Statistical Evaluation Of Microcontroller-Based Body Temperature Measuring Device For Smart Applications

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***Abstract*— In this paper, statistical evaluation of microcontroller-based body temperature measuring (MCBBTM) device for smart applications is presented. Empirical paired data collection was conducted on 104 patients in a hospital using the MCBBTM device and the Body Infrared Thermometer DJ-8861 (the DJ-8861 device) which is commonly used in various hospitals for body temperature measurements. The data were further sorted into two paired datasets, namely, those temperature dataset where the patient's body temperature is greater or equal to the ambient temperature (referred to in this paper as net positive temperature dataset which is about 73 data records) and those temperature dataset where the patient's body temperature is less than the ambient temperature (referred to in this paper as net negative temperature dataset which is about 31 data records). The repeated-samples t-test was conducted at 95 % confidence level on the paired 104 body temperature (°C) datasets, on the 73 net positive temperature dataset and on the 31 net negative temperature dataset. The repeated-samples t-test on the 104 body temperature datasets, show that the mean of the sample is 0.36538 °C which is beyond the 95 % interval of -0.34030 °C to +0.34030 °C. Hence, the results showed that when both the net positive and net negative dataset are taken together in the 104 body temperature datasets, the MCBBTM device is not accurate with respect to the reference DJ-8861 device. The repeated-samples t-test on the 73 net positive temperature dataset, show that the mean of the sample is 0.02603 °C which is within the 95 % interval of -0.5372 °C to +0.5372 °C. Hence, the results showed that the body temperature measured by the MCBBTM device is accurate with respect to the reference DJ-8861 device only when the net positive temperature dataset are considered. This is because the results for the 31 net negative temperature dataset, show that the mean of the sample is 1.16452 °C which is outside the 95 % interval of -1.09582°C to +1.09582°C.**

***Keywords*— Statistical Evaluation, Microcontroller Device, Body Temperature Measuring Device, Repeated-samples t-test, Smart Applications**

1. Introduction

The Internet era with web-based solutions, mobile device applications, e-solutions, the rise of embedded and smart embedded systems, sensor networks and Internet of Things has brought with it changes in the way we live and take care of our health [1,2,3,4,5,6,7,8,9,10, 11,12, 13, 14, 15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32] . Notably, the internet era emerged from the bedrock of various kinds of networks, ranging from the traditional wired networks, the fiber optic networks and the wireless networks which includes satellite communication networks [33,34,35,36, 37,38,39, 40,41,42, 43,44,45,46, 47,48,49,50, 51,52,53,54, 55,56, 575,585,59,60]. Accordingly, many industries are tapping into the potentials of the Internet and the associated networks. In the healthcare industry, the need for timely and sometimes, real-time information concerning the health status of patients has prompted the use of microcontroller-based Internet-ready devices and software solutions that can support remote access and web-based storage of requisite health related data records of patients. Accordingly, in this paper, the focus is on body temperature measuring device.

Basically, the body temperature measuring device can be described as a hardware that can be used to capture and quantify the temperature of human body [61,62,63,64]. The temperature measuring hardware presented in this paper has temperature sensor suitable for the body temperature range along with microcontroller and other electronic components that help to quantify and represent sensed temperature values in ways that can be stored, displayed and transmitted to remote storage locations [65,66]. The microcontroller-based body temperature measuring device is also interface with web application for online storage and management of the measured body temperature data records [67,68,69].

In any case, the ability to measure body temperature using the microcontroller-based body temperature measuring device is not enough; the accuracy of the measurements need to be ascertained for the readings to be useful for rea-life applications. Accordingly, in this paper, statistical evaluation of the microcontroller-based body temperature measuring device is presented. The evaluation is performed using an empirical measurement data obtained using Body Infrared Thermometer DJ-8861 as the reference measurement device [70,71,72]. The repeated-samples t-test approach [73,74,75,76,77] was used determine how accurate is the measurement of the microcontroller-based body temperature measuring device when compared with the body temperature measurement with the reference Body Infrared Thermometer DJ-8861 device.

2. Methodology

The study presents statistical evaluation of a microcontroller-based body temperature measuring (MCBBTM) device using a repeated-samples t-test approach. Empirical paired data collection was conducted on patients in a hospital using the MCBBTM device and the Body Infrared Thermometer DJ-8861 (Figure 1) which is commonly used in various hospitals for body temperature measurements.

Figure 1 Body Infrared Thermometer DJ-8861

2.2 Field measured body temperature datasets

The essence of the study in this paper is to check if the body temperature measured using the MCBBTM device is accurate when compared with the body temperature measured using the popular Body Infrared Thermometer DJ-8861 device. Accordingly, 104 patient's body temperature data were captured using the MCBBTM device and the hospital device (Body Infrared Thermometer DJ-8861 device). The MCBBTM device was used to simultaneously capture the ambient temperature at the time of capturing the body temperature. The data were further sorted into two paired datasets, namely, those temperature dataset where the patient's body temperature is greater or equal to the ambient temperature (referred to in this paper as net positive temperature dataset) and those temperature dataset where the patient's body temperature is less than the ambient temperature (referred to in this paper as net negative temperature dataset). There are about 73 data in the net positive temperature dataset while 31 data are in the net negative temperature dataset. The simultaneously measured complete 104 body temperature (°C) datasets measured using the MCBBTM device and the reference DJ-8861 device are shown in Table 1, Figure 2 and Figure 3.

Table 1: The simultaneously measured complete 104 body temperature (°C) datasets measured and ambient temperature measured using the MCBBTM device and the reference DJ-8861 device

S/N	MCBBTM Temp (°C)	Ref. DJ-8861 Temp (°C)	Ambient Temp (°C)	S/N	MCBBTM Temp (°C)	Ref. DJ-8861 Temp (°C)	Ambient Temp (°C)	S/N	MCBBTM Temp (°C)	Ref. DJ-8861 Temp (°C)	Ambient Temp (°C)
1	34.5	34.2	32.8	35	36.6	36.8	32.8	70	38.1	38.1	32.5
2	34.6	34.5	33.4	36	36.7	36.9	32.9	71	38.5	38.4	33.1
3	34.8	34.8	33.8	37	36.7	36.9	33.1	72	38.6	38.5	33.3
4	33.1	40.2	33.3	38	36.1	36.3	33.1	73	36.1	35	36.5
5	34.7	34.7	32.8	39	36.7	36.9	32.7	74	38.7	38.6	32.5
6	34.8	34.7	33.8	40	36.8	37	33.8	75	38.9	38.7	32.5
7	33.2	39.5	33.4	41	36.8	37	32.4	76	39	38.8	32.3
8	33.3	39.1	33.4	42	36.2	36.5	32.7	77	36.3	35	36.4
9	35	35.1	33.4	43	36.9	37.2	31.2	78	36.5	34.4	36.6
10	33.5	38.7	33.8	44	34.8	37.7	34.9	79	39.3	39	32
11	33.4	38.6	33.7	45	37	37.3	32.8	80	36.1	34.6	36.2
12	33.6	38.5	33.8	46	37.1	37.4	33.2	81	39.4	39.2	30.3
13	35	35.1	32.4	47	36.3	36.6	33	82	39.6	39.2	32.6
14	34.7	34.5	33.6	48	37.1	37.4	32.4	83	39.7	39.3	32.3
15	35.4	35.5	33.1	49	35.1	37.5	35.2	84	39.9	39.5	32.4
16	35.4	35.6	33.3	50	35.2	37.1	35.3	85	36.2	34.2	36.9
17	35.4	35.5	32.1	51	37.2	37.5	32.7	86	36.4	34.1	36.5
18	35.1	35.2	32.2	52	37.4	37.6	32.3	87	39.5	39.2	32.3
19	35.6	35.8	32.1	53	36.9	37.1	32	88	40	39.6	31.4

20	35.7	35.9	32.9	54	37.5	37.7	32	89	36.4	34.1	36.8
21	34	37.8	34.2	55	37.5	37.7	32.7	90	40.3	39.9	31.8
22	35.8	36	32.6	56	37.6	37.8	32.8	91	36.3	34.3	36.4
23	35.3	35.4	33	57	36.9	37.1	31.4	92	36.5	34	36.8
24	35.8	36	33.3	58	37.9	38	32.3	93	36.5	34	36.6
25	35.9	36	32.1	59	38	38.1	32.8	94	40.9	40.7	31.9
26	36	36.2	32.4	60	38.1	38.2	33	95	39.5	39.1	33.1
27	35.5	35.8	31.4	61	35.6	36.3	35.7	96	36.6	34	36.7
28	36.3	36.5	32	62	37.7	37.8	32.7	97	40.9	40.6	31.8
29	36.4	36.6	33.9	63	35.3	36.9	35.4	98	41.1	41	32.2
30	36.4	36.7	33.5	64	35.3	36.9	35.4	99	41.4	41.6	32.2
31	34.2	38	34.8	65	35.6	36.1	35.7	100	36.7	34	36.8
32	34.3	37.6	34.6	66	35.9	35.3	36.4	101	40	39.5	31.2
33	36	36.3	33	67	38.2	38.2	32.3	102	40.4	40	30.2
34	34.6	37.7	34.7	68	38.3	38.2	32.1	103	35.2	36.7	35.4
35	36.6	36.8	32.8	69	38.5	38.4	32.6	104	39	38.7	31.2

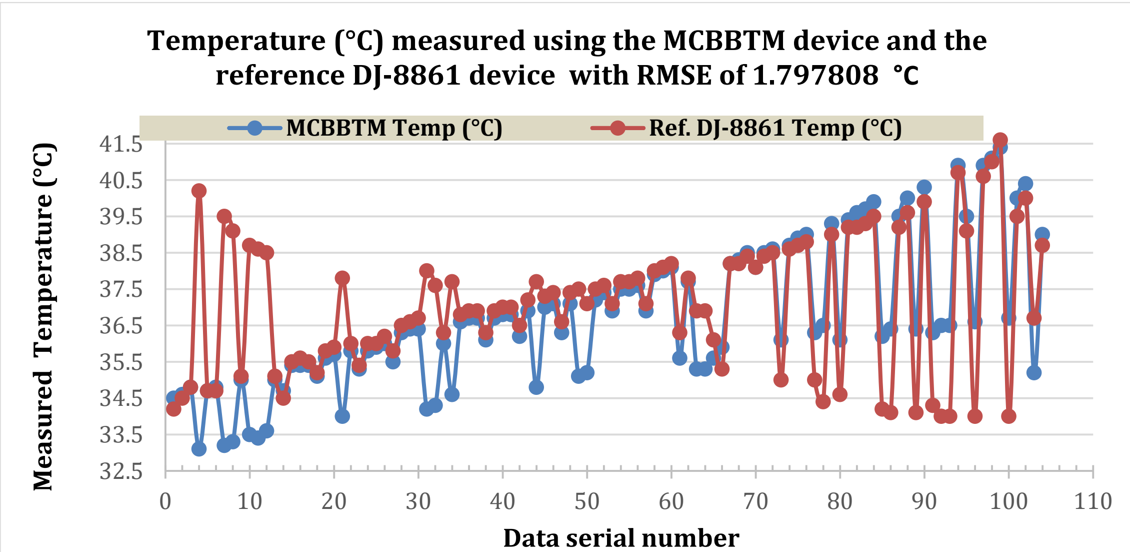

Figure 2: The graph of the simultaneously measured complete 104 body temperature (°C) datasets measured using the MCBBTM device and the reference DJ-8861 device

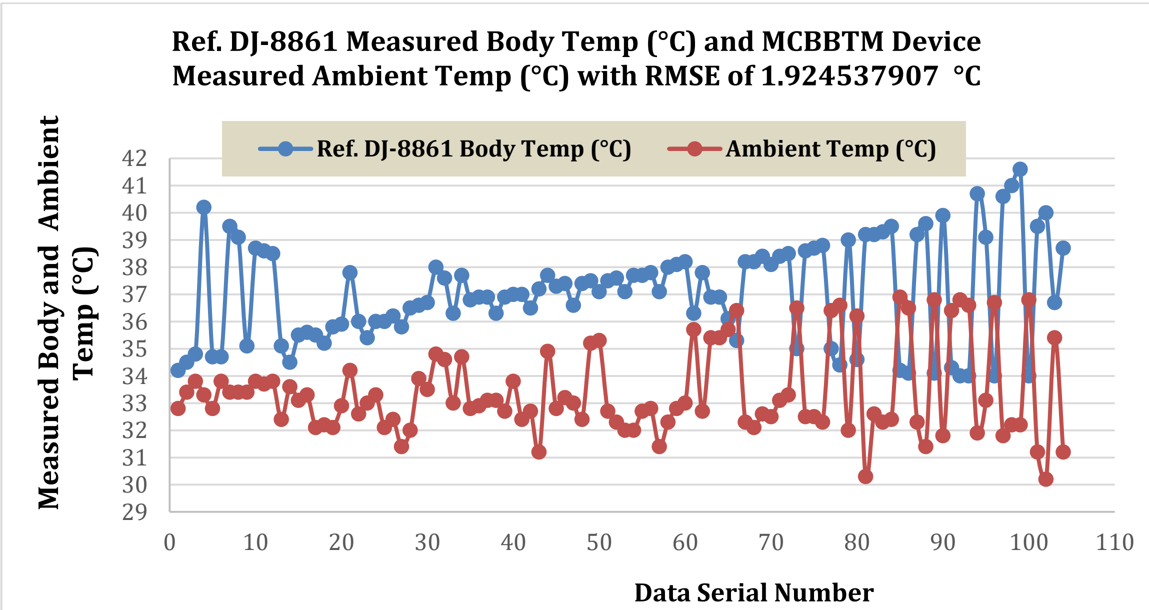

Figure 3: The graph of the complete 104 field measured body temperature (°C) dataset measured using the reference DJ-8861 device and the simultaneously measured ambient temperature (°C) dataset measured using the MCBBTM device and

3. Results and Discussion

The repeated-samples t-test was conducted at 95 % confidence level on the paired simultaneously measured 104 body temperature (°C) datasets measured using the MCBBTM device and the reference DJ-8861 device, as presented in Table 1 and Figure 2 and the result of the repeated-samples t-test is shown in Figure 4. The results in Figure 4 show that the in the repeated-samples t-test using the difference of the two datasets, the mean of the sample is 0.36538 °C which is beyond the 95 % interval of -0.34030 °C to +0.34030 °C. Hence, the mean of the two sample datasets, the simultaneously measured body temperature (°C) datasets measured using the MCBBTM device and the reference DJ-8861 device are not the same.

In view of the significant disparity between the mean of the two paired datasets, further classification was conducted on the datasets based on some observations. Notably, it was observed that the errors between the simultaneously measured body temperature datasets measured using the MCBBTM device and the reference DJ-8861 device is small when the measured body temperature is greater or equal to the measured ambient temperature. However, the errors between the two datasets are much when the measured body temperature is less than the measured ambient temperature. In view of these observations, the body temperature datasets were classified into the net positive body temperature dataset for those datasets where the measured body temperature is greater or equal to the measured ambient temperature. On the other hand, the net negative body temperature dataset is for those datasets where the measured body temperature is less than the measured ambient temperature. Each of the two categories of body temperature datasets was then subjected to further repeated-samples t-test.

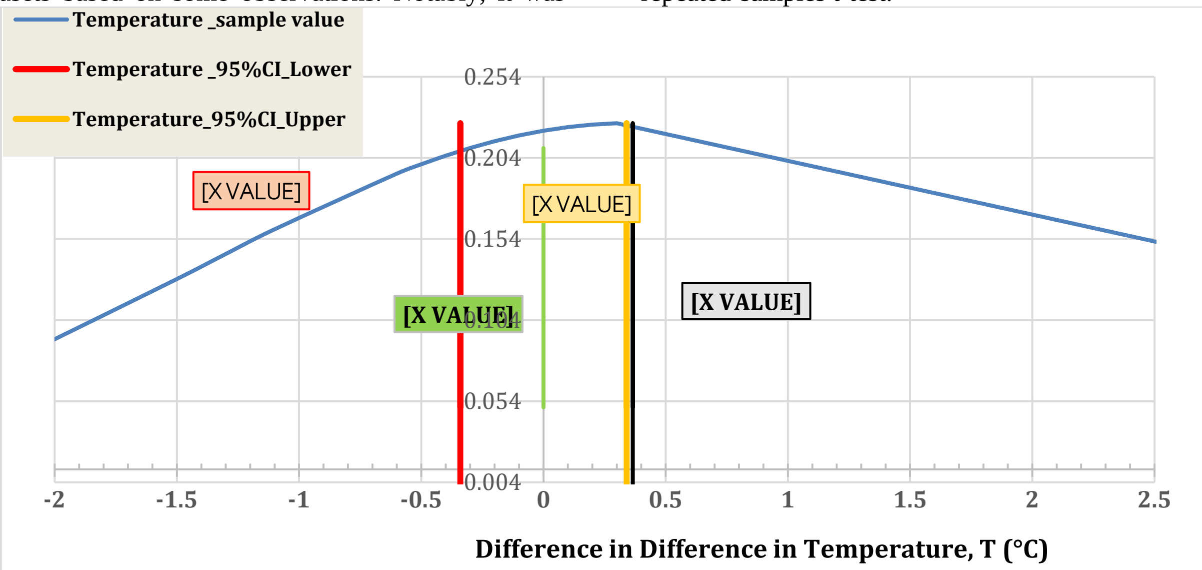

Figure 4 The results of the repeated-samples t-test was conducted at 95 % confidence level on the paired simultaneously measured 104 body temperature (°C) datasets measured using the MCBBTM device and the reference DJ-8861 device

3.1 Repeated-samples t-test for the net positive temperature dataset

The net positive body temperature dataset consists of a total of 73 data as shown in Table 2. The graph of the reference device DJ-8861 measured body temperature (°C) and MCBBTM device measured body temperature (°C) for the net positive temperature dataset is shown in Figure 5. Similarly, the graph of the MCBBTM device measured body temperature (°C) and MCBBTM device measured ambient temperature (°C) for the net positive temperature dataset is shown in Figure 6.

The repeated-samples t-test was carried out at 95 % confidence level for the reference device DJ-8861 measured body temperature (°C) and MCBBTM device measured body temperature (°C) for the net positive temperature dataset and the summary of the results are presented in Figure 7. The results in Figure 7 show that the in the repeated-samples t-test using the difference of the two datasets, the mean of the sample is 0.02603 °C which is within the 95 % interval of -0.5372 °C to +0.5372 °C. Hence, the mean of the two sample datasets, for the net positive temperature dataset are the same. It can be concluded that for the net positive temperature dataset, the MCBBTM device measurements are as accurate as the reference hospital body temperature measurement device, which is the Body Infrared Thermometer DJ-8861 device.

Table 2: The net positive body temperature dataset showing the showing the 73 data records of the reference device DJ-8861 measured body temperature (°C) and MCBBTM device measured body temperature (°C)

S/N	MCBBTM Body Temp (°C)	Ref. DJ-8861 Body Temp (°C)	Ambient Temp (°C)	S/N	MCBBTM Body Temp (°C)	Ref. DJ-8861 Body Temp (°C)	Ambient Temp (°C)
1	34.5	34.2	32.8	37	37.1	37.4	32.4
2	34.6	34.5	33.4	38	37.2	37.5	32.7
3	34.8	34.8	33.8	39	37.4	37.6	32.3
4	34.7	34.7	32.8	40	36.9	37.1	32
5	34.8	34.7	33.8	41	37.5	37.7	32

6	35	35.1	32.4	42	37.5	37.7	32.7
7	35	35.1	33.4	43	37.6	37.8	32.8
8	34.7	34.5	33.6	44	36.9	37.1	31.4
9	35.4	35.5	33.1	45	37.9	38	32.3
10	35.4	35.6	33.3	46	38	38.1	32.8
11	35.4	35.5	32.1	47	38.1	38.2	33
12	35.1	35.2	32.2	48	37.7	37.8	32.7
13	35.6	35.8	32.1	49	38.2	38.2	32.3
14	35.7	35.9	32.9	50	38.3	38.2	32.1
15	35.8	36	32.6	51	38.5	38.4	32.6
16	35.3	35.4	33	52	38.1	38.1	32.5
17	35.8	36	33.3	53	38.5	38.4	33.1
18	35.9	36	32.1	54	38.6	38.5	33.3
19	36	36.2	32.4	55	38.7	38.6	32.5
20	35.5	35.8	31.4	56	38.9	38.7	32.5
21	36.3	36.5	32	57	39	38.8	32.3
22	36.4	36.6	33.9	58	39	38.7	31.2
23	36.4	36.7	33.5	59	39.3	39	32
24	36	36.3	33	60	39.4	39.2	30.3
25	36.6	36.8	32.8	61	39.6	39.2	32.6
26	36.7	36.9	32.9	62	39.7	39.3	32.3
27	36.7	36.9	33.1	63	39.9	39.5	32.4
28	36.1	36.3	33.1	64	39.5	39.2	32.3
29	36.7	36.9	32.7	65	40	39.6	31.4
30	36.8	37	33.8	66	40.3	39.9	31.8
31	36.8	37	32.4	67	40.9	40.7	31.9
32	36.2	36.5	32.7	68	39.5	39.1	33.1
33	36.9	37.2	31.2	69	40.9	40.6	31.8
34	37	37.3	32.8	70	41.1	41	32.2
35	37.1	37.4	33.2	71	41.4	41.6	32.2
36	36.3	36.6	33	72	40	39.5	31.2
37	37.1	37.4	32.4	73	40.4	40	30.2

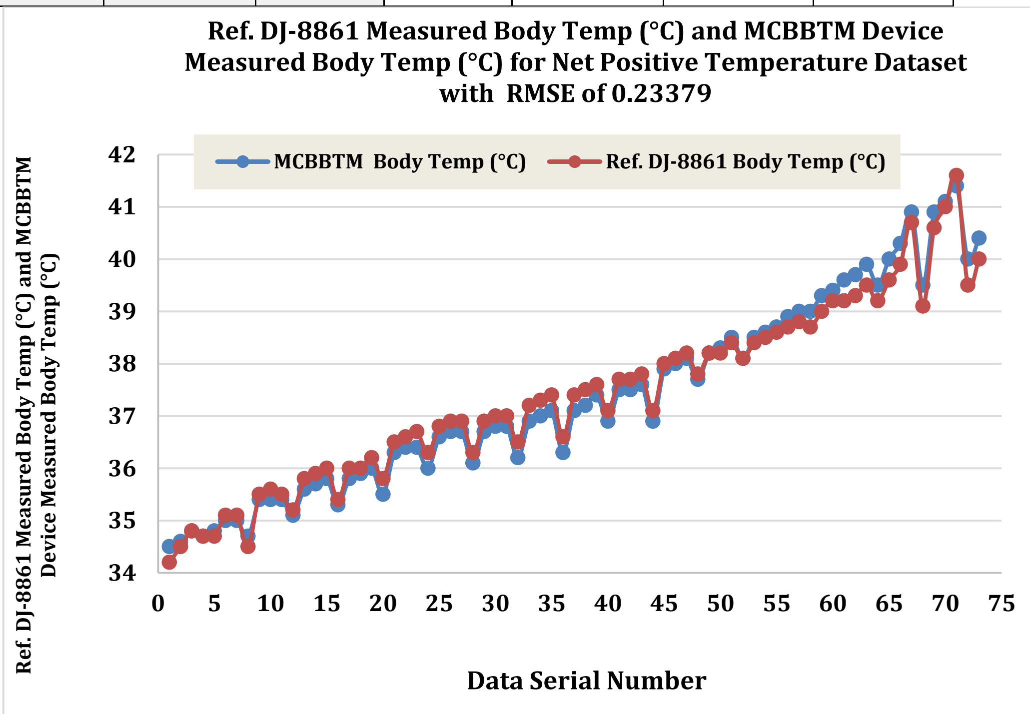

Figure 5 The graph of the Reference device DJ-8861 measured body temperature (°C) and MCBBTM device measured body temperature (°C) for the net positive temperature dataset

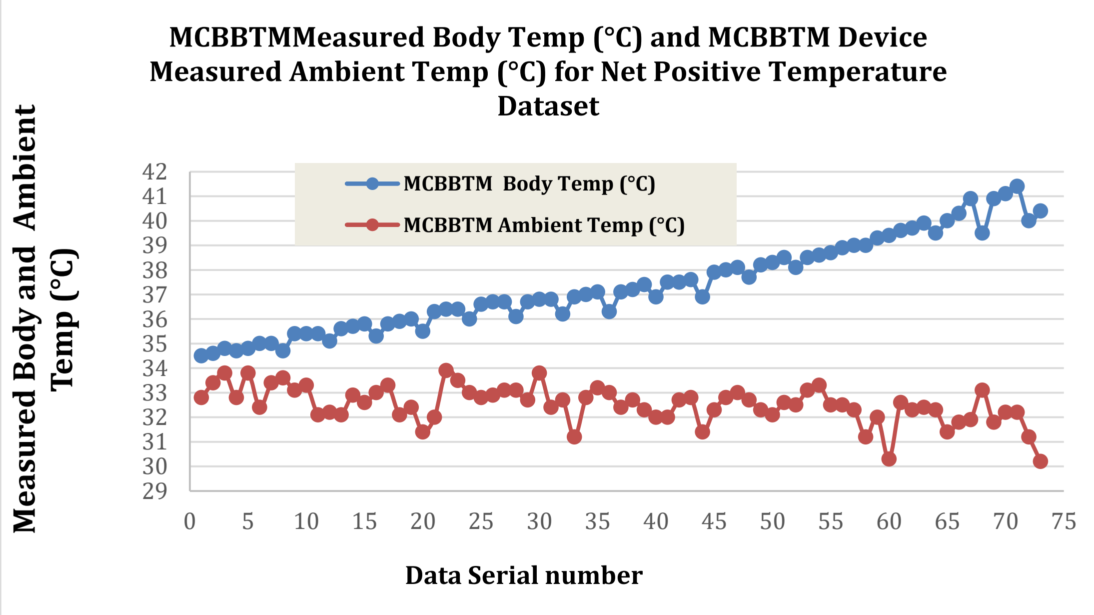

Figure 6 The graph of the MCBBTM device measured body temperature (°C) and MCBBTM device measured ambient temperature (°C) for the net positive temperature dataset

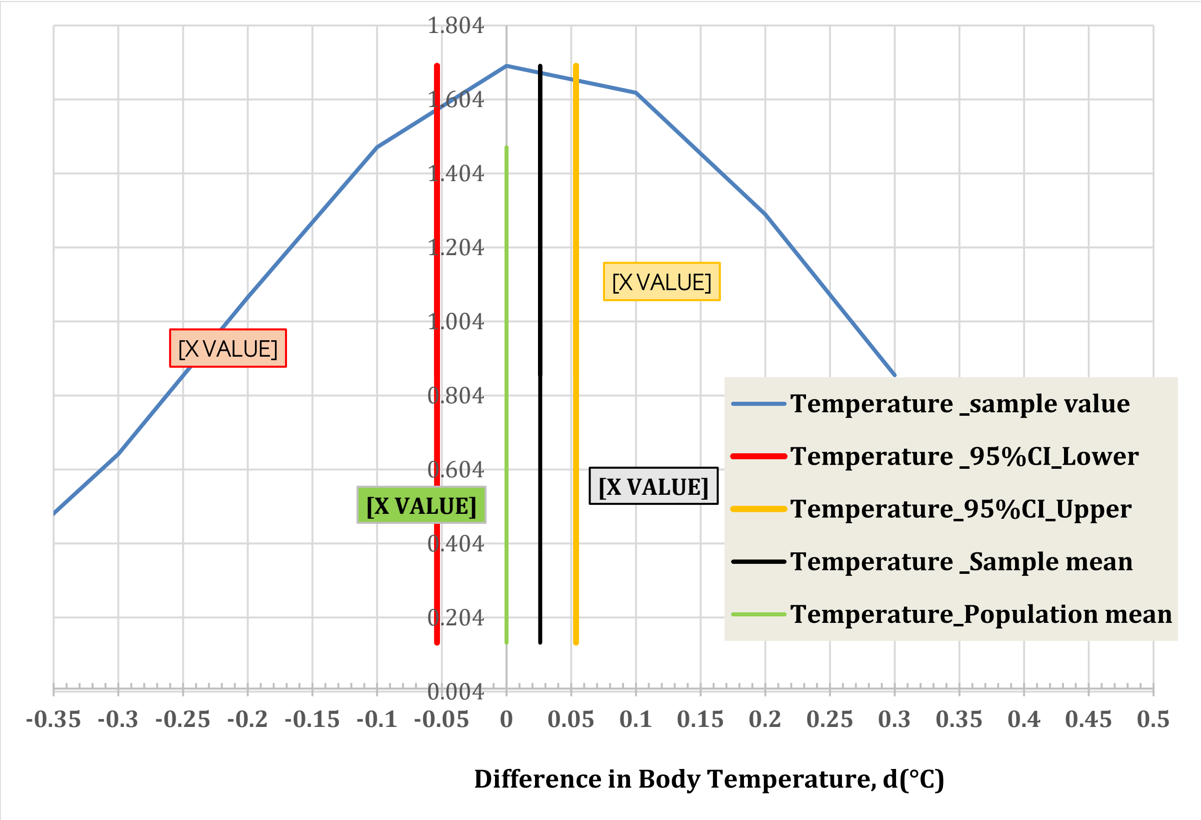

Figure 7 The repeated-samples t-test result for the net positive temperature dataset

3.2 Repeated-samples t-test for the net negative temperature dataset

The net negative body temperature dataset consists of a total of 31 data as shown in Table 3. The graph of the reference device DJ-8861 measured body temperature (°C) and MCBBTM device measured body temperature (°C) for the net negative temperature dataset is shown in Figure 8. Similarly, the graph of the MCBBTM device measured body temperature (°C) and MCBBTM device measured ambient temperature (°C) for the net negative temperature dataset is shown in Figure 9.

The repeated-samples t-test was carried out at 95 % confidence level for the reference device DJ-8861 measured body temperature (°C) and MCBBTM device measured body temperature (°C) for the net negative temperature dataset and the summary of the results are presented in Figure 10. The results in Figure 10 show that the in the repeated-samples t-test using the difference of the two datasets, the mean of the sample is 1.16452 °C which is outside the 95 % interval of -1.09582°C to +1.09582°C. Hence, the mean of the two sample datasets, for the net negative temperature dataset are not the same. It can be concluded that for the net negative temperature dataset, the

MCBBTM device measurements are not accurate with respect to the reference hospital body temperature measurement device, which is the Body Infrared Thermometer DJ-8861 device.

Table 3: The net negative body temperature dataset showing the showing the 31 data records of the reference device DJ-8861 measured body temperature (°C) and MCBBTM device measured body temperature (°C)

S/N	MCBBTM Body Temp (°C)	Ref. DJ-8861 Body Temp (°C)	Ambient Temp (°C)	S/N	MCBBTM Body Temp (°C)	Ref. DJ-8861 Body Temp (°C)	Ambient Temp (°C)
1	33.1	40.2	33.3	16	35.3	36.9	35.4
2	33.2	39.5	33.4	17	35.6	36.1	35.7
3	33.3	39.1	33.4	18	35.9	35.3	36
4	33.5	38.7	33.8	19	36.1	35	36.5
5	33.4	38.6	33.7	20	36.3	35	36.4
6	33.6	38.5	33.7	21	36.5	34.4	36.4
7	34	37.8	34.2	22	36.1	34.6	36.2
8	34.2	38	34.8	23	36.2	34.2	36.9
9	34.3	37.6	34.6	24	36.4	34.1	36.7
10	34.6	37.7	34.7	25	36.4	34.1	36.8
11	34.8	37.7	34.9	26	36.3	34.3	36.4
12	35.1	37.5	35.2	27	36.5	34	36.8
13	35.2	37.1	35.3	28	36.5	34	36.6
14	35.6	36.3	35.7	29	36.6	34	36.7
15	35.3	36.9	35.4	30	36.7	34	36.9
16	35.3	36.9	35.4	31	35.2	36.7	35.4

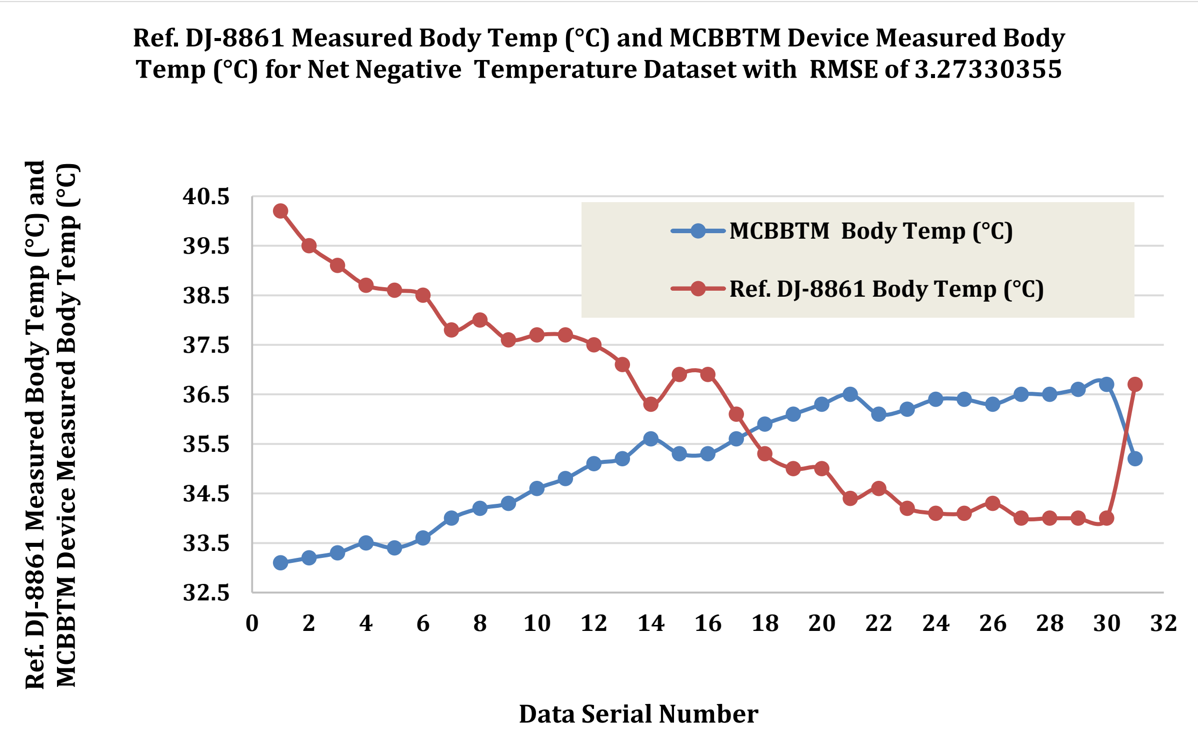

Figure 8 The graph of the Reference device DJ-8861 measured body temperature (°C) and MCBBTM device measured body temperature (°C) for the net negative temperature dataset

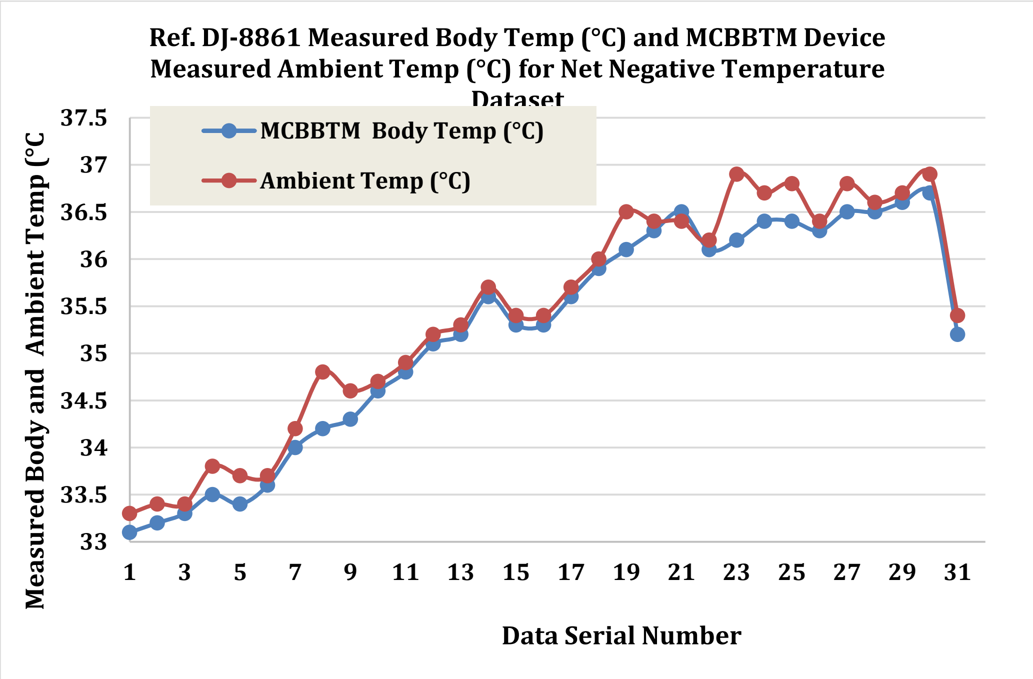

Figure 9 The graph of the MCBBTM device measured body temperature (°C) and MCBBTM device measured ambient temperature (°C) for the net genative temperature dataset

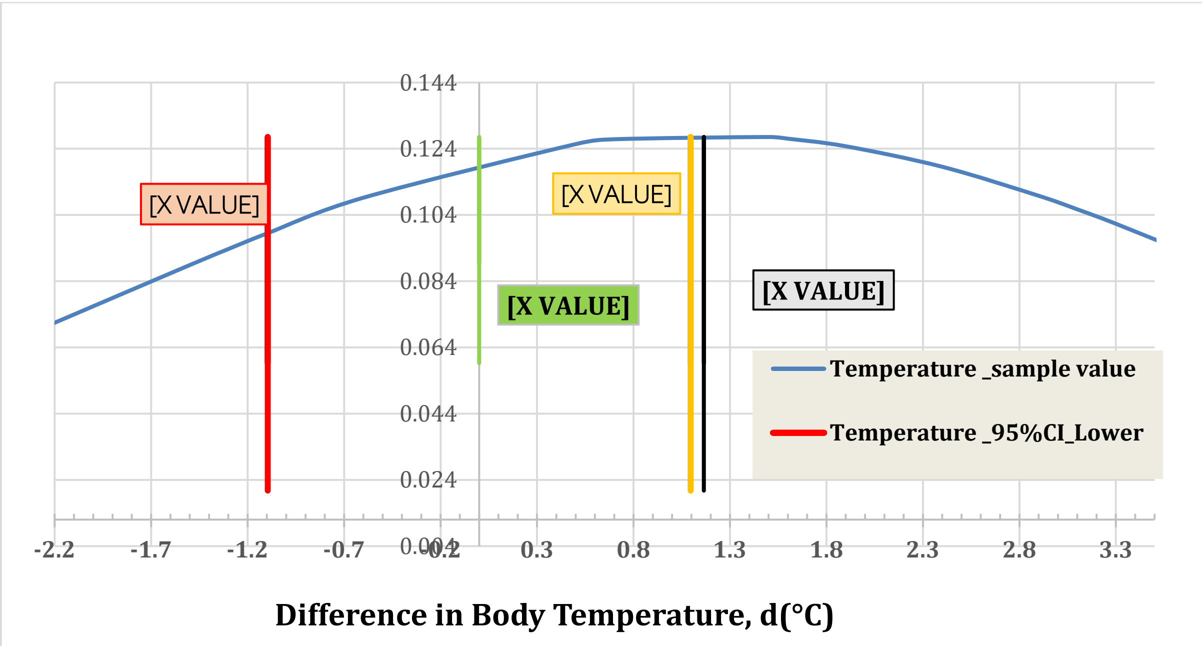

Figure 10 The repeated-samples t-test result for the net positive temperature dataset

4. Conclusion

The evaluation of measurement accuracy of a microcontroller-based body temperature measuring (MCBBTM) device was conducted using a repeated-samples t-test approach. The accuracy of the MCBBTM device is conducted with respect to a reference body temperature measuring device used in the hospital, which in this study is the Body Infrared Thermometer DJ-8861. Specifically, empirical field measurements was conducted using the two devices to simultaneously capture the patient's body temperature and at the same time use the MCBBTM device to capture the ambient temperature. The repeated-samples t-test was used to compare the mean of the difference between the MCBBTM device measured body temperature and the DJ-8861 device measured body temperature and the results of the repeated-samples t-test show that there is a significant difference in the mean of the two datasets.

Then, the datasets were split into two categories, namely, the net positive body temperature dataset and the net negative body temperature dataset. The net positive body temperature dataset is for those body temperature data items where the body temperature is higher than the ambient temperature whereas the net negative body temperature dataset is for those body temperature data items where the body temperature is lower than the ambient temperature. The results of the repeated-samples t-test show that there is no significant difference in the mean for the net positive body temperature dataset but there is significant difference in the mean for the net negative body temperature dataset. Hence, the conclusion is the MCBBTM device is only good for measuring the body temperature for those cases where the body temperature is higher than the ambient temperature. On the other hand, the device should not be used for measuring the body temperature when the ambi*ent temperature is higher than the body temperature.*

References

1. Gordon, O., **Ozuomba, Simeon**. & Ogbajie, I. **(2015).** Development of educate: a social network web application for e-learning in the tertiary institution. ***European Journal of Basic and Applied Sciences***, *2 (4)*, 33-54.
2. Sylvester Michael Ekpo, Kingsley M. Udofia, **Ozuomba Simeon (2019)** Modelling and Simulation of Robust Biometric Fingerprint Recognition Algorithm. ***Universal Journal of Applied Science*** *6(2): 29-38, 2019*
3. Chikezie, Aneke, Ezenkwu Chinedu Pascal, and **Ozuomba Simeon. (2014).** "Design and Implementation Of A Microcontroller-Based Keycard." ***International Journal of Computational Engineering Research (IJCER)*** *Vol, 04 Issue, 5 May – 2014*
4. Zion, Idongesit, **Simeon Ozuomba**, and Philip Asuquo. **(2020)** "An Overview of Neural Network Architectures for Healthcare." *2020* ***International Conference in Mathematics, Computer Engineering and Computer Science (ICMCECS).*** IEEE, 2020
5. Akpan, Nsikak-Abasi Peter, Kufre Udofia, and **Simeon Ozuomba (2018).** Development and Comparative Study of Least Mean Square-Based Adaptive Filter Algorithms. Development, 3(12). ***International Multilingual Journal of Science and Technology*** *(IMJST) Vol. 3 Issue 12, December - 2018*
6. **Simeon, Ozuomba. (2018)** "Sliding Mode Control Synthesis For Autonomous Underwater Vehicles" ***Science and Technology Publishing*** *(SCI & TECH*
7. Otumdi, Ogbonna Chima, Kalu Constance, and **Ozuomba Simeon (2018).** "Design of the Microcontroller Based Fish Dryer." *Journal of Multidisciplinary Engineering Science Studies (JMESS) Vol. 4 Issue 11, November - 201*
8. Maduka, N. C., **Simeon Ozuomba,** and E. E. Ekott. . **(2020)** "Internet of Things-Based Revenue Collection System for Tricycle Vehicle Operators." *2020* ***International Conference in Mathematics, Computer Engineering and Computer Science (ICMCECS).*** IEEE, 2020.
9. Thompson, E., Simeon, O., & Olusakin, A. (2020). A survey of electronic heartbeat electronics body temperature and blood pressure monitoring system. Journal of Multidisciplinary Engineering Science Studies (JMESS) Vol. 6 Issue 8, August – 2020
10. **Ozuomba Simeon,** Chukwedebe G. A. , Opara F. K., Ndinechi M. **(2013)** Preliminary Context Analysis Of Community Informatics Social Network Web Application. ***Nigerian Journal of Technology (NIJOTECH)*** Vol. 32. No. 2. July 2013, pp. 266-272
11. Ezenkwu C. P , **Ozuomba Simeon,** Kalu C. (2013) Community informatics social network for facilitated community policing: A case study of Nigeria . ***Software Engineering*** 2013; Vol.1(No.3): PP 22-30 . Published online November 20, 2013
12. **Ozuomba, Simeon,** and Etinamabasiyaka Edet Ekott. **(2020).** "Design And Implementation Of Microcontroller And Internet Of Things-Based Device Circuit And Programs For Revenue Collection From Commercial Tricycle Operators." ***Science and Technology Publishing*** (SCI & TECH) Vol. 4 Issue 8, August – 2020
13. **Ozuomba, Simeon,** Ekaette Ifiok Archibong, and Etinamabasiyaka Edet Ekott **(2020).** Development Of Microcontroller-Based Tricycle Tracking Using Gps And Gsm Modules. ***Journal of Multidisciplinary Engineering Science and Technology*** *(JMEST) Vol. 7 Issue 1, January - 2020*
14. **Ozuomba, Simeon. (2013).** Triple-win user innovation network and facilitated all-inclusive collective enterprise (TWUINFAICE): A postdoctoral research agenda for turning the youth bulge in Africa into blessing. ***Science Innovation****1*(3), 18-33.
15. Ekanem, Mark Sunday, and **Simeon Ozuomba**. **(2018).** ONTOLOGY DEVELOPMENT FOR PEDAGOGIC CONTENT INFORMATICS. ***European Journal of Engineering and Technology*** *Vol, 6(4).*
16. Bassey, M. U., **Ozuomba, Simeon,** & Stephen, B. U. A. **(2019).** DEVELOPMENT OF A FACILITATED CROWD-DRIVEN ONLINE PROFIT-MAKING SYSTEM. ***European Journal of Engineering and Technology*** *Vol, 7(5).*
17. Ezenkwu C. P , **Ozuomba Simeon,** Amaefule O. C. (2013) The Pure-Emic User Interface Design Methodology for an Online Community Policing Hub. ***Computer Engineering and Intelligent Systems*** Vol.4, No.11, 2013. ISSN 2222-1719 (Paper) ISSN 2222-2863 (Online)
18. Nicholas **Aigbobhiose Esene, Simeon Ozuomba, obinwa Christian Amaefule (2013)** Strategies for Improving Software Development and Acquisition Practices in Developing Countries. International Journal of Computer (ISSN 2307-4531) Vol. 8 No 1 (2013)
19. Chinedu Pascal Ezenkwu , **Simeon Ozuomba ,** Constance Kalu (2015) **,** *Application of k-Means Algorithm for efficient Customer Segmentation: A strategy for targeted customer services.* ***(IJARAI) International Journal of Advanced Research in Artificial Intelligence****, Vol. 4, No.10, 2015*
20. Ezeonwumelu, P., **Ozuomba, Simeon**. & Kalu, C. **(2015).** Development of swim lane workflow process map for enterprise workflow management

information system (WFMIS): a case study of comsystem computer and telecommunication ltd (CCTL) EKET. ***European Journal of Engineering and Technology,*** *3 (9)*, 1-13.

21. **Ozuomba, Simeon,** Kalu, C., & Anthony, U. M. **(2015).** Map Mashup Application And Facilitated Volunteered Web-Based Information System For Business Directory In Akwa Ibom State. ***European Journal of Engineering and Technology*** *Vol*, *3*(9).

22. Akpasam Joseph Ekanem, **Simeon Ozuomba,** Afolayan J. Jimoh **(2017)** Development of Students Result Management System: A case study of University of Uyo. ***Mathematical and Software Engineering,*** Vol. 3, No. 1 (2017), 26-42.

23. **Simeon Ozuomba , Gloria A. Chukwudebe , Felix K. Opara and Michael Ndinechi** (2014)Chapter 8: Social Networking Technology: A Frontier Of Communication For Development In The Developing Countries Of Africa . *In Green Technology Applications for Enterprise and Academic Innovation (Chapter 8).* **IGI Global, Hershey, PA 17033-1240, USA**

24. Ezenkwu, Chinedu Pascal, **Simeon Ozuomba**, and Constance **Kalu. (2013).** "Strategies for improving community policing in Nigeria through Community Informatics Social Network." *2013* ***IEEE International Conference on Emerging & Sustainable Technologies for Power & ICT in a Developing Society*** *(NIGERCON)*. IEEE, 2013.

25. Mathew-Emmanuel, Eze Chinenye, **Simeon Ozuomba**, and Constance Kalu. **(2017)** "Preliminary Context Analysis of Social Network Web Application for Combating HIV/AIDS Stigmatization." ***Mathematical and Software Engineering*** 3.1 (2017): 99-107

26. Stephen, B. U., **Ozuomba, Simeon**, & Eyibo, I. E. **(2018).** Development of Reward Mechanism for Proxy Marketers Engaged in E-Commerce Platforms**.** ***European Journal of Engineering and Technology Research,*** *3(10), 45-52.*

27. Eyibo, I. E., **Ozuomba, Simeon,** & Stephen, B. U. A. **(2018).** DEVELOPMENT OF TRUST MODEL FOR PROXY MARKETERS ENGAGED IN E-COMMERCE PLATFORMS. ***European Journal of Engineering and Technology*** *Vol, 6(4).*

28. Nicholas A. E., Simeon O., Constance K. (2013) Community informatics social e-learning network: a case study of Nigeria *Software Engineering 2013; 1(3): 13-21*

29. Inyang, Imeobong Frank, **Simeon Ozuomba,** and Chinedu Pascal Ezenkwu.**(2017)** "Comparative analysis of Mechanisms for Categorization and Moderation of User Generated Text Contents on a Social E-Governance Forum." ***Mathematical and Software Engineering*** 3.1 (2017): 78-86.

30. **Ozuomba, Simeon,** Constant Kalu, and Akpasam Joseph**. (2018).** Development of Facilitated Participatory Spatial Information System for Selected Urban Management Services. ***Review of Computer Engineering Research***, *5(2), 31-48.*

31. Kalu, Constance, **Simeon Ozuomba**, and Sylvester Isreal Umana. (2018). Development of Mechanism for Handling Conflicts and Constraints in University Timetable Management System. ***Communications on Applied Electronics*** *(CAE) 7(24).*

32. Ibanga, Jude, and **Ozuomba Simeon**, Obot, Akaniyene. B. **(2020)** "Development of Web-Based Learning Object Management System." Development 7, no. 3 (2020). ***Journal of Multidisciplinary Engineering Science and Technology*** *(JMEST) Vol. 7 Issue 3, March – 2020*

33. **Ozuomba Simeon** and Chukwudebe G. A.**(2003)** *An improved algorithm for channel capacity allocation in timer controlled token passing protocols, The Journal of Computer Science and its Applications* ***(An international Journal of the Nigerian Computer Society (NCS))*** *Vol. 9, No. 1 , June 2003 , PP 116 124*

34. Johnson, Enyenihi Henry, **Simeon Ozuomba**, and Ifiok Okon Asuquo. **(2019).** Determination of Wireless Communication Links Optimal Transmission Range Using Improved Bisection Algorithm. ***Universal Journal of Communications and Network,*** *7(1), 9-20.*

35. Bianzino, A. P., Chaudet, C., Rossi, D., & Rougier, J. L. (2010). A survey of green networking research. *IEEE Communications Surveys & Tutorials*, *14*(1), 3-20.

36. **Ozuomba Simeon** and Chukwudebe G. A. **(2004)** *A new priority scheme for the asynchronous traffic in timer-controlled token passing protocols, The Journal of Computer Science and its* ***Applications (An international Journal of the Nigerian Computer Society (NCS))*** *Vol. 10, No. 2 , December 2004 , PP 17 -25*

37. Alicea, J., Oreg, Y., Refael, G., Von Oppen, F., & Fisher, M. P. (2011). Non-Abelian statistics and topological quantum information processing in 1D wire networks. *Nature Physics*, *7*(5), 412-417.

38. **Ozuomba Simeon** and Chukwudebe G. A.**(2011) ;** *"Performance Analysis Of Timely-Token Protocol With Variable Load Of Synchronous Traffic"* ***NSE Technical Transactions , A Technical Journal of The Nigerian Society Of Engineers,*** Vol. 46, No. 1 Jan – March 2011, PP 34 – 46.

39. Spies Shapiro, L. A., & Margolin, G. (2014). Growing up wired: Social networking sites and adolescent psychosocial development. *Clinical child and family psychology review*, *17*, 1-18.

40. **Kalu, S. Ozuomba, G. N. Onoh (201**1) ANALYSIS OF TIMELY-TOKEN PROTOCOL WITH NON-UNIFORM HEAVY LOAD OF ASYNCHRONOUS TRAFFIC. Electroscope Journal Vol. 5 No. 5 (2011)

41. **Ozuomba Simeon ,** Chukwudebe G. A. and Akaninyene B. Obot **(2011); "***Static-Threshold-Limited On-Demand Guaranteed Service For Asynchronous Traffic In Timely-Token Protocol " Nigerian* ***Journal of Technology (NIJOTECH)*** Vol. 30, No. 2 , June 2011 , PP 124 – 142

42. Kalu C. , **Ozuomba Simeon,** Onoh G.N. **(2013)** Dynamic Threshold limited timed token (DTLTT) Protocol ***Nigerian Journal of Technology (NIJOTECH)*** Vol. 32. No. 1. March 2013, pp. 266-272.

43. **Ozuomba, Simeon,** Amaefule, C. O., & Afolayan, J. J. **(2013).** Optimal Guaranteed Services Timed Token (OGSTT) Media Access Control (Mac) Protocol For Networks That Support Hard Real-Time And Non Real-Time Traffic. ***Nigerian Journal of Technology (NIJOTECH)*** *32*(3), 470-477

44. **Kalu C., Ozuomba S., and Mbocha C.C. (2013)** Performance Analysis of Static- Threshold-Limited On-Demand Guaranteed Services Timed Token Media Access Control Protocol Under Non Uniform Heavy Load of Asynchronous Traffic. *NSE Technical Transactions, A Technical Journal of the Nigerian Society of Engineers,* Vol. 47, No. 3 July – Sept 2013,

45. Ogbonna Chima Otumdi , **Ozuomba Simeon,** Philip M. Asuquo (**2020**) Device Hardware Capacity And Rssi-Based Self Organizing Map Clustering Of 928 Mhz Lorawan Nodes Located In Flat Terrain With Light Tree Densities ***Science and Technology Publishing*** *(SCI & TECH) Vol. 4 Issue 9, September - 2020*

46. Constance Kalu, Simeon Ozuomba and **Umoren Mfonobong Anthony** (2015) Performance Analysis of Fiber Distribution Data Interface Network Media Access Control Protocol Under-Uniform Heavy load of Asynchronous Traffic. European Journal of Basic and Applied Sciences. Vol 2 No. 4

47. Constance Kalu, Simeon Ozuomba and **Umoren Mfonobong Anthony** (2015) Static-Threshold-Limited Bust Protocol, European Journal of Mathematics and Computer Science, Vol. 2 N0. 2

48. Uduak Idio Akpan, Constance Kalu, **Simeon Ozuomba,** Akaninyene Obot **(2013).** Development of improved scheme for minimising handoff failure due to poor signal quality**.** ***International Journal of Engineering Research & Technology (IJERT)****, 2(10), 2764-2771*

49. Anietie Bassey, **Simeon Ozuomba** & Kufre Udofia **(2015).** An Effective Adaptive Media Play-out Algorithm For Real-time Video Streaming Over Packet Networks. European. ***Journal of Basic and Applied Sciences*** *Vol, 2(4).*

50. Kalu, C., **Ozuomba, Simeon**. & Udofia, K. **(2015).** Web-based map mashup application for participatory wireless network signal strength mapping and customer support services. ***European Journal of Engineering and Technology,*** *3 (8),* 30-43.

51. Samuel, Wali, **Simeon Ozuomba,** and Philip M. Asuquo **(2019).** EVALUATION OF WIRELESS SENSOR NETWORK CLUSTER HEAD SELECTION FOR DIFFERENT PROPAGATION ENVIRONMENTS BASED ON LEE PATH LOSS MODEL AND K-MEANS ALGORITHM. EVALUATION, 3(11). ***Science and Technology Publishing*** *(SCI & TECH) Vol. 3 Issue 11, November - 2019*

52. Kalu, C., **Ozuomba, Simeon**., & Anthony, U. M. **(2015).** STATIC-THRESHOLD-LIMITED BuST PROTOCOL. ***European Journal of Mathematics and Computer Science*** *Vol, 2(2).*

53. Simeon, Ozuomba. (2016). Evaluation Of Bit Error Rate Performance Of Multi-Level Differential Phase Shift Keying. Evaluation, 1(8). ***International Multilingual Journal of Science and Technology*** *(IMJST) Vol. 1 Issue 8, August – 2016*

54. Samuel, W., **Ozuomba, Simeon,** & Constance, K**. (2019).** SELF-ORGANIZING MAP (SOM) CLUSTERING OF 868 MHZ WIRELESS SENSOR NETWORK NODES BASED ON EGLI PATHLOSS MODEL COMPUTED RECEIVED SIGNAL STRENGTH. ***Journal of Multidisciplinary Engineering Science and Technology*** *(JMEST) Vol. 6 Issue 12, December - 2019*

55. Njoku, Felix A., **Ozuomba Simeon**, and Fina Otosi Faithpraise **(2019).** Development Of Fuzzy Inference System (FIS) For Detection Of Outliers In Data Streams Of Wireless Sensor Networks. ***International Multilingual Journal of Science and Technology*** *(IMJST) Vol. 4 Issue 10, October - 2019*

56. Idio, Uduak, Constance Kalu, Akaninyene Obot, and **Simeon Ozuomba. (2013)** "An improved scheme for minimizing handoff failure due to poor signal quality." **In *2013 IEEE International Conference on Emerging & Sustainable Technologies for Power & ICT in a Developing Society*** *(NIGERCON)*, pp. 38-43. IEEE, 2013.

57. **Simeon, Ozuomba. (2020).** "Analysis Of Effective Transmission Range Based On Hata Model For Wireless Sensor Networks In The C-Band And Ku-Band." ***Journal of Multidisciplinary Engineering Science and Technology*** *(JMEST) Vol. 7 Issue 12, December - 2020*

58. Atakpo, F. K., Simeon, O., & Utibe-Abasi, S. B. (2021) A COMPARATIVE ANALYSIS OF SELFORGANIZING MAP AND K-MEANS MODELS FOR SELECTION OF CLUSTER HEADS IN OUT-OF-BAND DEVICE-TO-DEVICE COMMUNICATION. *Journal of Multidisciplinary Engineering Science Studies (JMESS).*

59. **Simeon, Ozuomba. (2020).** "APPLICATION OF KMEANS CLUSTERING ALGORITHM FOR SELECTION OF RELAY NODES IN WIRELESS SENSOR NETWORK." ***International Multilingual Journal of Science and Technology*** *(IMJST) Vol. 5 Issue 6, June - 2020*

60. Ogbonna Chima Otumdi , **Ozuomba Simeon**, Kalu Constance **(2020).** Clustering Of 2100 Mhz Cellular Network Devices With Som Algorithm Using Device Hardware Capacity And Rssi Parameters ***Science and Technology Publishing*** *(SCI & TECH) Vol. 4 Issue 2, February – 2020*

61. Akpan, Itoro J., **Ozuomba Simeon,** and Kalu Constance (2020). "Development Of A Guard

Channel-Based Prioritized Handoff Scheme With Channel Borrowing Mechanism For Cellular Networks." ***Journal of Multidisciplinary Engineering Science and Technology*** *(JMEST) Vol. 7 Issue 2, February – 2020*

62. Houdas, Y., & Ring, E. F. J. (2013). *Human body temperature: its measurement and regulation*. Springer Science & Business Media.

63. Yan, H., Xu, L. D., Bi, Z., Pang, Z., Zhang, J., & Chen, Y. (2015). An emerging technology–wearable wireless sensor networks with applications in human health condition monitoring. *Journal of Management Analytics*, *2*(2), 121-137.

64. Thielen, M., Sigrist, L., Magno, M., Hierold, C., & Benini, L. (2017). Human body heat for powering wearable devices: From thermal energy to application. *Energy conversion and management*, *131*, 44-54.

65. Nassar, J. M., Mishra, K., Lau, K., Aguirre-Pablo, A. A., & Hussain, M. M. (2017). Recyclable nonfunctionalized paper-based ultralow-cost wearable health monitoring system. *Advanced Materials Technologies*, *2*(4), 1600228.

66. Mansor, H., Shukor, M. H. A., Meskam, S. S., Rusli, N. Q. A. M., & Zamery, N. S. (2013, November). Body temperature measurement for remote health monitoring system. In *2013 IEEE International conference on smart instrumentation, measurement and applications (ICSIMA)* (pp. 1-5). IEEE.

67. Islam, M. M., Rahaman, A., & Islam, M. R. (2020). Development of smart healthcare monitoring system in IoT environment. *SN computer science*, *1*, 1-11.

68. Gupta, D., Parikh, A., & Swarnalatha, R. (2020). Integrated healthcare monitoring device for obese adults using internet of things (IoT). *International Journal of Electrical & Computer Engineering (2088-8708)*, *10*(2).

69. Kumar, N. (2017, August). IoT architecture and system design for healthcare systems. In *2017 International Conference on Smart Technologies for Smart Nation (SmartTechCon)* (pp. 1118-1123). IEEE.

70. Khan, M. M., Mehnaz, S., Shaha, A., Nayem, M., & Bourouis, S. (2021). IoT-based smart health monitoring system for COVID-19 patients. *Computational and Mathematical Methods in Medicine*, *2021*.

71. Teran, C. G., Torrez-Llanos, J., Teran-Miranda, T. E., Balderrama, C., Shah, N. S., & Villarroel, P. (2012). Clinical accuracy of a non-contact infrared skin thermometer in paediatric practice. *Child: care, health and development*, *38*(4), 471-476.

72. Rizzo, M., Arfuso, F., Alberghina, D., Giudice, E., Gianesella, M., & Piccione, G. (2017). Monitoring changes in body surface temperature associated with treadmill exercise in dogs by use of infrared methodology. *Journal of Thermal Biology*, *69*, 64-68.

73. Barnes, K. (2019). The Effects of Faces and the Preference for Different Object Types on the Generation of the N170 Event-Related Brain Potential.

74. Mönki, J., Rajamäki, M., Raekallio, M., Karikoski, N., Markku, S., & Mykkänen, A. (2019). Comparison of airway cytology in healthy adult horses housed either on peat bedding or wood shavings.

75. Papasozomenou, P., Athanasiadis, A. P., Zafrakas, M., Panteris, E., Loufopoulos, A., Assimakopoulos, E., & Tarlatzis, B. C. (2015). Three-dimensional versus two-dimensional ultrasound for fetal nasal bone evaluation in the second trimester. *The Journal of Maternal-Fetal & Neonatal Medicine*, *28*(12), 1432-1437.

76. Mensà, E., Recchioni, R., Marcheselli, F., Giuliodori, K., Consales, V., Molinelli, E., ... & Offidani, A. M. (2018). MiR-146a-5p correlates with clinical efficacy in patients with psoriasis treated with the tumour necrosis factor-alpha inhibitor adalimumab. *British Journal of Dermatology*, *179*(3), 787-789.

77. Zhang, Y., Bandyopadhyay, G., Topham, D. J., Falsey, A. R., & Qiu, X. (2019). Highly efficient hypothesis testing methods for regression-type tests with correlated observations and heterogeneous variance structure. *BMC bioinformatics*, *20*(1), 1-14.