第 49 卷第 05 期
2022 年 5 月

湖南大学学报（自然科学版）
Journal of Hunan University（Natural Sciences）

Vol. 49. No. 05.
May 2022

Open Access Article

WIRELESS VSMS AND ACCELEROMETER SENSORS WITH HIP POSITION ARE USED TO DESIGN A FALL DETECTOR WITH A PATIENT MONITORING.

Ali Yousif Mohawish
Department of Medical Instrumentation Techniques Engineering, Electrical Engineering Technical College, Middle Technical University, Baghdad, Iraq. aliyousif198230@gmail.com

Rasheed Ali Fayadh
Department of Medical Instrumentation Techniques Engineering, Electrical Engineering Technical College, Middle Technical University, Baghdad, Iraq. dr.rashedAli@mtu.edu.iq

Abbas Fadhal Humadi
Department of Medical Instrumentation Techniques Engineering, Electrical Engineering Technical College, Middle Technical University, Baghdad, Iraq.
drabbas1962@gmail.com

Abstract
Fall is regarded as one of the most prevalent and noticeable disorders among the elderly, with a significant influence on their life. The number of technology designed to detect falls has grown considerably in recent years. The proposed article will examine falls in the elderly using a body area sensor network in the hip position. Real-time data and analysis for detecting specific everyday activities as well as certain situations of falls. A wearable light gadget is powered by a battery and uses less energy. Our recommended invention includes a accelerometer sensor MPU 6050 in addition to a processor and a means of transferring data back and forward. Accelerations of aging body motions are provided by the sensor. The microcontroller then monitors the body's position and three-axis accelerations to determine if the body is falling. Also employed in the Vital Signs Monitoring System were TEMP, SPO2 and HR sensors, as well as GPS for location, GSM for data transfer, and a microcontroller for processing. Ten participants aged 35 to 55 years old participated in two ACC categorization trials. A total of 200 samples were collected for each posture in each of the two categories of activity in all of the studies (normal activities and falls). The fall detection system obtained 97.75 % accuracy, 98% sensitivity, and 97.5% specificity in detecting the patient's fall, according to the trial data. In addition, fall alerts were delivered, and the patient's position was detected with good precision in all situations. The vital sign values for the project were equivalent to or near to the benchmark.

Key words :Vital Signs Monitoring System, fall detection, GPS module ,GSM module, accelerometer sensor MPU 6050

1. Introduction

Every year, an estimated 684, 000 individuals die as a consequence of falls throughout the world, with low- and middle-income nations accounting for more than 80% of these deaths An estimated 37.3

Received: February 28, 2022 / Revised: March 31, 2022 / Accepted: April 29, 2022 / Published: May 20, 2022
About the authors：Ali Yousif Mohawish
Email: aliyousif198230@gmail.com

million people require medical attention each year as a result of injuries they sustain from a fall. The fatality rate from falls was highest among adults over 60. [1]. In the preceding year, 27.5% of individuals over 65 reported falling (35.6 million falls), while 10.2% reported an injury connected to a fall in 2018. (8.4 million wounds). When looking at the percentage of adults who say they've had a fall, it rose from 2012 to 2016, but then fell from 2016 to 2018. [2]. Falls in older persons, as well as the precondition for recognizing these functions, have become more popular study issues. Wearable gadgets have been designed for patients to screen vital indicators (for example, pulse (HR), internal temperature (Temp), and quickening) and then transmit a warning to a contact health center via remote technologies such as GSM, ZigBee, and Bluetooth [3, 4]. Also, a GPS module has been used to relay the patient's geographical position to a CEC [5]. Analysts have recently been interested in the design and expansion of the fundamental signs checking framework(VSMS) in light of remote body region sensor organizations (WBSNs). Previous research has examined two important limits for these frameworks: Human Resources and Finance [3,5 - 7]. Based on the sensor technology utilized for monitoring, all current fall detection systems may be categorized into three categories: wearable sensors, ambient sensors, and vision-based sensors. In the majority of wearable fall detectors, an accelerometer is employed [8]. A real-time fall detection and rescue device for monitoring a big population. Smartphones, Raspberry Pi, Arduino, and bespoke Embedded Systems are all viable options. The accelerometer information from the devices are continually sent to a multithreaded server. The suggested machine finish has a 97 % accuracy, a 96.3 % sensitivity, and a 99.6 % specificity of 99.6 %.If a fall is observed, the server sends an SMS to the mediator in the consumer's region. As a failsafe, the matching gadget sounds the alarm to inform surrounding persons [9].

The following contributions are made by this paper:

1. A novel FFD prototype that identifies the patient's fall event precisely utilizing GSM WSN and VSMS.
2. Alerts were issued to caretakers or family members.

2. System Model

The FDS is made up of two major parts, the transmitter node and the receiver node, which are as follows:

a) The FDD is designed to monitor a wide range of physiological and respiratory functions. TEMP, ECG, SPO2, and ACC biosensors, a CPU, GPS, and GSM modules to convey notifications to a smartphone make up the device. [10].

b) In the suggested FDD, the patient's hip is coupled to the FDB- HRT, TEMP, ECG, SPO2 algorithm, which performs monitoring and decision-making tasks. caretakers in the CEC receive messages via their smartphones and can read them on the display.

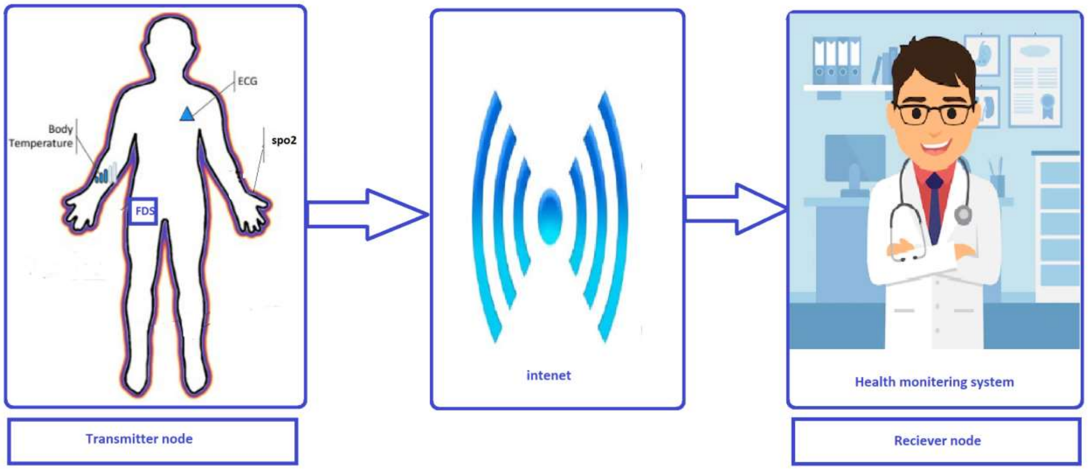


Figure (1) Block diagram of the overall FDD with (a) Transmitter node and (b) Receiver node

2.1 Fall Detection Device (FDD) Hardware

1- Accelerometer Sensor MPU-6050TM
2- SPO2 and HR sensor MAX30100
3- ECG Sensor (AD8232)
4- Non-Contact IR Temperature Sensor MLX90614
5-GPS SIM808 modules 6 -Arduino mega
7-Arduino Nano Microcontroller 8- Voltage DC sensor
9- SD card leader micro 10- Battery laithium 3.7 V ,3800 MA

2.2 smart phone

A smartphone (the Samsung A7) has been adopted and placed in the CEC with the caregivers as part of this endeavour. Receiving SMS communications from the FDD, such as patient IDs, health status updates, and the location of caregivers, is one of its primary functions. Apps with more sensors can be developed using free software based on Arduino programming in C++.

2.3 FD Algorithm

A flexible application based on the Android operating system was created using an embedded 3-axis accelerometer sensor. This software will track both activity and physiological data, implying that many processes will be running on the phone at the same time. The operation of the FD algorithm was thoroughly detailed in the following phases.

1. First, the memory card is inspected and formatted since it will be used to store all of the patient's data, including vital signs and fall data.
2. Connecting the project to the Internet using the GSM MODUL, and using the atheer sim card with the GSM module.
3. Connect to the GPS modul to locate the nearest patient.
4. Connect to the BLYNK cloud, and this application is installed on the smartphone or the calculator, displaying vital indicators as well as symptoms of falling and the patient's location.

5. Setting up and testing the acceleration, ECG, SPO2, and TEMP sensors. If the sensors are successfully tested and setup, each sensor begins measuring its own signal within the limitations preset into the microcontrollers.

6- If the vital signs are aberrant, or if the acceleration sensor reading is larger or less than the threshold as shown in Fig (2) the microcontroller will command the GSM to send a message to the ambulance station through the blynk platform. Simultaneously, the microcontroller will direct the transmitter to the GPS to determine the patient's position. In normal circumstances, the controller will order the sensors to repeat the data every 1 second.

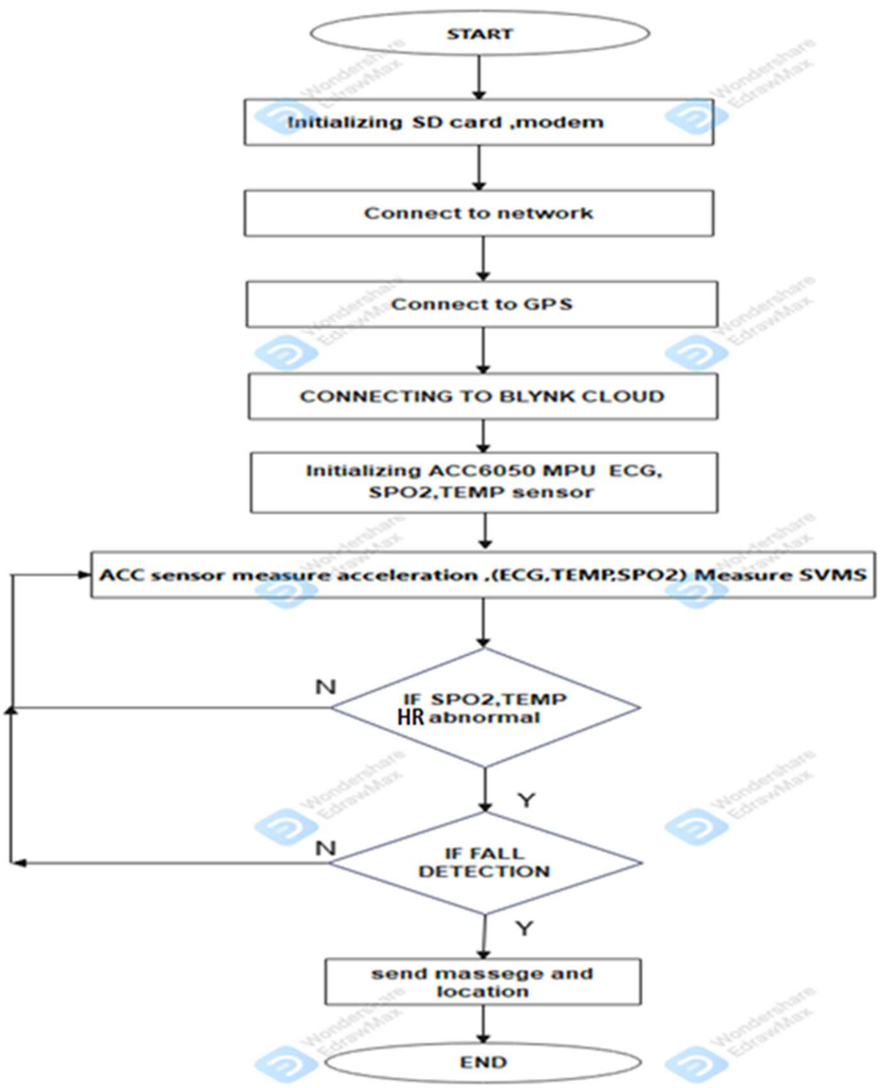
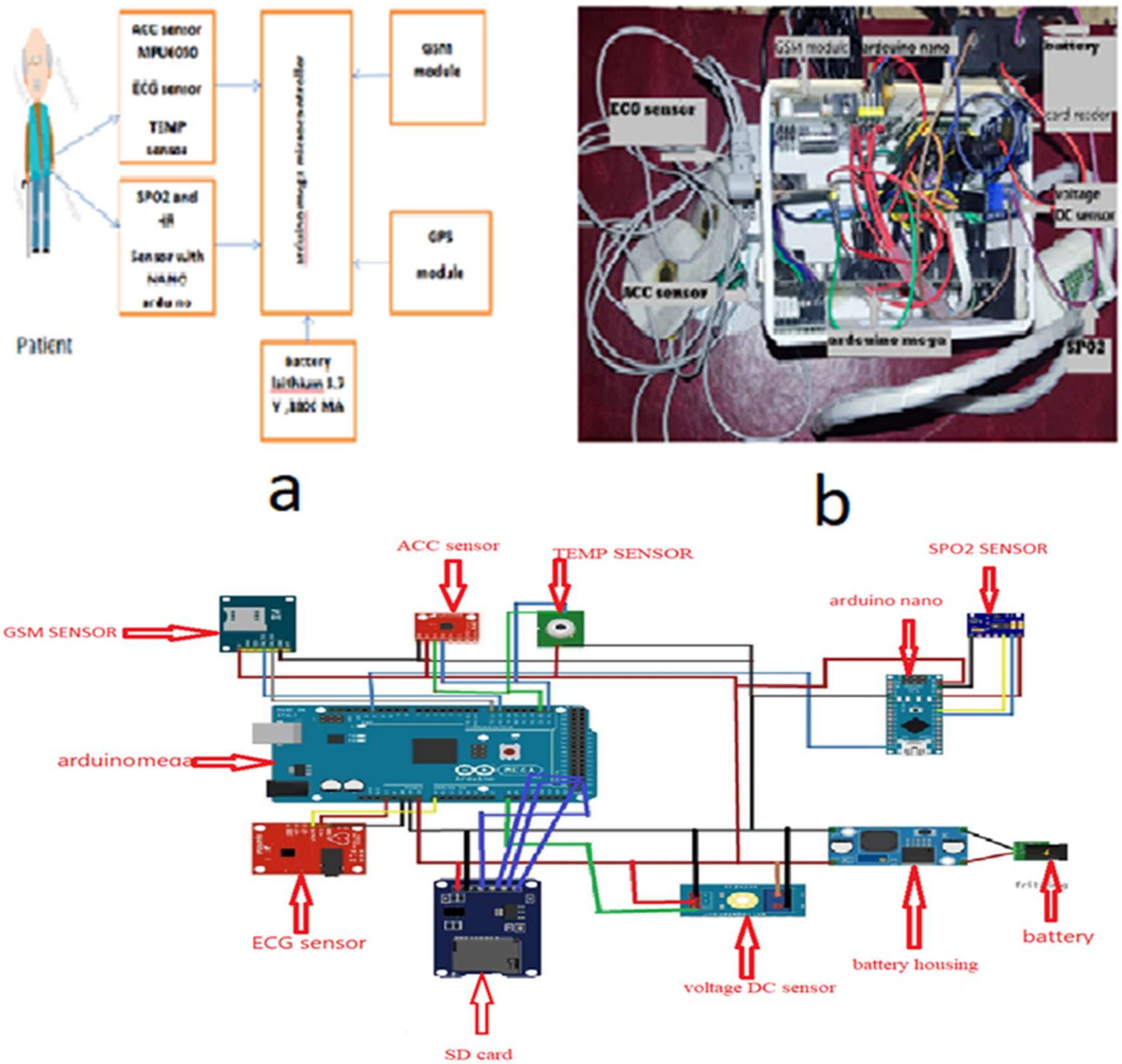


Figure (2) Flow chart of FD algorithm

3-FDD Prototype Design and Development

In this research, a prototype FDD based on WBSN was employed to detect the fall of a human body. The FDD, as shown in Figure 3 (a), is made up of the components listed in Section 3.1. As illustrated in Figure 3 , these components are combined onto a PCB circuit and incorporated into a lightweight wearable device (b). The FDD schematic diagram is shown in Figure 3 (c). Based on the VSMS and ACC sensors, the FDD monitors vital sign data and acceleration. Both sensors' to measure parameters are forwarded to the microcontroller for processing and monitoring. The suggested FDB-VSMS method is used by the microcontroller to determine if a detected value is abnormal.



(c)

Figure (3): Experimental parts of FDD

4 .FDD Experimental Configurations

The FDD is belt-attached to the hip and has SPO2, and TEMP sensors. For ACC classification, four trials were conducted. The proposed system was placed in a shock-resistant plastic container, which protected all FDD components. Each experiment was repeated twice, and samples were collected from ten individuals for two different types of exercise (normal activities and falls).

5 .FDD Validation Metrics in Relation to the Benchmark (BM)

For comparison with the FDDs, an NIHON KOHDEN VISMO device was used as the BM (HR and SPO2). The Vismo collection of bedside monitors is available from Nihon Kohden, a global maker of creative goods and smart technology (a). Furthermore, because the degree of accuracy indicated in this type reaches 0.3 device as illustrated in Figure 4 , the thermometer type Aicare technology was used as the BM for comparison with the TEMP of FFD (b). The FDD's measurements differed somewhat from the BM device's. The sensors SPO2, TEMP, and ECG were put once on the anterior part of each volunteer's abdomen for the FDD and BM as shown in Figure 4 The information is kept on SD memory and may be examined on a computer.

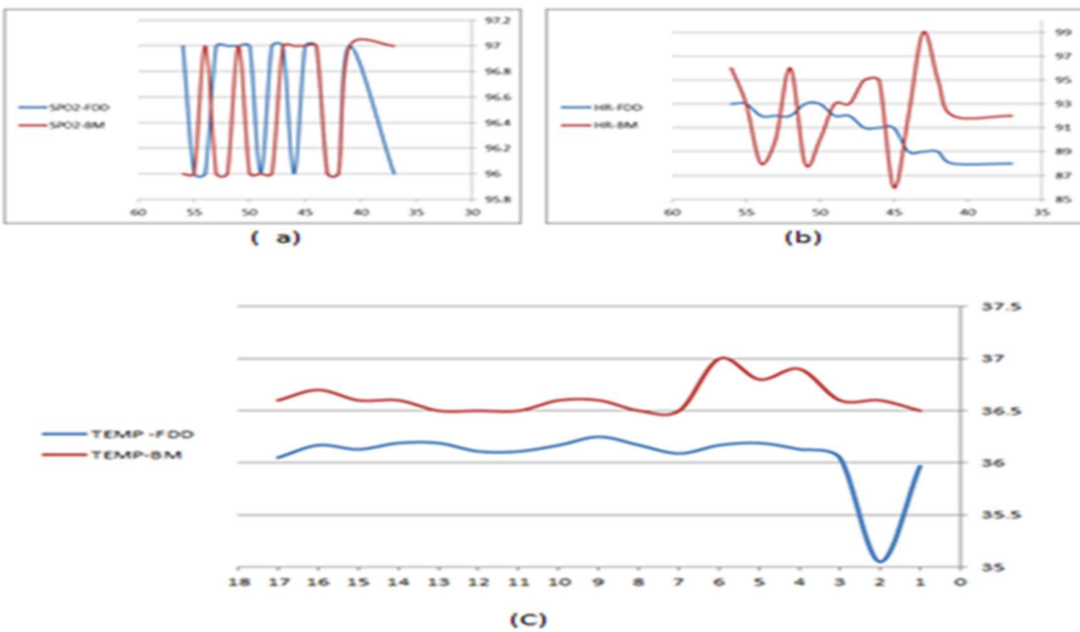


Figure (4) Measurements of FDD Relative to BM (a) SPO2, (b) HR, and (c)TEMP

Figure (5)(a) BM for (ECG,HR,SPO2)

figure (5)(b)

Figure (5) (a) BM for ECG, HR, SPO2 and (b) BM for TEMP

6. Results and Discussions

The findings of the ACC, SPO2, HR, TEMP, and ECG sensors, as well as data delivery, will be shown in this part.

6.1 Measurement of accelerometer

The FDD's performance in respect to FD is assessed for 10 activities. According to Table (1), the total extracted data for all subjects includes 200 samples are cleared in Table 2 ACC sensor validation is discussed in terms of how accurate the sensor is at classifying falls from everyday activities. MPU6050 sensor-based ACCs have high resolution (13-bit up to 16 g) and are calibrated before use, making it possible for them to detect inclination angle variations of 0.250°. As a result, the overall measurement accuracy of the system is unaffected.

Table (1) Experiments stages with ACC system

Table (2). The extracted data for all volunteers included 200 samples.

6.2 Measuring of SPO2, HR, and TEMP :

The experiment was carried out to assess the accuracy of the suggested vital sign measuring method. Figure (6) depicts the average of 100 data collected for each a set of sensor experiments (TEMP, SPO2, HR) for both FDS and BM for comparison and statistical analysis .

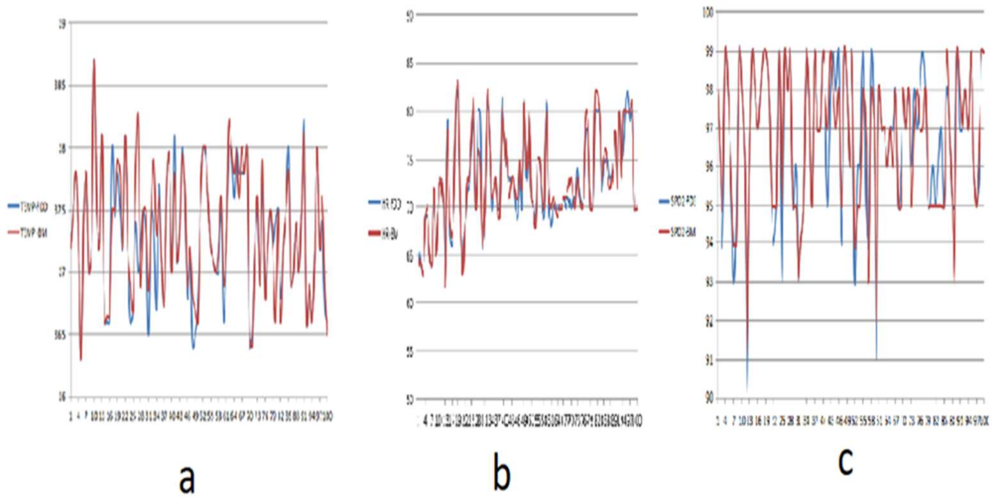


Figure (6): (a) Temp measurement comparison between FDS and Benchmark, (b) HR measurement comparison between FDS and BM, and (c) A comparison of FDS and BM for SPO2 measurements.

6.3 Error Test

For each device (FDD and BM), 100 total samples for each of the HR,SPO2 and TEMP) measurements were collected from all participants and statistically analyzed to estimate the absolute error between them and the readings are presented in Table 3.

Table (3) Results of the error test.

error	HR	SPO2	TEMP
MAE	0.8	0.41	0.1015
MSE	1.58	0.53	0.045675
RMSE	1.256981	0.728011	0.213717
MAPE	1.082992	0.004283	0.002714
STD	4.815002	1.94687	0.504249

6.4 Accuracy

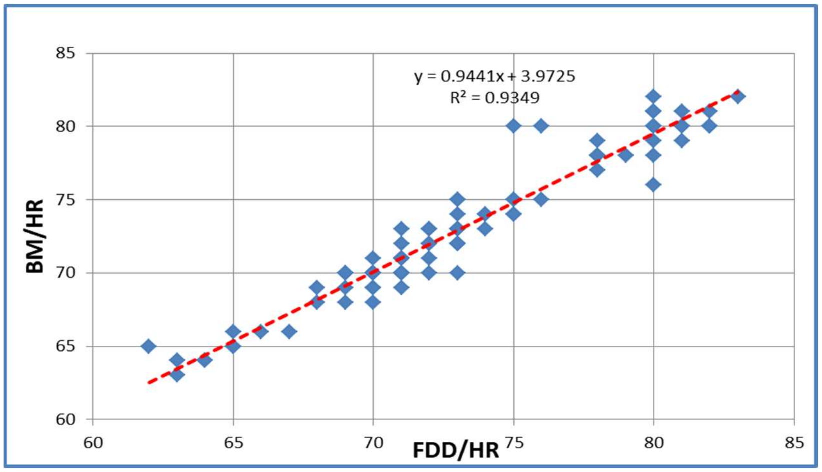
The measurement accuracy is defined as the difference between the suggested FDD's VSMS readings and the BM. The Table 4 below shows the extent of accuracy in measuring the HR, SPO2, and TEMP. The results of the FDD were closed or identical to the results of the BM after the accuracy.

Table (4) Results of the Accuracy

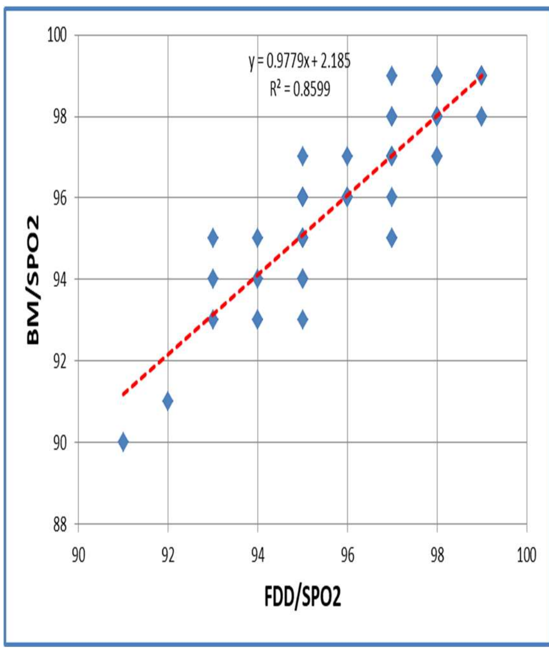
HR	SPO2	TEMP
98.91%	99.57%	99.72%

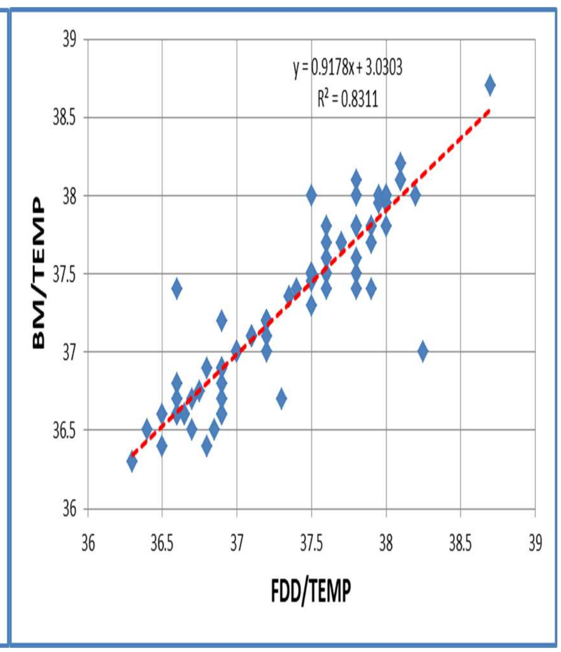
6.5 . Correlation Coefficient

In terms of HR, SPO2, and TEMP readings, the correlation coefficient (R) is employed to determine the correlation between the FDD and BM. FDD values are displayed on the x-axis, while BM measurements are plotted on the y-axis. Figure 7 depicts the relationship between FDD and BM as a straight line drawn between the data points. The R values for HR, SPO2 and TEMP were 0.9669, 0.8599, and 0.9116, respectively. These results show that the FDD and BM measures are very closely aligned. Additionally, a R value around 1 suggests a strong positive linear relationship



(a)





(b) (c)

Figure (7) Correlation between FDD and BM (a) for HR (b) for SPO2 and (c) for TEMP.

6.6 Test Data Distribution

In Figure (8), an emergency call center receives a message from an FDS who is using a smartphone. A GSM module based on SIM808 was used to transmit in an urban area. This is a more reliable position for sending messages to a smartphone when needed. Table 5 shows the results of message transmission testing in Iraqi cities Baghdad and Babylon.

Figure (8). Messages sent to the smartphone at the CEC with patient data and location on the Google map.

Table (5) Results of message transmission tests in several Iraqi cities.

City	No. of Messages Sent	No. of Messages Received	Message Loss
Baghdad	5	5	0
Babylon	10	10	0

7. Conclusion:

Based on a prototype of FDD, this study produced a FDS for senior patients in outdoor circumstances. Additionally, giving vital sign information to the patient and locating the patient. The intended FDD was small, light, and used little power. In terms of ACC classification, the proposed device obtained exceptional accuracy of 98.5 % for FD by designing an algorithm that used the inherent functions of the chosen ACC sensor to determine whether or not the body was falling. As a consequence, when compared to comparable proposed devices, this device displayed exceptional efficacy in biological data monitoring and ascertain the patient's location.

Refrences:

[1] https://www.who.int/news-room/fact-sheets/detail/falls.

[2] G. Bergen, M. R. Stevens, and E. R. Burns, “Falls and Fall Injuries Among Adults Aged ≥65 Years — United States, Sep. 2014,” Morbidity and Mortality Weekly Report (MMWR), vol. 65, no. 37, pp. 993–998

[3] S. K. Gharghan , S. L. Mohammed, A. Al-Naji, M. J. Abu-Alshaeer, H. M. Jawad, A. M. Jawad, and J. Chahl, “Accurate fall detection and localization for elderly people based on neural network and energy-efficient wireless sensor network,” Journal of Energies, vol. 11, no. 11, pp. 1-32, 2018.

[4] H. Yan, L. Da Xu, Z. Bi, Z. Pang, J. Zhang, and Y. Chen, “An emerging technology – wearable wireless sensor networks with applications in human health condition monitoring,” Journal of Management Analytics, Vol. 2, no. 2, pp.121–137, 2015.

[5] S. Rihana and J. Mondalak, “Wearable fall detection system,” In Proceedings of the 2016 3rd Middle East Conference on Biomedical Engineering (MECBME), Beirut, Lebanon, pp. 84-87, 6–7 October 2016.

[6] F. J. González-Cañete and E. Casilari, “Consumption analysis of smartphone based fall detection systems with multiple external wireless sensors,” Sensors (Switzerland), vol. 20, no. 3, 2020, doi: 10.3390/s20030622.

[7] Tripathi, M. A., Tripathi, R., Sharma, N., Singhal, S., Jindal, M., & Aarif, M. (2022). A brief study on entrepreneurship and its classification. International Journal of Health Sciences, 6(S2). https://doi.org/10.53730/ijhs.v6nS2.6907

[8] Fatma, Dr Gulnaz & Pirzada, Nahla & Begum, Sameena. (2022). Problems, Illusions and Challenges Faced by a non -Arabic Speaker in Understanding Quran: A Sub-Continental Study. 5422-5426.

[9] Fatma, Dr Gulnaz. (2014). Ruskin Bond: man, and Writer. 10.13140/RG.2.1.1551.4001.

[10] Fatma, Dr Gulnaz. (2012). A Short A Short History History of the of the Short Story Short Story Western and Asian Traditions Worldwide Appreciation of the Short Story Form Spans Cultures and Centuries!.

[11] T. Nguyen Gia et al., “Energy efficient wearable sensor node for IoT-based fall detection systems,” Microprocess. Microsyst., vol. 56, no. October 2017, pp. 34–46, 2018 doi: 10.1016/j.micpro.2017.10.014.

[12] E. Kantoch, D. Grochala, and M. Kajor, "Bio-inspired Topology of Wearable Sensor Fusion for Telemedical Application," in Proceeding of The International Conference on Artificial Intelligence and Soft Computing, Zakopane, Poland, 27 May 2017.

[13] H. Ali Hashim, S. L. Mohammed, and S. K. Gharghan, “Accurate fall detection for patients with Parkinson’s disease based on a data event algorithm and wireless sensor nodes,” Meas. J. Int. Meas. Confed., vol. 156, p. 107573, 2020, doi: 10.1016/j.measurement.2020.107573.

[14] E. Baba, A. Jilbab, and A. Hammouch, “A health remote monitoring application based on wireless body area networks,” 2018 Int. Conf. Intell. Syst. Comput. Vision, ISCV 2018, vol. 2018-May, pp. 1–4, 2018, doi: 10.1109/ISACV.2018.8354042.

[15] Alalmai, Ali & A., Arun & Aarif, Mohd. (2022). Social Media Advertising Impact on the Consumer Purchasing.