Jurnal Krisnadana (Jurnal Komputer, Sistem Kendali & Jaringan)
Vol 4, Issue 2, January 2025 , pp. 103-110
https://doi.org/10.58982/krisnadana.v4i2.723

E-ISSN: 2808-3563
P-ISSN: 2808-3520

Implementation of Median Filter in Data Processing of Temperature and Humidity Monitoring System with DHT 11 and DHT 22 Sensors

Luqman Aji Kusumo[1*]

[1*]*Program Studi Teknologi Instrumentasi Industri Petrokimia, Politeknik Industri Petrokimia Banten, Indonesia*

[1*]*luqman.aji@poltek-petrokimia.ac.id*

ARTICLE INFO

Article history:
Received 30 November 2024
Accepted 26 December 2024
Published 31 January 2025

Keywords:
DHT11;
DHT22;
Median Filter;
Noise Reduction;
Temperature Data Accuracy

ABSTRACT

This research focuses on enhancing the accuracy and stability of temperature measurements obtained from DHT11 and DHT22 sensors through the application of a median filter. Data was collected using an ESP32 microcontroller and stored as a time-series dataset in a MySQL database. Given that the DHT11 sensor is more prone to inaccuracies and noise compared to the higher-precision DHT22 sensor, the median filter was implemented to minimize outliers and fluctuations in the recorded readings. The results indicate that the median filter significantly improves data stability for the DHT11 sensor, effectively reducing noise-induced anomalies. Meanwhile, for the DHT22 sensor, the filter has minimal impact due to its already high accuracy and lower susceptibility to noise. These findings demonstrate that the median filter is particularly beneficial for sensors with lower precision, offering a cost-effective method for refining temperature data in monitoring applications. The study underscores the importance of noise reduction techniques in enhancing sensor performance, making the median filter a practical solution for improving data reliability in real-time temperature monitoring systems.

1. Introduction

Temperature is one of the research objects that is often the focus of study. Studies conducted on temperature parameters are related to monitoring and control of temperature. Temperature monitoring and control is greatly influenced by the type of temperature sensor used in the system[1] . Some sensors that are commonly used in temperature measurement are DHT11 and DHT22 sensors. DHT11 and DHT22 sensors are temperature and humidity sensors from Aosong Electronics that can measure temperature and humidity simultaneously with output results in the form of digital signals[2] . DHT11 and DHT22 sensors have been widely used in various studies such as in automatic plant watering systems[3] , in grain dryer equipment[4] , and egg hatching tools[5].

The median filter is one of the smoothing filters used to perform smoothing of real-valued data from real environments because it is very robust, can preserve measurement boundaries, can preserve values, but can be used for efficient calculations[6] . The median filter is well suited for use on large amounts of data and with large window sizes[7] . Median filter on time series data works based on the statistical principle of data sorting, where this method can reduce noise in the data[8] . Median filter can be used in various applications such as ECG signal processing and signal smoothing in *wearable devices*[9][10] . In addition, the use of median filters is widely applied in the application of wireless sensor networks[11][12] because environmental monitoring sensors in wireless sensor networks are installed in extreme environments so that the measurements taken will have noise in the measurement results.

In this research, the author applies a median filter to the temperature measurement data using DHT11 and DHT22 sensors connected to the ESP32 microcontroller. The purpose of applying a median filter to temperature measurement data using DHT11 and DHT22 sensors is to reduce measurement noise, handle outliers in measurement results, and improve the stability of temperature readings by both sensors. The median filter is preferred in this study because the median filter has a robustness against noise when compared to other types of data filters such as moving average filters which are only suitable for general data smoothing[13] . This can improve the accuracy and stability of data readings from DHT11 and DHT22 sensors.

2. Method

In this research, the method used consists of several main stages, namely data collection and the application of smoothing filters for data analysis. Data collection is done by installing DHT11 and DHT22 sensors on the wall of a closed room to measure environmental parameters such as temperature and humidity.

DHT11 and DHT22 sensors were chosen because they have different characteristics in terms of accuracy, resolution, and measurement range. The DHT11 is a sensor with lower resolution than the DHT22, but has the advantage of lower cost. In contrast, the DHT22 has higher accuracy and a wider measurement range, making it more suitable for applications that require high-fidelity data. The technical specifications of the DHT11 and DHT22 sensors are described in table 1.

Table 1. Specifications of DHT11 and DHT22 Sensors
[Source: DHT11 Sensor Datasheet[14] and DHT22][15]

No.	Technical Specifications	DHT11	DHT22
1	Power Supply	3.3 - 5.5V DC	3.3 - 6V DC
2	Output Signal	Digital signal via Aosong 1-wire bus	Digital signal through single-bus
3	Sensing Element	Polymer humidity resistor	Polymer capacitor
4	Operational Range	Humidity 20-90%RH; Temperature 0~50Celsius	Humidity 0-100%RH; Temperature -40~80Celsius
5	Accuracy	Humidity ±5%RH; Temperature ±2Celsius	Humidity ±2%RH; Temperature ±0.5Celsius
6	Resolution or Sensitivity	Humidity 1%RH; Temperature 1Celsius	Humidity 0.1%RH; Temperature 0.1Celsius
7	Recurrence	Humidity ±2%RH; Temperature ±1Celsius	Humidity ±1%RH; Temperature ±0.2Celsius
8	Humidity Hysteresis	±1%RH	±0.3%RH
9	Long-term Stability	±1%RH/year	±0.5%RH/year
10	Sensing Period	-	Average: 2 seconds

These two sensors are connected to an ESP32 microcontroller that has been connected to a wireless network and programmed to send data from the DHT11 and DHT22 sensor readings to the server computer. This research consists of several main stages that are carried out systematically to obtain valid results and can be analyzed properly. The following are the stages of research that have been carried out and visualized in the form of a

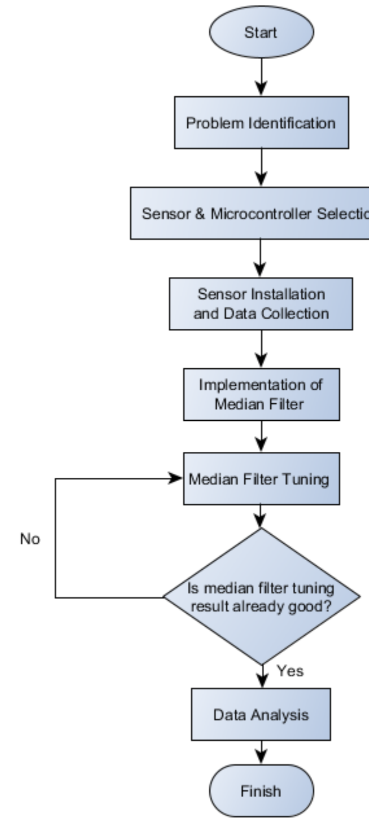

Figure 1. The Flowchart of Implementation of Median Filter in Data Processing of Temperature and Humidity Monitoring System with DHT 11 and DHT 22 Sensors.
[Source: Personal Documentation]

The following is an illustration of the DHT11 and DHT 22 sensor temperature data recording system that has been made

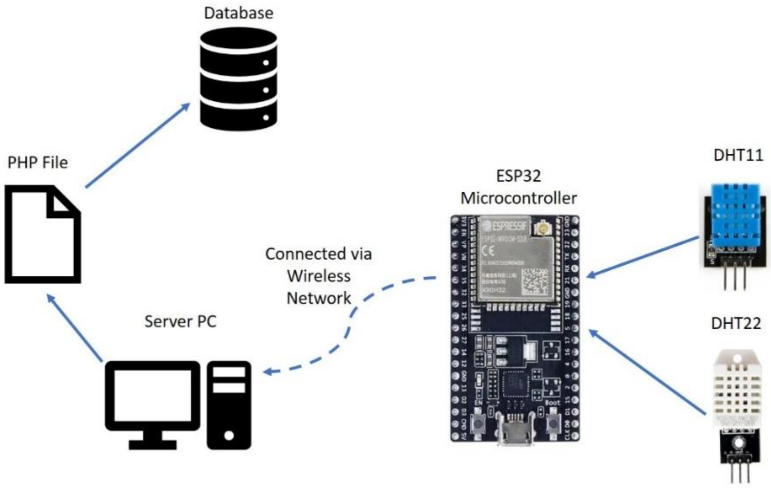

Figure 2. The Schematic of DHT11 and DHT22 Temperature Sensor Data Recording System
[Source: Personal Documentation]

Sending sensor reading data is done through the HTTP protocol connected to a PHP file with the POST method with an interval of sending sensor reading data per 10 seconds. On the server computer, the DHT11 and DHT22 sensor reading data is received with a PHP script that is used to enter the measurement data into the MySQL database. The data is recorded in time-series with an interval of± 10 seconds. Data collection is carried out starting at 11:00 WIB until 07:00 WIB the following day. After the temperature measurement data is obtained, a smoothing filter is applied to smooth the data. The smoothing filter used is the median filter. Before applying the median filter, first determine the window size used. The window size used must be adjusted to the amount of data to be processed using the median filter. This needs to be done in order to achieve a balance between the detail of the data and the smoothing of the temperature reading data by the sensor. After the window size is obtained, the median filter can be applied to the temperature measurement data from the DHT11 and DHT22 sensors. Temperature measurement data with DHT11 and DHT22 sensors that have been processed with median filters are compared with temperature measurement data without processing from median filters.

3. Results and Discussions

After taking data from the DHT11 and DHT22 sensors, the temperature data recorded by the two sensors is obtained. The following is a graph of temperature measurement results with DHT11 and DHT22 sensors before applying a smoothing filter in the form of a median filter to the data obtained. To assess the effectiveness of the median filter, a comparison is made with the original data, namely the temperature data before and after the application of the median filter is compared visually using graphs and observations of data fluctuation patterns to see the difference in noise levels before and after filtering.

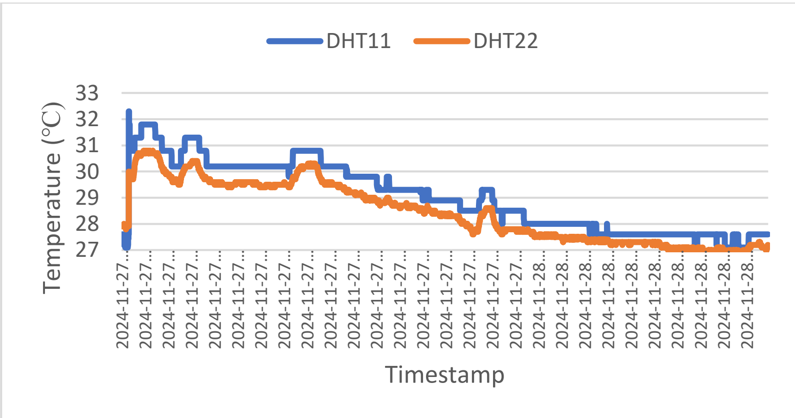

Figure 3. Graph of Measurement Data from DHT 11 and DHT 22 Temperature Sensor Before Treated by Median
[Source: Personal Documentation]

Based on the temperature measurement data obtained, the DHT22 sensor has smoother output data compared to the output data from the DHT11 sensor. This is due to the different temperature measurement accuracy levels between the DHT11 and DHT22 sensors, where the DHT11 sensor has a smaller temperature measurement accuracy when compared to the DHT22 sensor. DHT11 sensors are characterized by lower accuracy than DHT22 and high sensitivity to environmental noise. As a result, data from DHT11 tends to experience greater fluctuations, including more frequent occurrence of outlier values.

To handle this, a smoothing filter in the form of a median filter is used on temperature measurement data. Median filter works by replacing the value of a data point with the median of a number of values in a particular window. This method is very effective in reducing noise and handling outliers that are common in low accuracy sensors such as DHT11. This median filter is applied to measurement data from DHT11 and DHT22 sensors. The following is a graph showing the results of applying the median filter to temperature measurement data with DHT11 and DHT22 sensors.

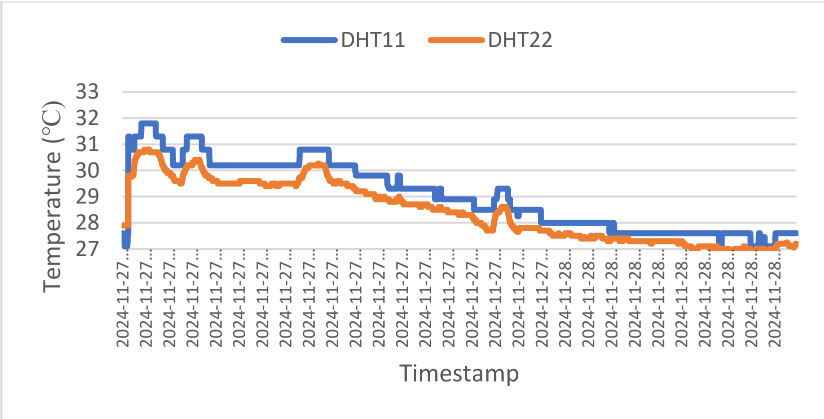

Figure 4. Graph of Measurement Data from DHT 11 and DHT 22 Temperature Sensors After Treated by Median Filter
[Source: Personal Documentation]

The application of median filter on temperature measurement data using DHT11 and DHT22 sensors shows smoother measurement data than temperature measurement results without median filter. This is because the outlier data that was previously present in the measurement results becomes more dampened, so that the measurement results become more accurate. The application of the median filter to DHT11 data shows a significant improvement in data quality, with a reduction in extreme variations in measurement results. In contrast, for the DHT22 sensor, which has a higher stability, the application of the median filter makes little difference to the measurement results. This is particularly evident in the temperature measurement data with the DHT11 sensor. In the temperature measurement results with the DHT11 sensor, outlier data displayed on the graph where the data shows a value that is too high or too low becomes more dampened. However, in the temperature measurement results with the DHT22 sensor, the application of the median filter does not really cause changes in the measurement data graph. This is due to the high level of temperature measurement accuracy of the DHT22 sensor.

This research not only implements the median filter but also quantitatively measures its impact on DHT11 and DHT22 sensors where the median filter is very effective in reducing noise on DHT11 but has minimal impact on DHT22. This research also tested the sensors in real environmental conditions with long-term data collection. The data collected in a certain time interval provides a more accurate picture of the effectiveness of filtering in temperature monitoring systems. This research shows that low-cost sensors such as the DHT11 can still produce more accurate data with data processing using median filters which can open up opportunities for the use of DHT11 sensors in a wider range of temperature monitoring applications at a more efficient cost.

4. Conclusion

The DHT22 sensor has smoother output data than the DHT11 due to its higher measurement accuracy. In the temperature measurement results from both sensors, there are outlier values that are more striking on the DHT11 sensor. To overcome this problem, a median filter is used as a smoothing filter. The results of applying the median filter show an improvement in data quality, especially for the DHT11 sensor, by significantly reducing the number of outliers. In contrast, for the DHT22 sensor, the application of the median filter did not provide significant changes because this sensor already has a high level of accuracy from the start. In terms of novelty, this research not only demonstrates the effectiveness of the median filter in reducing noise, but also proves how the characteristics of low-accuracy sensors affect the filtering results. In addition, the experimental method in a real environment strengthens the validity of the results obtained. Thus, this research can serve as a basis for the optimization of low-cost sensor-based temperature monitoring systems through proper data processing techniques.

References

[1] S. Hadi, R. P. M. D. Labib, and P. D. Widayaka, “Perbandingan Akurasi Pengukuran Sensor LM35 dan Sensor DHT11 untuk Monitoring Suhu Berbasis Internet of Things,” *STRING (Satuan Tulisan Ris. dan Inov. Teknol.*, vol. 6, no. 3, p. 269, Apr. 2022, doi: 10.30998/string.v6i3.11534.

[2] A. H. Saptadi, “Perbandingan Akurasi Pengukuran Suhu dan Kelembaban Antara Sensor DHT11 dan DHT22,” *J. INFOTEL - Inform. Telekomun. Elektron.*, vol. 6, no. 2, 2014, doi: 10.20895/infotel.v6i2.16.

[3] J. Jumingin, A. Atina, and A. Juanda, “Sistem Penyiraman Tanaman Otomatis Menggunakan Sensor DHT11,” *J. Ampere*, vol. 7, no. 2, p. 73, Dec. 2022, doi: 10.31851/ampere.v7i2.9172.

[4] A. Alfith, A. Effendi, A. Premadi, and Y. Saputra, “PENGUJIAN SUHU DAN KELEMBAPAN PADA ALAT PENGERING GABAH MENGGUNANAKAN SENSOR DHT11,” *Ensiklopedia J.*, vol. 4, no. 2, 2022, doi: 10.33559/eoj.v4i2.1074.

[5] I. W. Kinnansih and Dzulkiflih, “RANCANG BANGUN ALAT PENGONTROL SUHU DAN KELEMBAPAN PADA TEMPAT PENETASAN TELUR MENGGUNAKAN SENSOR DHT22 DAN MOTOR SWING BERBASIS IoT,” *57Jurnal Inov. Fis. Indones.* , vol. 11, no. 3, 2022.

[6] M. Storath and A. Weinmann, “Fast Median Filtering for Phase or Orientation Data,” *IEEE Trans. Pattern Anal. Mach. Intell.*, vol. 40, no. 3, 2018, doi: 10.1109/TPAMI.2017.2692779.

[7] K. D. Sherwin, K. I. K. Wang, P. Thiagaraj, B. Stappers, and O. Sinnen, “Median Filters on FPGAs for Infinite Data and Large, Rectangular Windows,” *ACM Trans. Reconfigurable Technol. Syst.*, vol. 15, no. 4, 2022, doi: 10.1145/3530273.

[8] Y. Song and J. Liu, "An improved adaptive weighted median filter algorithm," *J. Phys. Conf. Ser.*, vol. 1187, no. 4, 2019, doi: 10.1088/1742-6596/1187/4/042107.

[9] A. Pal, H. M. Rai, S. Agarwal, and N. Agarwal, "Advanced Noise-Resistant Electrocardiography Classification Using Hybrid Wavelet-Median Denoising and a Convolutional Neural Network," *Sensors*, vol. 24, no. 21, 2024, doi: 10.3390/s24217033.

[10] N. A. Almujally *et al.*, "Biosensor-Driven IoT Wearables for Accurate Body Motion Tracking and Localization," *Sensors*, vol. 24, no. 10, p. 3032, May 2024, doi: 10.3390/s24103032.

[11] M. Zhang, J. Guo, X. Li, and R. Jin, "Data-driven anomaly detection approach for time-series streaming data," *Sensors (Switzerland)*, vol. 20, no. 19, pp. 1–17, 2020, doi: 10.3390/s20195646.

[12] D. B. Tay, "Sensor network data denoising via recursive graph median filters," *Signal Processing*, vol. 189, 2021, doi: 10.1016/j.sigpro.2021.108302.

[13] D. Yulizar, S. Soekirno, N. Ananda, M. A. Prabowo, I. F. P. Perdana, and D. Aofany, *Performance Analysis Comparison of DHT11, DHT22 and DS18B20 as Temperature Measurement*, vol. 1. Atlantis Press International BV, 2023. doi: 10.2991/978-94-6463-232-3_5.

[14] T. Liu, "Digital relative humidity & temperature sensor DHT11," *2014*, pp. 1–6, 2014, [Online]. Available: http://dlnmh9ip6v2uc.cloudfront.net/datasheets/Sensors/Weather/RHT03.pdf

[15] T. Liu, "Digital-output relative humidity & temperature sensor/module DHT22 (DHT22 also named as AM2302)," *Aosong Electron. Co.,Ltd*, vol. 22, pp. 1–10, 2015, [Online]. Available: https://www.sparkfun.com/datasheets/Sensors/Temperature/DHT22.pdf