Internet Of Things Ergonomic Blood Pressure Monitoring WithMobile App Integration

1st Yohannes Nathan Andrew N.
Faculty of Electrical Engineering
Telkom University
Bandung, Indonesia
yonaan@student.telkomuniversity.ac.id

2nd Muhammad Azaria Widyadhana
Faculty of Electrical Engineering
Telkom University
Bandung, Indonesia
mazariawidyadhana@student.telkomuniversity.ac.id

3rd Sri Astuti
Faculty of Electrical Engineering
Telkom University
Bandung, Indonesia
sriastuti@telkomuniversity.ac.id

***Abstract* — Regular blood pressure monitoring is vital for health maintenance and preventing complications. However, existing digital sphygmomanometers lack immediate blood pressure category results, necessitating separate searches or consultations. Manual medical record-keeping causes data separation and loss. This thesis addresses these issues via an IoT-integrated digital sphygmomanometer. The device offers accurate monitoring and real-time category results. An ergonomic design enhances portability for anytime use. A software app ensures secure data transmission and storage. Through rigorous testing, the IoT-integrated sphygmomanometer matches desktop accuracy.It empowers individuals and aids providers with accurate patient data for better healthcare delivery. The research combines accuracy, convenience, and efficient data management, improving healthcare outcomes and provider workflows.**

***Keywords* – IoT, digital sphygmomanometer, blood pressure monitoring, blood pressure category, data management**

I. INTRODUCTION

Regular blood pressure monitoring is vital for managing hypertension, linked to serious health risks like heart attacks and strokes. Concerns arise as studies report up to a 13 percent increase in hypertension-related deaths. Relying solely on physician-recommended checks is insufficient, emphasizing the need for home monitoring [1].

Digital sphygmomanometers are popular for user-friendly frequent checks, especially among outpatients [2]. However, they lack blood pressure category results interpretation, leading users to search online or consult professionals, straining healthcare. Indonesia's reliance on manual medical records poses challenges in data management, loss, and accessibility [3]. Accurate, timely medical databases are crucial for efficient healthcare and research.

This thesis introduces an IoT-integrated sphygmomanometer, merging ergonomic design with IoT technology to match desktop sphygmomanometer accuracy. The device offers convenient monitoring, instant reliable results, and blood pressure category identification, empowering timely intervention. Data transmits to a secure database via a software application for analysis.

In conclusion, this thesis improves digital sphygmomanometers, enhancing accuracy, portability, and category identification. This empowers individuals in managing blood pressure and contributing to accessible healthcare practices.

II. THEORITICAL REVIEW

Blood pressure monitoring is essential for managing hypertension, linked to severe health complications like heart attacks and strokes. Existing digital sphygmomanometers lack immediate blood pressure category results, hindering timely intervention. Manual medical record-keeping practices exacerbate data separation and loss, necessitating a modern approach. This paper proposes an IoT-integrated digital sphygmomanometer for accurate measurements and real-time category results. The ergonomic design enhances portability, while an integrated application securely transmits data to a centralized database, streamlining healthcare workflows.

The integration of IoT and machine learning underscores the system's transformative potential. Rigorous testing and validation highlight accuracy, reliability, and user-friendliness. Benefits encompass proactive health management, improved healthcare accessibility, and reduced healthcare burdens. By addressing limitations in current digital sphygmomanometers, this research aims to revolutionize blood pressure monitoring. Its emphasis on accuracy, convenience, and immediate categorization empowers users to take charge of their health. This solution aligns with evolving healthcare trends, fostering more efficient and accessible practices. Ultimately, the proposed system represents a pivotal step towards enhancing healthcare outcomes and promoting personal health management.

III. METHODS

A. Blood Pressure Measurement Tool and Mobile Application

Figure 1 presents a meticulously engineered system that seamlessly integrates IoT technology with an ergonomic blood pressure monitoring solution, harmonizing with a mobile application. This design empowers users to measure and visualize blood pressure data on their smartphones, simultaneously recording it for future access. The heart of this setup is the MPX5700AP sensor, intricately linked to an Arduino Mega2560 microcontroller. This synergy captures blood pressure data using an air pump mechanism, guided by precision calculations and calibrations for accuracy. Upon data collection, an intelligent air valve ensures smooth air release.

Complementing this architecture is the user-centric mobile application, boasting an intuitive interface for seamless data entry. Its minimalist design simplifies user interactions, facilitating effortless blood pressure recording and streamlined management. Through this app, users can effortlessly monitor their readings, supported by a user-friendly environment.

In essence, this system epitomizes the convergence of cutting-edge sensor technology, meticulous data processing, and user-focused software design. By merging IoT capabilities, precise sensor data acquisition, and intuitive mobile interface, it enables hassle-free blood pressure monitoring while storing historical data for easy retrieval. This synthesis of technology and user convenience transforms healthcare management, fostering proactive monitoring and user-centric health empowerment.

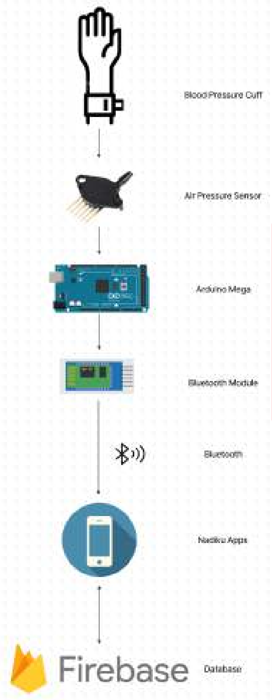

FIGURE 1
(Flowchart of How the Mobile Application and the Tool Work)

B. Blood Pressure Category Indicator

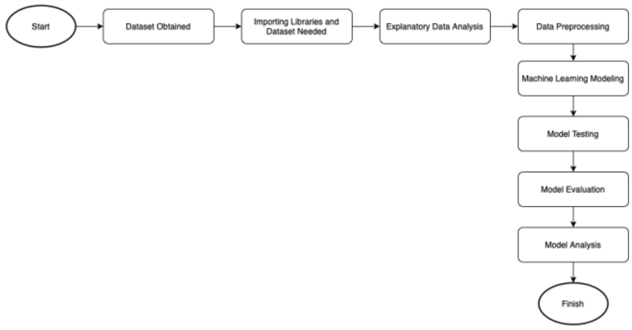

FIGURE 2
(Flowchart of the Implementation of Blood Pressure Category Indicator)

Figure 2 illustrates the systematic methodology employed in this thesis project, consistently applied to each scenario. After collecting datasets from OMRON and the self- developed tool, they underwent machine learning processing. Essential libraries such as pandas, NumPy, matplotlib, seaborn, and scikit-learn, including the random forest classifier, were imported. Exploratory data analysis (EDA) followed, encompassing data type checks, statistics examination, and visualization to ascertain patterns and balance.

Data preprocessing included splitting into training, validation, and test sets with varying ratios (60-20-20, 60-25-15, and 80-10-10). Machine learning modeling followed, with n_estimator and max_depth parameters tailored to hypotheses. Multiple variations for n_estimator (100, 300, 500) and max_depth (8, 10, 15) were explored. Notably, not all hypotheses yielded accurate results due to diverse parameter settings.

Model evaluation concluded the process, entailing performance analysis on training, test, and validation sets. Assessments encompassed test and training loss, ROC curve, learning curves, accuracy calculation, confusion matrix, feature importance determination, and outlier checks. Model outcomes were interpreted based on test results and parameter specifications outlined in the hypotheses.

IV. RESULTS AND DISCUSSIONS

FIGURE 3
(Results of Blood Pressure Measurement Tool and Mobile Application)

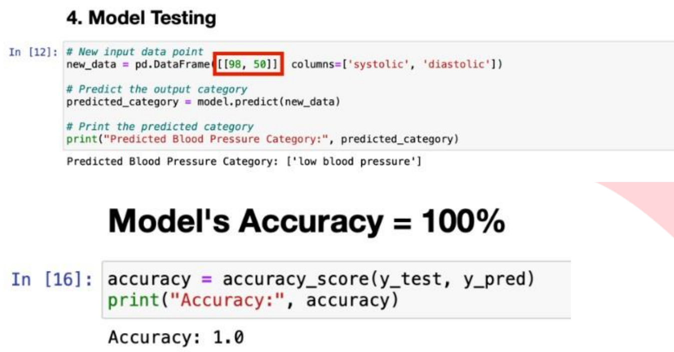

FIGURE 4
(Results of Blood Pressure Category Indicator)

Based on Figure 3 and Figure 4, it can be confidently concluded that the integration of all system solutions has been highly successful. The blood pressure measurement tool effectively captures systolic and diastolic values, and efficiently transmits this data to the mobile application. The mobile application, in turn, accurately displays the user's current blood pressure results and maintains a comprehensive history of past measurements. Additionally, the machine learning algorithm, utilizing the systolic and diastolic inputs, effectively indicates the corresponding blood pressure category. Together, these achievements showcase the seamless operation and effectiveness of the entire system.

V. CONCLUSIONS

The tool's testing demonstrated consistent performance in executing BP reading algorithms. However, limitations were uncovered. The pressure-controlling components (air pump and valve) overheated and occasionally caused the valve to stick, hindering proper BP measurement. Mechanical limitations prevented fine-tuning of valve movements for accurate decompression. Sensor errors affected accuracy, restricting measurements to non-extreme BP categories (100- 130mmHg systolic, 60-80mmHg diastolic).

The mobile app functioned as intended, recording registered user data in Firebase authentication. Bluetooth successfully connected with the tool, transmitting data seamlessly.

In conclusion, parameter exploration for BP classification unveiled insights. The OMRON dataset's optimal parameters were n_estimator=100, max depth=10, and a 60-20-20 split. In contrast, the tool dataset exhibited consistent patterns regardless of parameter changes due to its smaller size and simplicity. Both models achieved 100% accuracy, partly attributed to dataset size and simplicity. This underscores dataset attributes' impact on parameter effects. Findings underscore the need for dataset-specific parameter tuning. In the broader context, these insights guide optimal machine learning model configuration for various real-world applications, including medical diagnostics like BPcategorization.

VI. REFERENCES

- [1] A. H. A. News, “High blood pressure causing more deaths despite drop in heart disease, stroke deaths,” American Heart Association, 1 May 2018. [联机]. Available: https://www.heart.org/en/news/2018/05/01/high- blood-pressure-causing-more-deaths-despite-drop- in-heart-disease-stroke-deaths. [访问日期: 24 December 3033].
- [2] J. B. Cohen, “HISTORY AND JUSTIFICATION OF A NATIONAL BLOOD PRESSURE MEASUREMENT VALIDATED DEVICE LISTING,” HHS Author Manuscripts, 卷 73, 编号2, pp. 258-264, 2019.
- [3] K. Srinivasan, “Transforming Health Information from Manual to Digital (Electronic) World–Reference and Guide.,” 卷 %1，共%2 卷1307-6892, 2015.