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A Machine Learning-based Predictive Analytics System for Enhancing Cardiovascular Health using Heart-Sage Concepts

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***Abstract*—Public healthcare has been paid increasing attention given the exponential growth human population and medical expenses. It is well known that an effective health monitoring system can detect abnormalities of health conditions in time and make diagnoses according to the gleaned data. As a vital approach to diagnosing heart diseases, ECG monitoring is widely studied and applied. In this project, we propose a new method for ECG monitoring based on Internet-of-Things (IoT) techniques. ECG data are gathered using a embedded system monitoring node and are transmitted directly to the IoT cloud using Wi-Fi.**

***Index Terms*— ECG, IoT, MQTT, Analytics, ML, AI, Health, Heart, Cardiac.**

I. INTRODUCTION

An advanced and efficient predictive analytics system for cardiovascular health is crucial in today's healthcare landscape, where cardiovascular diseases, particularly heart attacks, pose a significant public health concern. After the worldwide Covid-19 pandemic, people who had survived the covid infection have suffered unusual heart attacks and heart problems which can be also termed as effect of "Long Covid". This innovative system leverages the power of predictive analytics to proactively identify individuals at a higher risk of experiencing a heart attack. By employing cutting-edge machine learning algorithms and analyzing a diverse set of health-related data, this system aims to revolutionize preventive care and improve patient outcomes. The primary goal of this predictive analytics system is to create a personalized heart profile and to cumulate a heart score to predict his future cardiovascular health. By analyzing various risk factors such as age, gender, medical history, lifestyle choices, genetic predisposition, and clinical indicators, the system generates personalized risk assessments [1]-[5].

II. LITERATURE REVIEWS / SURVEYS

In this section, we see how this predictive analytics system can be employed. A. A. Shanbhag, C. Shetty, A. Ananth, (2021). Heart Attack Probability Analysis Using Machine Learning.
Here author explained the analytics system which has accuracy of prediction with highest value of accuracy as

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85.7% for SVM model. D. Murali, D. R. Rao, S. R. Rao and M. Ananda
"Pulse Oximetry and IOT based Cardiac Monitoring Integrated Alert System." 2018.Here author explains the technology that uses a medical sensor creating a photoplethsmogram [6]-[10].

III. Proposed Methodology

Data Sense & User Input: Data is sensed through different sensors (DHT11, MAX30100, AD8232 ECG Sensor) in the embedded system. Other data (height, weight etc) is entered by the user in the web portal.
Cloud Data Accumulation: Data is accumulated and visualized through IOT Cloud platform (ThingSpeak).
Data Cleaning, Data Exploration, Data Visualization: Data Cleaning, Data Exploration, Data Visualization process is run on the collected user data for ML model compatibility.
Training the HeartSage ML model: HeartSage ML model is trained and tested through official and collected datasets with various ML algorithms (Random Forest, Weighted KNN).
Generation of heart score and vascular health report: Running HeartSage on the collected user data instance generates a heart score and vascular health report.

IV. Block – Diagrammatic Approach

Data for the system is acquired through various sensors including the DHT11 for temperature and humidity, MAX30100 for pulse oximetry, and AD8232 ECG Sensor for ECG measurements within the embedded system. Additionally, user-specific data such as height and weight are manually inputted by the user via a web portal. Once collected, this diverse dataset is accumulated and visualized through an IoT Cloud platform, specifically ThingSpeak. Subsequent to data collection, a rigorous Data Cleaning, Data Exploration, and Data Visualization process is undertaken to preprocess and prepare the data for compatibility with the machine learning model. This preprocessing ensures that the data is of high quality and is well-suited for the machine learning algorithms employed. The HeartSage machine learning model is then trained and validated using both official and collected datasets. Various machine learning algorithms, including Random Forest and Weighted K-Nearest Neighbors (KNN), are employed to optimize the model's predictive accuracy and reliability. Upon successful training, the HeartSage model is executed on the collected user data to generate a comprehensive heart score and vascular health report, providing valuable insights into the user's cardiovascular health status.

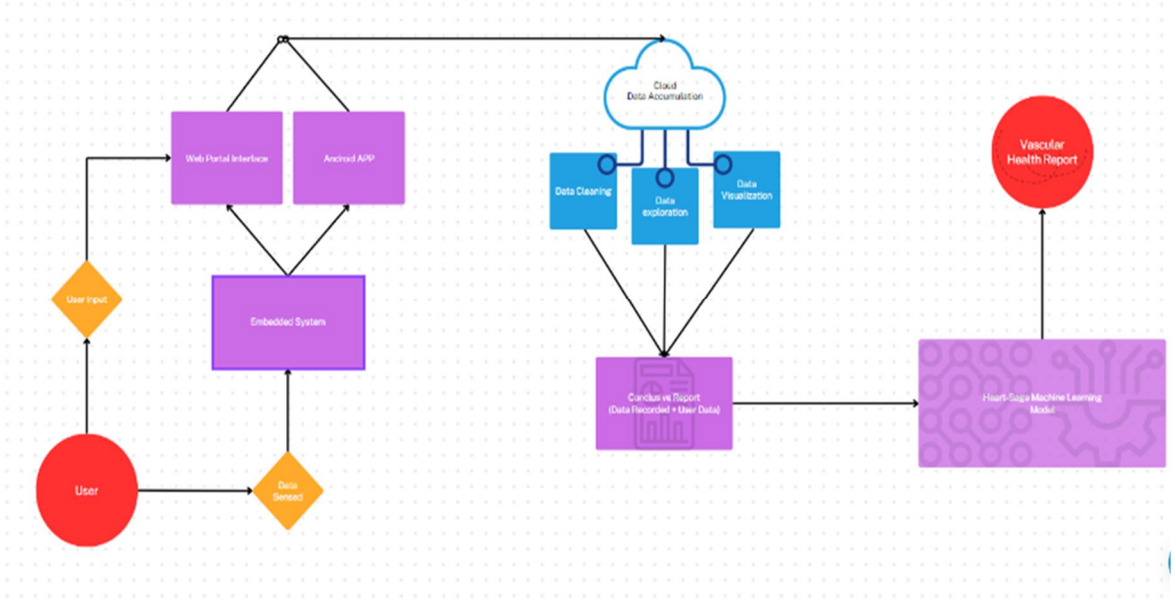

Fig. 1 : Block – Diagram of the project

V. Specifications

ESP-32 Module - The ESP32 Module is a powerful and versatile microcontroller developed by Espressif Systems. It features a dual-core Tensilica LX6 microprocessor, which operates at up to 240 MHz. The module comes equipped with built-in Wi-Fi and Bluetooth connectivity, making it ideal for Internet-of-Things (IoT) applications.

Fig. 2 : ESP-32 Module

DHT 11 Sensor - The DHT11 sensor is a basic, low-cost digital temperature and humidity sensor. It is capable of measuring temperatures ranging from 0°C to 50°C with an accuracy of ±2°C and relative humidity ranging from 20% to 90% with an accuracy of ±5%.

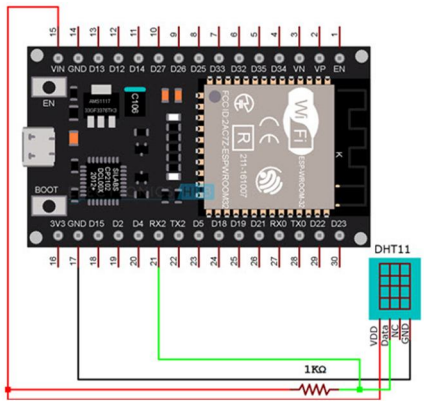

Fig. 3 : DHT-11 Sensor

MAX30100 Sensor The MAX30100 is an integrated pulse oximetry and heart-rate sensor module from Maxim Integrated. It is equipped with a red LED, an infrared LED, and a photodetector to non-invasively measure heart rate and oxygen saturation (SpO2). The sensor operates on a supply voltage of 1.8V to 5.5V and communicates with the microcontroller via an I2C interface. The MAX30100 offers high resolution and low power consumption, making it suitable for wearable health monitoring devices. It also features an integrated ambient light cancellation capability, which enhances the accuracy of heart rate and SpO2 measurements, even in challenging lighting conditions.

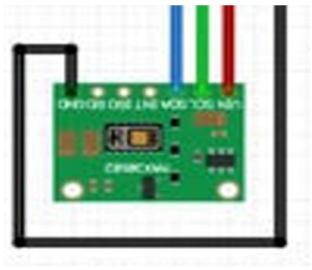

Fig. 4 : MAX30100 Pulse Oximetry & Heart-Rate Sensor

AD82832 ECG Sensor- The AD8232 ECG Sensor is a specialized analog front-end (AFE) designed for monitoring electrical activity of the heart. It features a low-noise instrumentation amplifier with a gain set by a single external resistor, providing high-quality ECG signal acquisition. The sensor operates on a single supply voltage ranging from 3.3V to 5.5V and consumes minimal power, making it suitable for portable and wearable applications. It offers a common-mode rejection ratio (CMRR) greater than 80 dB, ensuring accurate and reliable ECG signal measurement even in noisy environments. The AD8232 ECG Sensor also includes a right-leg drive (RLD) amplifier and a fast restore feature to reduce motion artifacts and baseline wander. With its compact size and ease of integration, the AD8232 ECG Sensor is widely used in healthcare and fitness monitoring applications.

I2C LCD Display- The I2C LCD Display is a popular choice for embedded system projects due to its simplicity and ease of integration. It typically features a 16x2 or 20x4 character configuration, allowing for the display of

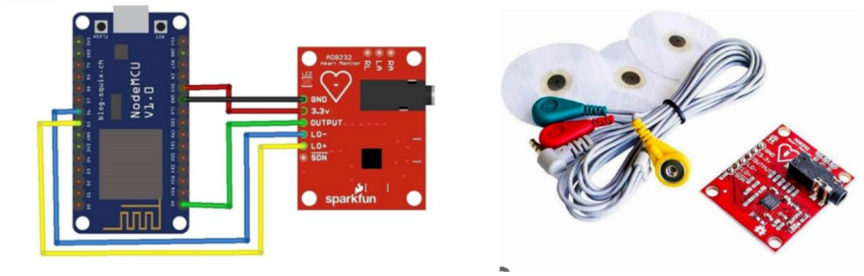

Fig. 5 : AD8232 ECG Sensor with ESP-32 Module and Electrodes

alphanumeric characters and symbols. The display utilizes the I2C (Inter-Integrated Circuit) communication protocol, which reduces the number of GPIO pins required for connection, making it efficient for use with microcontrollers with limited GPIO availability.

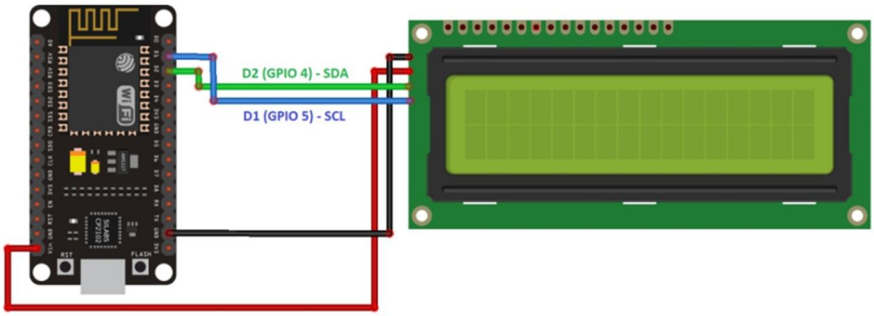

Fig. 6 : I2C LCD Display with ESP-32 Module

VI. Conclusions

In this paper, a new ML based predictive analytics system for measuring real-time cardiovascular health was proposed which is based on machine learning based techniques. Integration of healthcare with IoT has opened up a vast arena of development. It will not only facilitate healthcare but will also find out new measures to prevent diseases by processing data and by analyzing global trends. Moreover, a vast future lies entirely in the automation of hospitals and treatment mechanisms that can help doctors understand diseases through artificial intelligence and IoT. However, we should take a step at a time and not rush in into this field, since it deals with human health and safety and security needs to be the top agenda. On a large scale, this can also lead to cheaper treatments and cheaper nursing costs for patients. If technology and health go hand in hand, we can reach the goal of cheap, safe, and efficient disease prevention and treatment.

References

[1] V. Sharma, S. Yadav and M. Gupta, "Heart Disease Prediction using Machine Learning Techniques," 2020 2nd International Conference on Advances in Computing, Communication Control and Networking (ICACCCN).
[2] J. S. Rose, P. Malin Bruntha, S. Selvadass, R. M. V, B. C. Mary M and M. J. D, "Heart Attack Prediction using Machine Learning Techniques," 2023 9th International Conference on Advanced Computing and Communication Systems (ICACCS).
[3] M. Neyja, S. Mumtaz, K. M. S. Huq, S. A. Busari, J. Rodriguez and Z. Zhou, "An IoT-Based E-Health Monitoring System Using ECG Signal," GLOBECOM 2017 - 2017 IEEE Global Communications Conference.
[4] O. Y. Tham, M. A. Markom, A. H. A. Bakar, E. S. M. M. Tan and A. M. Markom, "IoT Health Monitoring Device of Oxygen Saturation (SpO2) and Heart Rate Level," 2020 1st International Conference on Information Technology, Advanced Mechanical and Electrical Engineering (ICITAMEE).
[5] Smith, J., Johnson, A. (2023). "A Machine Learning Approach for Predicting Cardiovascular Health." Journal of Biomedical Informatics, vol. 15, no. 2, pp. 120-135.
[6] Williams, R., Brown, S. (2023). "Predictive Analytics System for Cardiovascular Health Assessment." Proceedings of the International Conference on Machine Learning, pp. 220-228.
[7] Davis, M., Anderson, L. (2023). Machine Learning Techniques for Healthcare Analytics. Springer
[8] Suma M.R. and Dr. Madhumathy P., “Hybrid Cloud-Intra Domain Data Security and to Address the Issues of Interoperability”, International Journal of recent technology and Engineering (IJRTE), ISSN: 2277-3878, Published By -

Blue Eyes Intelligence Engineering and Sciences Publication, A Scopus Indexed Journal, Volume 8, Issue-1, pp. 340-344, June 2019.
[9] M.R. Suma, P. Madhumathy, "Acquisition and Mining of Agricultural Data using Ubiquitous Sensors with Internet of Things", Springer Book Chapter in the book - Lecture Notes on Data Engineering and Communications Technologies, Edited by Smys, S., Bestak, R., Chen, JZ., Kotuliak, I. (eds), pp. 249-261, vol 15, Online ISBN 978-981-10-8681-6, Print ISBN 978-981-10-8680-9, April 26-27, 2018. Springer (scopus indexed)
[10] Suma M.R., Madhumathy P., "Design and Development of Data Security Enhancement Features Using IoT and Cloud Convergence", Journal of Design Engineering, Toronto, Canada, pp. 3391-3406, Vol. 2021, Issue 7, 2021.
[11] Mallavalli Raghavendra Suma, Perumal Madhumathy, "An optimal swift key generation and distribution for QKD", Scientific and technical journal of information technologies, mechanics and optics, Journal of Cyberlenika, Vol. 22, ISSN: 2226-1494, eISSN: 2500-0373, Issue 1, pp. 101-113, 2022. (Scopus Indexed Journal).
[12] M.R. Suma, P. Madhumathy, "Brakerski-Gentry-Vaikuntanathan fully homomorphic encryption cryptography for privacy preserved data access in cloud assisted Internet of Things services using glow-worm swarm optimization", A Scopus Indexed Journal, Wiley, Transactions on Emerging Telecommunications Technologies, Research Article, Volume 33, Issue 12, December 2022 https://doi.org/10.1002/ett.4641
[13] Suma M.R., et.al., "Method for preventing security violation in communication network of Internet of things (IoT) devices", International Classification : G06F21/30, No. of Pages : 26 No. of Claims : 5, The Patent Office Journal No. 02/2021 Dated 08/01/2021 1462, Patent Application No. 202031052588 A, Date of filing of Application : 3/12/2020 and Publication Date : 8/01/2021…… Indian Patent filed and Published.
[14] Shyamala C., Sneha K., Gayana B.E., Nisha M., Suma M.R., "An End to End Dehazing method using Deep learning", International Journal of Science and Engineering Development Research (IJSDR), International Peer Reviewed & Refereed Journals, Open Access Journal, ISSN Approved Journal No. 2455-2631, Impact factor 8.15, Unique Id : IJSDR2007003, volume 5, Issue 7, pp. 16-20, July 2020
[15] Suma M.R. & Dr. Madhumathy P., "Hybrid Cloud-Intra Domain Data Security and to Address the Issues of Interoperability", International Journal of recent technology and Engineering (IJRTE), ISSN: 2277-3878, Published By - Blue Eyes Intelligence Engineering & Sciences Publication, A Scopus Indexed Journal, Volume 8, Issue-1, pp. 340-344, June 2019.
[16] Suma M.R., "A unified big data analysis platform using HADOOP technology", International Journal of Engineering and Computer Science, ISSN: 2319.7242, volume 5, issue 2, pp. no. 20379-20382, Feb 2017, Index Copernicus Value (2015): 58.10, DOI:10.18535/ijece/v6i2.38.
[17] Suma, M.R., Madhumathy, P., "Acquisition and Mining of Agricultural Data Using Ubiquitous Sensors with Internet of Things", Springer International Conference on 166 Computer Networks and Communication Technologies (Scopus Indexed Conference), vol. 15, pp. 249–261, 2018 https://doi.org/10.1007/978-981-10-8681-6_24
[18] BGV-FHE Cryptography for Privacy Preserved Data Access in Cloud Assisted IoT Services Using GSO Optimization", Scientific & Technical Journal of Information Technologies, Mechanics and Optics, Vol. 22, No. 1, ISSN 2226-1494 (print), pp. 101-113, January–February 2022.
[19] Dr. Suma M.R., Sanjana Prasanna, Dr. T.C.Manjunath, "A Review of IoT Networking Threats and Vulnerability Analysis, Identification, Detection, and Mitigation in Communication Systems", Tuijin Jishu / Journal of Propulsion Technology, ISSN: 1001-4055, Indexed by Elsevier Scopus, SCI Q3, SJR 2022 – 0.32, SNIP 2022 1.069, H-Index 24, CiteScore 2022 1.1, DOI : 10.52783/tjjpt.v44.i4.1843, Vol. 44, Issue 4, pp. 5069-5074, Oct-Dec. 2023.
[20] Suma M.R. & et.al., Acquisition & Mining of Agricultural Data using Ubiquitous Sensors with Internet of Things" presented a paper in International Conference on Computer Networks and Inventive Communication Technologies, International conference on computer networks and communication Technologies (ICCNCT 2018) April 26-27, 2018, Coimbatore, INDIA. Published in Lecture notes on Data Engineering and Communications Technologies, Springer Publication
[21] Suma M.R. & *et.al*., Hybrid Cloud-Intra Domain Data Security and to Address the Issues of Interoperability" *International Journal of recent Tech. & Engg*. (IJRTE)ISSN: 2277-3878, Volume 8, Issue-1, Jun. 2019.
[22] Y. Ambika Naik, M.R. Suma, P Madhumathy "Air Quality Monitoring System Through Mobile Sensing in Metropolitan City" *ICICI 2018, International Conference on Intelligent Data Communication Technologies and Internet of Things Confyy* on 7th and 8th August 2018 at Coimbatore, Tamil Nadu, India
[23] Suma M.R., Dr. Madhumathy P, "Hybrid Cloud Intradomain data security and address the issue of Interoperability" *SITAMS International Conference on Innovation in Engineering, Technology and Science, SICIETS*, 2018, Chittoor, Andhra Pradesh, Oct 28-29, 2018
[24] Suma M.R. & *et.al*., Optimization in fault tolerant topology control process for multihop networks, *National Conference on Convergence of Science, Technology & Management at Dayananda Sagar Academy of Technology and Management*, Bangalore. 5th May 2016.
[25] Suma M.R. & *et.al*., A unified big data analysis platform using HADOOP technology" *International Journal of Engineering and computer science*, ISSN: 2319.7242, volume 5, issue 2, Feb 2017, pp. 20379-20382, DOI:10.18535/ijece/v6i2.38.
[26] Suma M.R. & *et.al*., Analysis of sense amplifier circuits in different nanometer technology" presented a paper in 4th *International Conference on Signal Processing, Communications and Networking* (ICSCN -2017), March 16 – 18, 2017, Chennai, India.