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The Effect of Lost Data on the IoT Platform on the Formation of Fetal Heart Rate Graphs for Remote Diagnostic Purposes

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ABSTRACT FHR is the fetal heart rate from bpm recording detected by doppler, FHR monitoring is very important to monitor fetal health to avoid fetal distress or fetal death, FHR provides more in-depth information about how the baby is doing compared to traditional monitoring of the baby. IoT media is a medium for monitoring remote sensor values using internet connections, but there are several obstacles, namely there are doubts about the data displayed by IoT media, namely the risk of missing or unsent data, this will be very dangerous if the data that is should be monitored by doctors as a reference for medical diagnosis and treatment is lost or not displayed on the IoT, because if there is missing data it will cause inaccurate diagnosis or health treatment decisions by doctors. The aim of this study to analyze the effect of lost data on the formation of the Fetal Heart Rate graph on the IoT platform as a medium for remote diagnosis. In addition, FHR data can be saved for further diagnosis by a doctor if needed. This study uses an ESP32 microcontroller which will also be used to send data to IoT (Thinger.io). The independent variable used in this study is FHR data before it is uploaded to the IoT, and the dependent variable is FHR data when it is uploaded to the IoT. The greatest data loss is at the farthest distance of 30 meters with a value of 62.47%. Based on the research that has been done, this study has the advantage that the results obtained from Doppler are close to the BPM value in humans. And also this research has developments that can be done in the future such as adding storage to the website that is used for monitoring, and placing the right position on Doppler so that the results are more stable.

INDEX TERMS FHR, BPM, Doppler, IoT, Thingspeak

I. INTRODUCTION

Health consultations can be carried out remotely, thus making the ease of examining patients higher, but at the time of remote examination it is only limited to consultations without any data from patients that can be used as a reference and can improve the accuracy of diagnosis and treatment carried out by doctors[1][2][3]. This condition can be overcome by sending and recording patient data with certain parameters through IoT media[4], IoT media is a medium for monitoring remote sensor values using internet connection, but there are several obstacles, namely there are doubts about the data displayed by IoT media, namely the risk of missing or unsent data, this will be very dangerous if the data that should be monitored by doctors as a reference for medical diagnosis and treatment is lost or not displayed on IoT[4][5][6], because if there is missing data it will cause it to be inaccurate a diagnosis or health treatment decision by a doctor, such as when monitoring the condition of the fetus through the FHR, when there is missing data it will affect the FHR chart[5][7][8]. FHR is the fetal heart rate from bpm recording detected by Doppler, in some cases of pregnancy[9][7][10][11], FHR monitoring is very important to monitor fetal health to avoid fetal distress or fetal death, FHR provides more in-depth information about how the baby is doing compared to traditional monitoring of the baby's heart rate. FHR retrieval can be done in the first way, namely FHR retrieval using a time reference, where BPM will be recorded for a certain time interval and then observed the average BPM is taken in that time interval , as for the frequency of BPM data retrieval, where BPM[12][13] will be taken several times according to a predetermined frequency which will then be determined by FHR through the difference in BPM at that frequency interval. By knowing the FHR, doctors and nurses can find out the condition of the fetus and doctors can make decisions for handling patients[14][15].

There are several studies that discuss fetal doppler including, in 2011 there were Lukas Zach, Vaclav Chud, Jakub Kuz, who discussed the appearance of FHR parameters on CTG using an android application[2][16]. Heart rate although in this study there is a CTG[17][18] title but the researcher only sends and displays FHR, the researcher concludes that the use of the android application as a medium to display FHR data in the future can be used as a reference for the telemedicine system in monitoring FHR data, but this study has not discussed about lost data that exists when sending and receiving data. Furthermore, in 2014, Wendi Yang, Kai Yang, Hanjun Jiang, et al discussed the use of mobile internet[19] to display CTG results in this study discussing the concept of using the internet as a medium for monitoring fetal heart rate in fetuses, but unfortunately in this study heart rate tapping the fetus is still using a stethoscope [20]which has the potential to mix the baby's heartbeat with the mother's heartbeat, and this research does not show clear results regarding acceptance on smartphone media or from the results of using mobile internet, so the data presented in this journal has not discussed in detail about use of smartphone media. Then in 2019, Imam Azimi et al with their research discussed the effect of data loss on decision making in the world of Health[21][20][22].

This study discusses the concept of monitoring data through IoT media and the influence of the risk of missing data will affect the diagnosis by doctors, in this study the researchers concluded that the loss of data[23][17] in remote monitoring would be very dangerous, because lost data will affect the actions to be taken by the doctor. Previous research has discussed the importance of the FHR value and the effect of data loss on decision making in the world of Health, but the research that has been done has not discussed the lost data that exists during data transmission and reception. Based on the research that has been done previously, the author will make a study entitled "The Effect of Lost Data on the IOT Platform on the Formation of FHR Graphs for Remote Diagnostic Purposes" which is a development of previous research, this study aims to examine the existing lost data. on the IoT platform so that the data displayed on the IoT platform can be known.

The aim of this study to analyze the effect of lost data on the formation of the Fetal Heart Rate graph on the IoT platform as a medium for remote diagnosis.

II. METHOD

This study using one respondent, then will be treated by one respondent. Sampling is done randomly by taking the results one time. This study used Power supply and charger module, ESP32 Microcontroller for data acquisition and communication to computer units using IoT Notification. The research design used in making the module is Pre-experimental with the After Only Design type. In this design the researcher only uses one group of subjects and only sees the results without measuring and knowing the initial conditions, but there is already a comparison group.

This paragraph can explain FIGURE 1 The block diagram above has 3 main parts, namely the Doppler node MCU and the IoT platform, Doppler consists of a Doppler probe and a Doppler frequency generator circuit and a Doppler signal receiver circuit which is the source of data input at the MCU node ADC, the MCU node section consists of an ADC that functions as receiving data from the Doppler signal receiver circuit, calculating BPM as a calculation of the BPM value from the Doppler signal and uploading BPM data to IoT which serves to send BPM data to the IoT platform, in the IoT platform process there is data reception from the MCU[24][25]node and appearance on the IoT platform display.

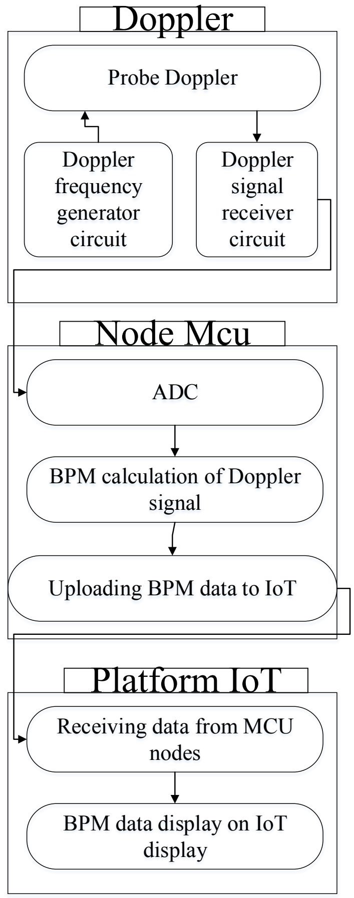

FIGURE 1. The System Block Diagram in Research Fetal Heart Rate

Refer to FIGURE 2 Turn on the ON button after the module is turned on then the process will initialize after the initialization process is complete it will continue in the next section, namely reading the FHR, When the doppler has worked, it continues in the process of checking WIFI whether it is connected or not, When the WIFI condition is not connected then the process returns to reading FHR, and When Bluetooth is connected, the process will continue on sending IoT platform data and forming FHR graphs on the IoT data display.

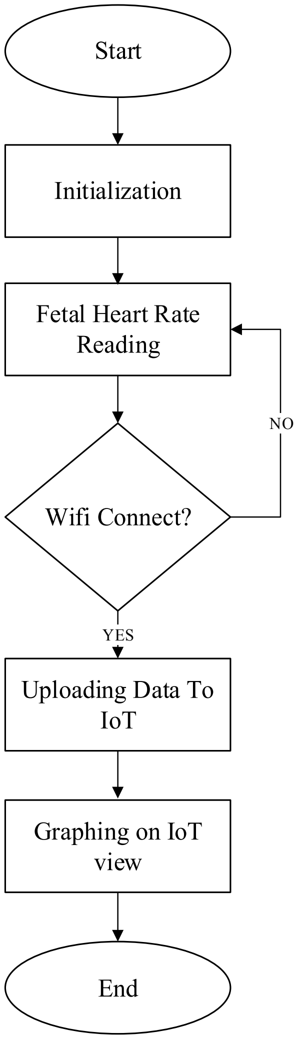

FIGURE 2. System Flowchart

Measurements of each parameter. The average value of the measurement is obtained by using the mean or the average by applying the equation (1). The average is the number obtained by dividing the number of values by the number of data in the set.:

$$\overline{x} = \frac{x1+x2\ldots+xn}{n} \quad (1)$$

where x denotes the mean (mean) for the n-measurements, x1 denotes the first measurement, x2 denotes the second measurement, and xn denotes n measurements. Standard deviation is a value that indicates the degree (degree) of variation in a data set or a measure of the standard deviation of the mean. The standard deviation (SD) formula can be shown in the equation (2):

$$SD = \sqrt{\frac{\sum(xi-\overline{x})^2}{(n-1)}} \quad (2)$$

where xi indicates the number of desired values, x indicates the average of the measurement results, n indicates the number of measurements. Uncertainty (UA) is a doubt that appears in each measurement result[26][18][27]. The uncertainty formula is shown in the equation (3):

$$UA = \frac{SD}{\sqrt{n}} \quad (3)$$

where UA indicates the uncertainty value of the total measurement, SD indicates the resulting standard deviation, and n indicates the number of measurements. %error indicates a system error. The lower Error value is the average difference of each data. Errors can indicate deviations between the standard and the design or model. The error formula is shown in the equation (4).

$$\%ERROR = \frac{(x_n-\mathrm{x})}{x_n} \times 100\% \quad (4)$$

where xn is the measured value of the machine calibrator. X is the measured value of the design.

III. RESULT

FIGURE 1 and FIGURE 2 are a microcontroller circuit consisting of an ESP32, a battery circuit, an envelope, and an amplifier circuit. The power supply circuit is made using 1 18650 battery which will enter the voltage up module. The output of the first step up module is +6V which will enter the Arduino which is used as a voltage source for the entire circuit. Inside the Arduino[28] is equipped with a wifi connection which can transmit or send data through the wifi, and will send data to IOT using wifi delivery[29].

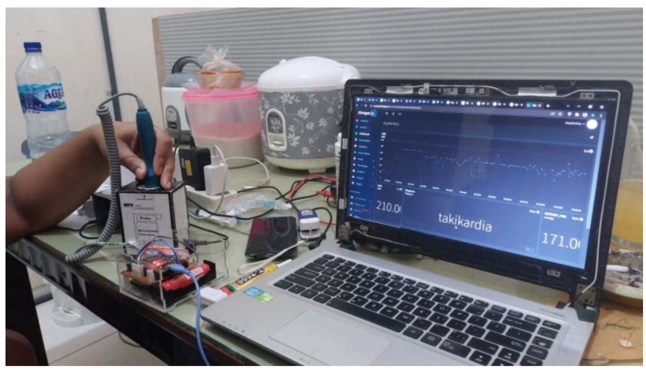

FIGURE 1 . Front View Module with experiments on a fetal heart rate simulator

In FIGURE 3 is the result of FHR measurements on respondents with a BPM setting of 60. There are a number of FHR graphs of 120 data stored on the SD - Card and IoT then the average of 120 data is taken every 2 minutes resulting in an average BPM value of 2 minutes is 60.10 in SD-card and on Thinger.io 46.29 BPM. The smallest data loss is at a distance of 5 meters with a value of 1.95%. Of the 7221 data sent, the data received on thinger.io was 7080. The largest data loss[17][17] was at the furthest distance of 25 meters with a value of 50.33%. Of the 7185 data sent, only 3569 data were received by the thinger.io.

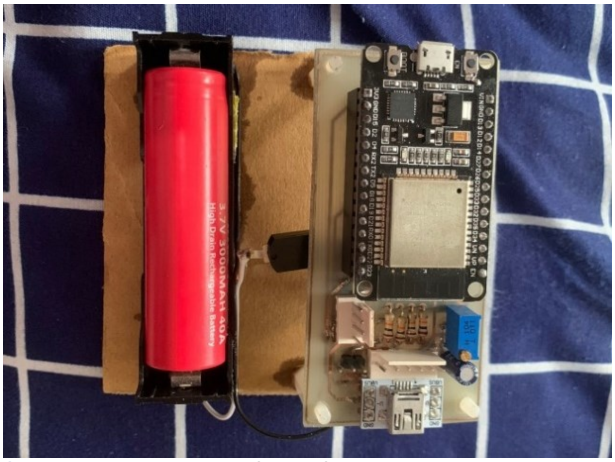

FIGURE 2 . Design Modul and Overall Circuit Design in Research on Fetal Heart Rate with ESP32

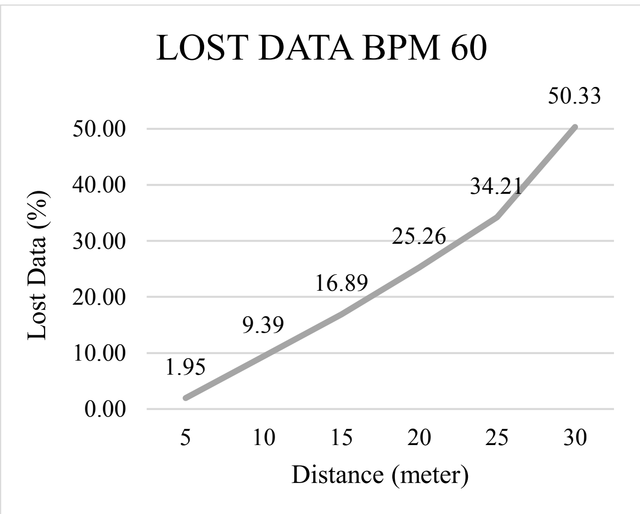

FIGURE 3 . Experiment using a fetal heart rate simulator at the Lost Data BPM setting of 60

In FIGURE 4 is the result of FHR measurements on respondents with a BPM setting of 90. There are a number of FHR graphs of 120 data on the SD - Card and IoT then the average is taken from 120 data every 2 minutes producing an average BPM value of 2 minutes is 90.05 on the SD-card and on Thinger.io 67.79 BPM. The smallest data loss is at a distance of 5 meters with a value of 0.56%. Of the 10810 data sent, the data received on thinger.io was 10750. The largest data loss was at the farthest distance of 30 meters with a value of 58.78%. Of the 10795 data sent, only 4450 data were received by the thinger.io. In FIGURE 5 is the result of FHR measurements on respondents with a BPM setting of 120. There are a number of FHR graphs of 120 data on the SD - Card and IoT then the average is taken from 120 data every 2 minutes resulting in an average BPM value of 2 minutes is 120.91 on the SD-card and on Thinger.io 94.72 BPM. The smallest data loss is at a distance of 5 meters with a value of 0.14%. Of the 14511 data sent, the data received on thinger.io was 14490. The largest data loss was at the farthest distance of 30 meters with a value of 53.02%. Of the 14895 data sent, only 6997 data were received by the thinger.io.

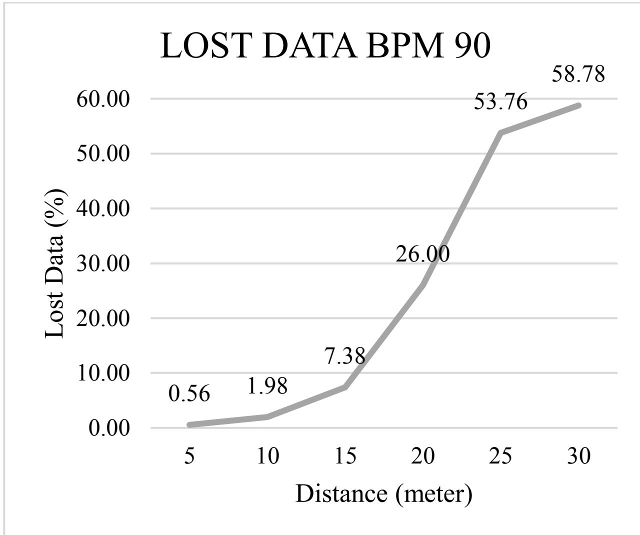

FIGURE 4 . Experiment using a fetal heart rate simulator at the Lost Data BPM setting of 90

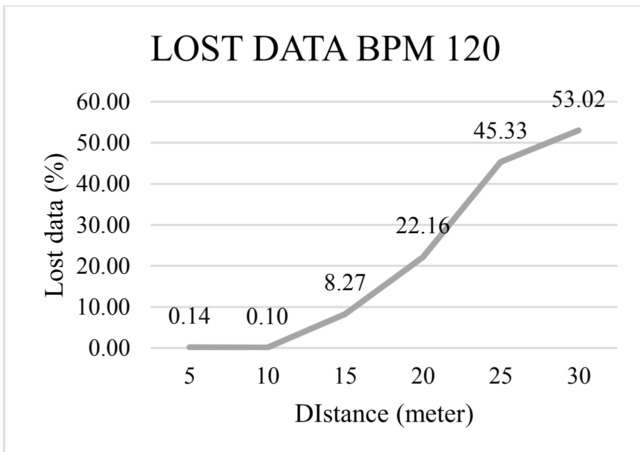

FIGURE 5 . Experiment using a fetal heart rate simulator at the Lost Data BPM setting of 120

In FIGURE 6 is the result of FHR measurements on respondents with a BPM setting of 150. There are a number of FHR graphs of 120 data on the SD - Card and IoT then the average is taken from 120 data every 2 minutes producing an average BPM value of 2 minutes is 150.15 on the SD-card and on the Thinger.io 105.57 BPM. The smallest data loss is at a distance of 5 meters with a value of 0.67%. Of the 18075 data sent, the data received on thinger.io was 17953. The largest data loss was at the farthest distance of 30 meters with a value of 53.88%. Of the 17870 data sent, only 8241 data were received by the thinger.io.

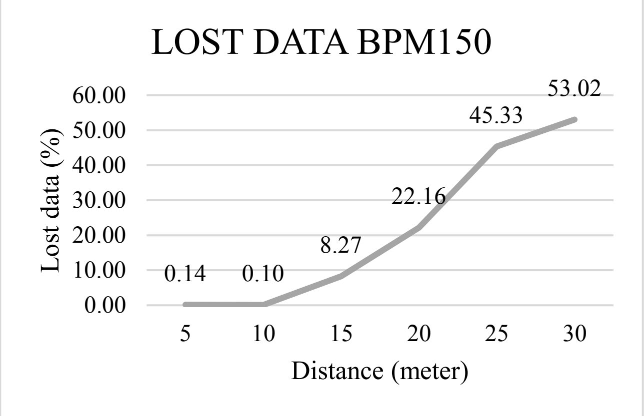

FIGURE 6 . Experiment using a fetal heart rate simulator at the Lost Data BPM setting of 150

In FIGURE 7 is the result of FHR measurements on respondents with a BPM setting of 180. There are 120 FHR graphs of data on SD – Card and IoT then the average is taken from 120 data every 2 minutes producing an average BPM value of 2 minutes is 180.20 on SD-card and on Thinger.io 122.41 BPM. The smallest data loss is at a distance of 5 meters with a value of 0.35%. Of the 21571 data sent, the data received on thinger.io was 21495. The largest data loss was at the farthest distance of 30 meters with a value of 56.13%. From the total 21499 data sent, only 9432 data were received by the thinger.io.

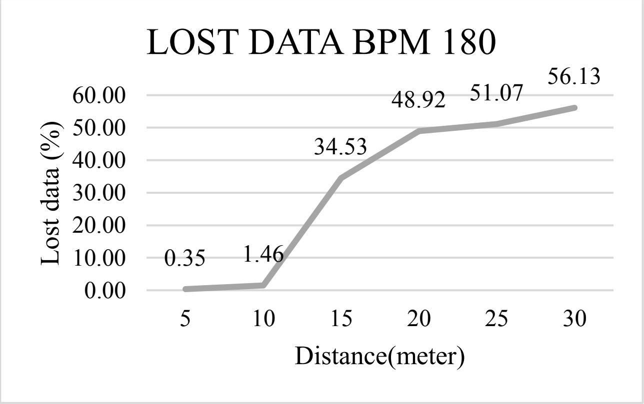

FIGURE 7 . Experiment using a fetal heart rate simulator at the Lost Data BPM setting of 180

In FIGURE 8 is the result of FHR measurements on respondents with a BPM setting of 210. There are a number of FHR graphs of 120 data on SD-Card and IoT then the average is taken from 120 data every 2 minutes producing an average BPM value of 2 minutes is 208.84 on SD-card and on Thinger.io 143.19 BPM. The smallest data loss is at a distance of 5 meters with a value of 0.71%. Of the 25315 data sent, the data received on thinger.io was 25135. The largest data loss was at the furthest distance of 25 meters with a value of 62.97%. Of the 24955 data sent, only 9241 data were received by the thinger.io.

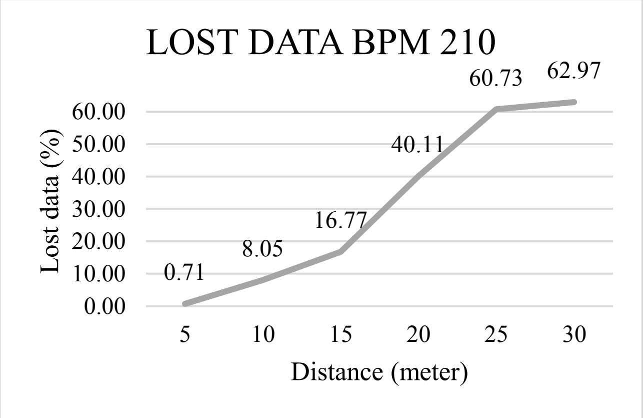

FIGURE 8 . Experiment using a fetal heart rate simulator at the Lost Data BPM setting of 210

In FIGURE 9 Based on the boxplot graph below, it can be seen that in testing with an LTE network, the data from the heart rate reading on SD-Card compared to IOT has a slight difference in data, although there is a zero heart rate reading of 0 which indicates lost data on IOT, on the 3G network test the results can be seen. sd card heart rate readings compared to IOT have quite a large difference in readings, which means there are a lot of lost data between sd cards and IOT, in the 2G test the sd card reading data compared to IoT shows a very large difference so it can be concluded that the most lost data values between networks LTE, 3G and 2G are on 2G networks.

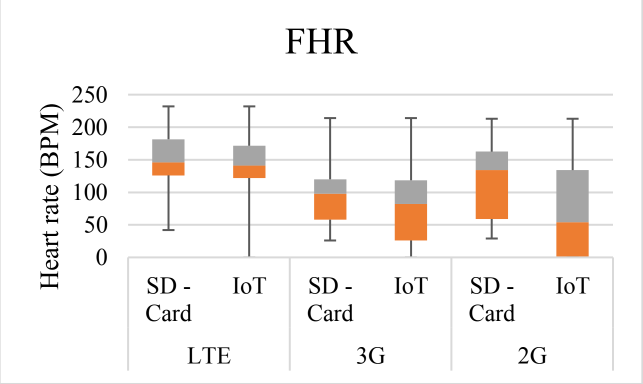

FIGURE 9 . lost data with respondents based on the type of internet network connection.

IV. DISCUSSION

After testing the module, data collection and analysis of the results are carried out to determine the stability and accuracy of making the module. This study also has a goal to analyze the quality of data transmission on data transmission using IoT thinger.io[30][31][32], in the BPM 60 measurement, there are 120 FHR graphs of data on SD – Card and IoT and then the average is taken from 120 data every 2 minutes resulting in an average BPM value of 2 minutes is 60.10 on Sd-card and 46.29 BPM on thinger.io. The smallest data loss is at a distance of 5 meters with a value of 1.95%. Of the 7221 data sent, the data received on thinger.io was 7080. The largest data loss was at the furthest distance of 25 meters with a value of 50.33%. Of the 7185 data sent, only 3569 data were received by the thinger.io.In the BPM 90 measurement, there are 120 FHR graphs of data on SD – Card and IoT then the average is taken from 120 data every 2 minutes resulting in an average BPM value of 2 minutes is 90.05 on SD-card and 67.79 BPM on Thinger.io . The smallest data loss is at a distance of 5 meters with a value of 0.56%. Of the 10810 data sent, the data received on thinger.io was 10750. The largest data loss was at the farthest distance of 30 meters with a value of 58.78%. Of the 10795 data sent, only 4450 data were received by the thinger.io. In the BPM 120 measurement, there are 120 FHR graphs of data on SD – Card and IoT then the average of 120 data is taken every 2 minutes resulting in an average BPM value of 2 minutes is 120.91 on Sd-card and 94.72 BPM on Thinger.io. The smallest data loss is at a distance of 5 meters with a value of 0.14%. Of the 14511 data sent, the data received on thinger.io was 14490. The largest data loss was at the farthest distance of 30 meters with a value of 53.02%. Of the 14895 data sent, only 6997 data were received by the thinger.io. In the BPM 150 measurement, there are 120 FHR graphs of data on SD – Card and IoT then the average is taken from 120 data every 2 minutes resulting in an average BPM value of 2 minutes is 150.15 on Sd-card and on Thinger.io 105.57 BPM. The smallest data loss is at a distance of 5 meters with a value of 0.67%. Of the 18075 data sent, the data received on thinger.io was 17953. The largest data loss was at the farthest distance of 30 meters with a value of 53.88%. Of the 17870 data sent, only 8241 data were received by the thinger.io. In the 180 BPM measurement, there are 120 FHR graphs of data on SD – Card and IoT then the average is taken from 120 data every 2 minutes resulting in an average BPM value of 2 minutes is 180.20 on SD-card and 122.41 BPM on Thinger.io. The smallest data loss is at a distance of 5 meters with a value of 0.35%. Of the 21571 data sent, the data received on thinger.io was 21495. The largest data loss was at the farthest distance of 30 meters with a value of 56.13%. From the total 21499 data sent, only 9432 data were received by the thinger.io. In the BPM 210 measurement, there are 120 FHR graphs of data on SD – Card and IoT and then the average of 120 data is taken every 2 minutes, resulting in an average BPM value of 2 minutes is 208.84 on SD-card and 143.19 BPM on Thinger.io. The smallest data loss is at a distance of 5 meters with a value of 0.71%. Of the 25315 data sent, the data received on thinger.io was 25135. The largest data loss was at the furthest distance of 25 meters with a value of 62.97%. Of the 24955 data sent, only 9241 data was received by the thinger.io.

Several studies conclude that data monitoring through IoT media and the impact of the risk of missing data will affect the making of diagnoses by doctors[33][15][5]. it can be concluded from this research that the researcher concludes that the loss of data in this remote monitoring will be very dangerous, because the lost data will affect the actions that will be taken by the doctor. with some limitations of the problems in this study such as the data retrieval method by comparing the data displayed on the IoT platform with the existing data on the module, then using ESP32 as a microcontroller, and the value displayed is the Fetal Heart Rate (FHR) value.

V. CONCLUSION

Overall, this research can be concluded that the Influence of Lost Data on the IoT Platform on Fetal Heart Rate Graph Formation for Remote Diagnostic Purposes has been successfully created and can be used properly. This means that the tool can apply the use of IoT to the measurement of Fetal Heart Rate by using a short – far distance. This study shows the effect of lost data on the formation of the Fetal Heart Rate graph on the IoT platform as a medium for remote diagnosis. Where, the highest lost data is at a distance of 25m and the lowest lost data value is at a distance of 5m. In the measurement of BPM 60 Lost the smallest data is at a distance of 5 meters with a value of 1.95%. The largest data loss is at the farthest distance of 30 meters with a value of 50.33%. In the measurement of BPM 90 Lost the smallest data is at a distance of 5 meters with a value of 0.56%. The largest data loss is at the farthest distance of 30 meters with a value of 58.78%. In the measurement of BPM 120 Lost the smallest data is at a distance of 5 meters with a value of 0.14%. The largest data loss is at the farthest distance of 30 meters with a value of 53.02%. In the measurement of BPM 150 Lost the smallest data is at a distance of 5 meters with a value of 0.67%. The largest data loss is at the farthest distance of 30 meters with a value of 53.88%. In the measurement of BPM 180 Lost the smallest data is at a distance of 5 meters with a value of 0.35%. The greatest data loss is at the farthest distance of 30 meters with a value of 56.13%. In the measurement of BPM 210 Lost the smallest data is at a distance of 5 meters with a value of 0.71%. The greatest data loss is at the farthest distance of 30 meters with a value of 62.47%. The development that can be done in this research is to use a website that already has data storage directly on the website. then equipped with an ideal position for retrieval of Doppler data so that the results are stable.

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