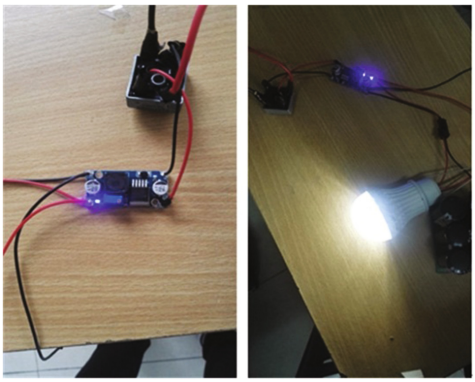

Fig. 2. Energy-saving system realization.

In the stimulating system as shown in Fig. 2, The AC terminal and its diagonal position of KBPC3510 (diode rectifier) are connected to the anode and cathode of the generator respectively. Likewise, the positive terminal and its diagonal position is connected to the anode and cathode of the load which is corresponding to the LM2596 in this system. As for LM2596, the part with completed function of protecting circuit and current limitation, is the output module of the step-down power source control chip with a fixed frequency oscillator (150 kHz) and reference voltage regulator (1.23 V). Utilizing this module and several peripheral components, an efficient circuit with adjusted voltage could be built.

3.2 Data Collecting on ARM

The sensors, such as pressure sensor and pulse sensor, with a carrier of ARM are the basic neurons of the intelligence. For instance, the system could use pressure sensor to estimate if the gesture is standard, pulse sensor to estimate if the amount of exercise has reached the consumer's max physical limit. Also, a speed sensor can be introduced on the chain to detect if users are moderately operating the equipment. Those data could then be shown to the users through WAP browser to ensure a proper gestures and sports intensity which could even be more thorough than the coaches of the gym. Take the pulse sensor (Fig. 3) as an example to set the ARM register: Pulse Sensor measures human being's heart beat by various light transmittance of the human tissue in the veins followed by the process of ARM to transform the stimulate signals into digital signals [8]. Finally, the signals are transformed into electric signals and amplified for an easier calculation.

```
Part of pseudo-code:
rTSADCCON1  |= (1<<16); // resolution set to 12bit
rTSADCCON1  |= (1<<14);     // enable clock prescaler
rTSADCCON1  &= ~(0xFF<<6);
rTSADCCON1  |= (65<<6);// convertor clock=66/66M=1MHz, MSPS=200KHz
rTSADCCON1  &= ~(1<<2);// normal operation mode
rTSADCCON1  &= ~(1<<1);// disable start by read mode
rADCMUX     &= ~(0x0F<<0);
rADCMUX     |= (1<<0);      // MUX choose ADCIN1
while (external interrupt){
    rTSADCCON1  |= (1<<0);         //open ADC
    while (!(rTSADCCON1 & (1<<15))); //wait for opening
      val = rTSDATX1;                  //data from pulsesensor
         upload( val & (0xFFF<<0));
         delay();
}
```

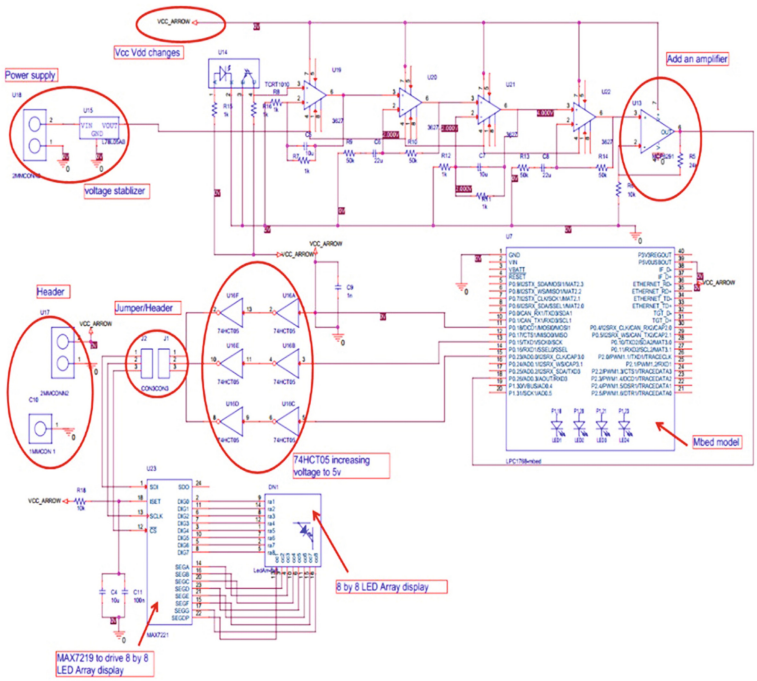

Fig. 3. Pulse sensor circuit realization.

3.3 System Realization Based on Arduino

By presenting a simulated embedded back muscles trainer we can intuitively understand the feasibility of this project. Back muscles trainer is a rather complicated equipment which can demonstrate most of the interfaces needed in this system. So once this part is tackled, we can finish the rest rapidly. The simulated system is based on Arduino, which is more affordable for students and can perform as well as ARM in simple development.

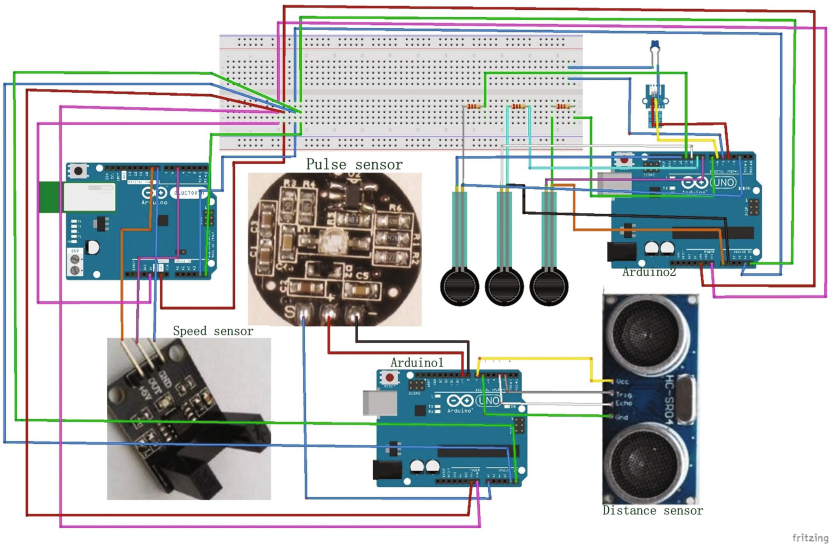

Fig. 4. Schematic of intelligent back muscles trainer based on Arduino.

As initially intended, the sensors are introduced for motion correcting. The schematic is showed in Fig. 4. Sensors are placed on 3 Arduinos to avoid interrupts set for the sensors interfering each other. THD11 is added on Arduino2 to judge the need for warm-up by reading the room temperature. There are also three pressure sensors on Arduino2. Two of them are to detect which part of the bar is held, because which part users hold determines which part of muscles users exercise. The third pressure sensor serves as counter with an external interrupt set. Pulse sensor and range sensor (HC-SR04) are placed on Arduino1. A FIFO queue is used on data from HC-SR04 to acquire the shortest distance which can be combined with users' height gathered from application to calculate if users pull the bar low enough. Timer interrupts are introduced on pulse sensor and speed sensor on Arduino BT (Arduino3) to fulfill the security needs. I2C serial communication technique is applied for data transmission between Arduinos and Bluetooth is used to connect mobile terminal.

```
Key Code:
  Wire.requestFrom(2, 6);
  while(Wire.available())
  {
    count = Wire.read()*256 + Wire.read();
    Serial.print(count); Serial.print('/');
    which = Wire.read()*256 + Wire.read();
    Serial.print(which); Serial.print('/');
    temp = Wire.read()*256 + Wire.read();
    Serial.print(temp); Serial.print('/');
  }

  Wire.requestFrom(3, 6);
  while(Wire.available())
  {
    heart = Wire.read()*256 + Wire.read();
    Serial.print(heart); Serial.print('/');
    cmH = Wire.read()*256 + Wire.read();
    cmL = Wire.read()*256 + Wire.read();
    cm[0] = cm[1]; cm[1] = cm[2];
    cm[2] = (double)cmH+(double)cmL/100;
  }
  if(cm[1]<=cm[0]&&cm[1]<=cm[2])
    mc = cm[1];
  Serial.print(mc); Serial.print('/');
  Serial.println(speet);
  delay(300);
}
```

3.4 Communication Module on ARM

Wi-Fi, a technology that normally uses the radio frequency of 2.4G UHF or 5G SHF ISM, allows the electronic devices connected into the WLAN (Wireless Local Area Network). One of the most significant features of the WLAN is that the internet terminals do not need to be connected by the internet cable, which makes the construction of the internet and the mobile of terminals more flexible.

This system updates the data directly to the cloud without utilizing the traditional sports sensors link between cells and sensors. One of the reasons is that the function of building the base station through the ARM could update the data directly through WLAN. On the other hand, the data that are processed in the cloud could be more accurate than those from ARM terminals. Moreover, the information that state in front of the consumers could be more variable.

The flowchart of the structure of Wi-Fi devices with the software of Linux is shown as Fig. 5. (including WLAN and SPI port drives). In other words, WLAN drive is the interface of the whole process of receiving the data flow from the first stage applications and emitting information through the SPI to the Wi-Fi

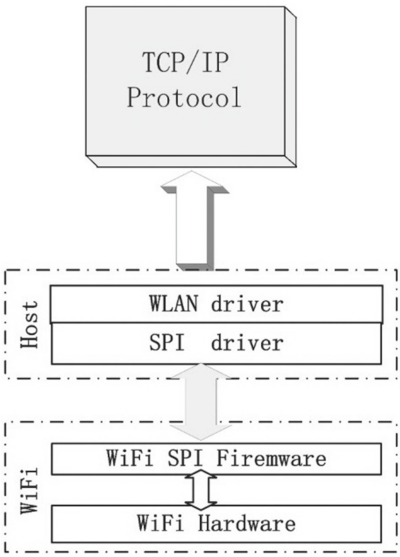

Fig. 5. The structure of Wi-Fi devices.

hardware device. Additionally, if the response from the Wi-Fi hardware devices is cut off, it would read the data from the snuffer region and send them to the first stage applications by the protocol function registered by the programmer [9].

3.5 Feedback Interface and Cloud Server

The cloud and mobile terminals demonstrates the mechanized data and information in front of us in a mimic way as demonstrated in Fig. 6. The cloud data has two parts: first of all, storage of the information from the ARM with the basic information of the consumers forms a view history where people could keep a trace on their effect of body building. Secondly, all kind of recommendation in the cloud could be shared to different groups of people by analyzing their information in cloud. An algorithm is expected to offer them a more scientific way of doing exercise, for instance, share motivating articles about keeping fit to the over-weight groups, and advanced articles that contain more professional guidance to consumers who are already fit and doing exercise regularly.

Nowadays, the methods of cloud storage and transmission are rather sophisticated. Apart from that, mobile application programming has been mastered by a growing number of people. Mysql, thanks to the application of WEB that could be easily used because of the compatibility for most of the programming languages, can customize databases on cloud according to the need of users. On top of that, Apache, an admirable choice of WEB server of WAMP or LAMP is often chosen by most of developers. The PHP (Professional hypertext Preprocessor) is a free open-source scripting language for the service terminal of learning

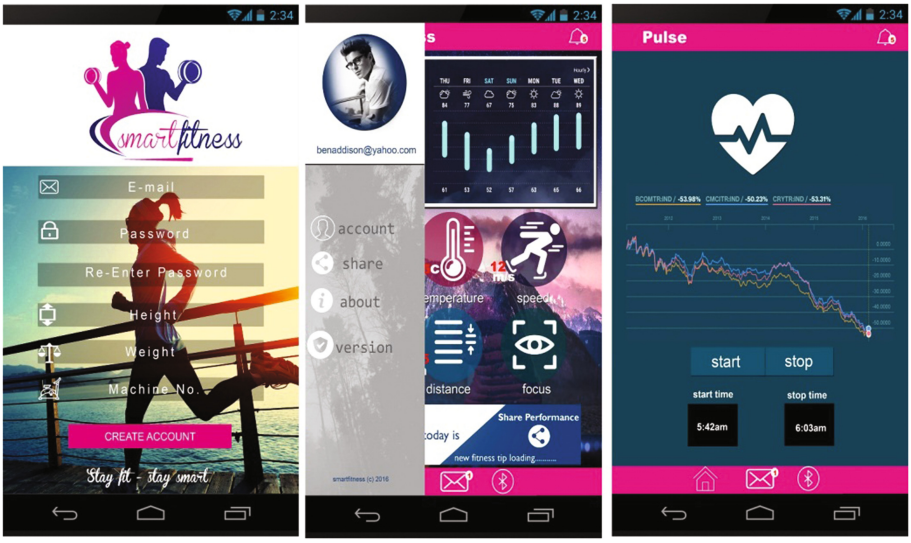

Fig. 6. Mobile App.

```
mysql> select * from userinfo
    -> ;
+----+----------+----------+
| id | username | password |
+----+----------+----------+
|  1 | do       | 4        |
|  2 | GG       | 44       |
|  3 | q        | 1        |
+----+----------+----------+
3 rows in set (0.08 sec)

mysql> select * from sportinfo;
+----+----------------------+--------------------+---------+-----------+--------
---+---------------+------------+-------------+------------+
| id | uid                  | heart_mes          | tmp_mes | sport_mes | light_m
es | generation_mes | sport_time | calorie_mes | date       |
+----+----------------------+--------------------+---------+-----------+--------
---+---------------+------------+-------------+------------+
|  1 | <!DOCTYPE HTML PUBLI | 91.4               | 37.2 C  | 1988J     | 20.4min
   | 4.2?           | 00:15      | 203k        | 2016-11-10 |
| 45 | <!DOCTYPE HTML PUBLI | 46.75              | 37.2 C  | 2232J     | 21.2min
   | 4.2°C          | 00:14      | 213K        | 2016-11-12 |
```

Fig. 7. Data stored on cloud server.

construct dynamic interactive stage. It can also be used cross-platform such as between a Windows or Linux on cloud (Fig. 7). Those kinds of platforms are becoming more and more common, the obstacles in the exploration of the cloud and mobile terminal are barely seen in the current network environment [10].

Along with the development of IoT, the interaction between human and computer becoming more diversified, which means once the interface is provided, technically, we can communicate with one another. Cloud storage enable us to share experience to others, and this feature cater the basic need of being listened. This is the point of this project and the reason it can outperform gym culture.

We focus more on matching fitness with the daily requirement. With a friendly interface shown to users, it is a more effective way to overcome the obstacles mentioned above.

4 Conclusions

A foundation of an industry is not that easy to be overthrown by several experimental experiments. A large quantities of capitals are required if this fitness system is coming onto the market. However, to achieve an expected economic benefit, one of the idea is to match the rigid demand of consumers to attract more users and to sell more entities to gain more profit. A set of sophisticated system after R&D can be manufactured at market price of approximately $1300. The match of hardware and software make the training more scientific and safer. Likewise, facing the shortage on the coaches in the gym, the matching application could enable users to have a personal area to work out with professional instructions. As the replacement of the gym culture, it not only gets rid of the weakness but inherit the previous advantages. In the skyrocketed development IoT industry, our lifestyle is supposed to have more changes than ever by getting rid of the out-of-date methods and choosing the more scientific ones.

Acknowledgments. This work is financially supported by the National Natural Science Foundation of P. R. China (No. 61373017, No. 61572260, No. 61572261, No. 61672296, No. 61602261), the Natural Science Foundation of Jiangsu Province (No. BK20140886, No. BK20140888), Scientific & Technological Support Project of Jiangsu Province (No. BE2015702, BE2016185, No. BE2016777), Natural Science Key Fund for Colleges and Universities in Jiangsu Province (No. 12KJA520002), China Postdoctoral Science Foundation (No. 2014M551636, No. 2014M561696), Jiangsu Planned Projects for Postdoctoral Research Funds (No. 1302090B, No. 1401005B), Natural Science Foundation of the Jiangsu Higher Education Institutions of China (Grant No. 14KJB520030), Jiangsu Postgraduate Scientific Research and Innovation Projects (SJLX15_0381, SJLX16_0326), Project of Jiangsu High Technology Research Key Laboratory for Wireless Sensor Networks (WSNLBZY201509), NUPTSF (Grant No. NY214060, No. NY214061) and the STITP projects of NUPT (No. XZD2016032 and No. XYB2016532).

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