Real Time Calorie Burn Prediction System Using Iot Sensors and Machine Learning

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***Abstract*—Accurately estimating calorie expenditure during physical activity is crucial for fitness tracking, weight management, and personalized health monitoring. This paper presents a real-time calorie burn prediction system leveraging the synergy of Internet of Things (IoT) sensors and machine learning techniques. The system employs non-invasive physiological sensors, specifically the MAX30102 pulse oximeter for heart rate monitoring and the MLX90614 infrared thermometer for body temperature measurement. These sensors are seamlessly integrated with ESP8266 microcontrollers to facilitate real-time data acquisition and transmission.**

In addition to the dynamic physiological inputs, the system incorporates static user-specific parameters, including age, gender, height, and weight, along with the duration of the activity. This comprehensive dataset forms the basis for training a robust machine learning model. We have implemented a Random Forest Regression algorithm, chosen for its inherent ability to handle non-linear relationships and provide high prediction accuracy in regression tasks. The trained model effectively learns the complex interplay between physiological responses, user characteristics, and activity duration to estimate calorie expenditure.

To provide users with immediate feedback, a user-friendly Streamlit web application has been developed, featuring an aesthetically pleasing dark theme. This intuitive interface displays the real-time calorie burn predictions, enabling users to monitor their energy expenditure during workouts or daily activities. Furthermore, all collected sensor data, user details, and the corresponding calorie burn predictions are persistently stored in a MySQL database. This facilitates data analysis, historical tracking of calorie expenditure, and potential future enhancements to the prediction model. The developed system demonstrates an effective and practical application of IoT sensor technology, machine learning algorithms, and efficient data management for real-time calorie burn estimation, offering a valuable tool for health and fitness enthusiasts.

***Index Terms*—ESP8266(Micro controller) MAX30102(Heart Rate sensor) MLX90614(Temperature Sensor)**

I. INTRODUCTION

In an increasingly health-conscious world, the ability to accurately monitor and understand energy expenditure during physical activity holds significant value. This project addresses the critical need for a precise and accessible method for real-time calorie burn prediction. Existing methods often rely on generalized estimations or require manual input, lacking the granularity and immediacy offered by continuous physiological monitoring. To overcome these limitations, we present a novel Real-Time Calorie Burn Prediction System that seamlessly integrates the power of Internet of Things (IoT) sensors and machine learning algorithms.

This innovative system leverages physiological inputs, specifically heart rate and body temperature, which are strong indicators of metabolic activity and energy expenditure. These vital signs are captured in real-time using the MAX30102 pulse oximeter and heart rate sensor, and the MLX90614 non-contact infrared temperature sensor. These compact and efficient sensors are interfaced with cost-effective ESP8266 microcontrollers, enabling seamless data acquisition and transmission over a Wi-Fi network.

Beyond real-time physiological data, the system incorporates crucial user-specific details that significantly influence calorie expenditure. These parameters include age, gender, height, and weight, providing a personalized context for the prediction model. Furthermore, the duration of the physical activity is also considered, allowing for a comprehensive assessment of total calories burned over a specific period.

To translate the collected sensor data and user information into accurate calorie burn estimations, we employ a robust machine learning technique: Random Forest Regression. This ensemble learning method is renowned for its high predictive accuracy, ability to handle non-linear relationships, and resilience to overfitting, making it well-suited for the complexities of human metabolism. The trained Random Forest model learns the intricate patterns between the input features and the corresponding calorie expenditure, enabling precise real-time predictions.

The output of this sophisticated prediction engine is presented to the user through an intuitive and visually appealing Streamlit web application, featuring a user-friendly dark theme for enhanced readability and aesthetics. This web interface provides a dynamic display of the real-time calorie burn estimates, empowering users to monitor their energy expenditure effectively during workouts or daily activities.

To ensure data integrity and facilitate future analysis, all collected sensor data, user details, and the resulting calorie burn predictions are securely stored in a MySQL database. This structured data storage enables comprehensive tracking of individual progress, facilitates the identification of trends, and lays the foundation for potential future enhancements and research.

In essence, this project demonstrates an effective and synergistic integration of cutting-edge technologies. By combining the real-time data acquisition capabilities of IoT sensors, the predictive power of machine learning, and the user-friendly interface of a web application, this Real-Time Calorie Burn Prediction System offers a significant advancement in personalized fitness tracking and health management. This work highlights the potential of leveraging interdisciplinary approaches to create practical and impactful solutions in the realm of health and wellness.

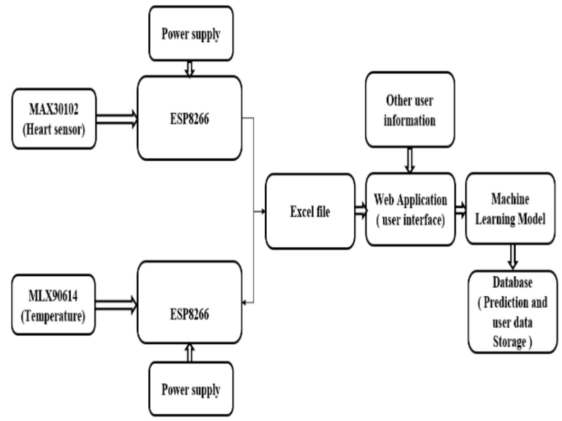


Figure 1: Block Diagram

II. LITERATURE SURVEY

The escalating focus on personal health and well-being has spurred significant research into accurate and real-time calorie expenditure estimation. Existing literature highlights various approaches leveraging physiological parameters, user demographics, and activity data to predict calorie burn. Studies have explored the use of wearable sensors like heart rate monitors and accelerometers to capture real-time data, often processed through machine learning algorithms such as Random Forest, XGBoost, and Support Vector Machines to establish predictive models. These models aim to provide users with valuable insights into their energy expenditure during physical activities, aiding in fitness tracking and informed decision-making. Furthermore, the integration of IoT devices and web-based platforms has enabled the development of user-friendly systems for data collection, visualization, and personalized feedback. However, many existing systems rely on commercially available wearables, and there's a growing need for cost-effective, custom-built solutions that seamlessly integrate real-time sensor data with robust machine learning models for accurate calorie burn prediction, coupled with efficient data management for long-term tracking and analysis. This project addresses this gap by developing a real-time calorie burn prediction system utilizing custom-integrated IoT sensors, a high-accuracy Random Forest Regression model, and a user-friendly web application with a MySQL database for comprehensive data management.

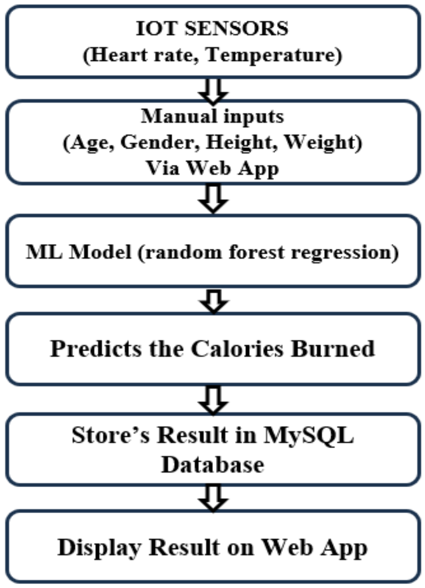


Figure 2: Flow Diagram

ESP8266(Micro controller)

The ESP8266 is a remarkable, low-cost Wi-Fi microcontroller that has become a cornerstone of the Internet of Things (IoT) landscape. Developed by Espressif Systems, this small yet powerful chip integrates a 32-bit RISC processor, memory, and importantly, a full Wi-Fi stack, all within a compact package. Its affordability and built-in Wi-Fi capabilities have democratized IoT development, allowing hobbyists, makers, and professionals alike to create connected devices with relative ease.

At its heart, the ESP8266 features a Tensilica L106 32-bit micro controller unit, typically running at 80 MHz, providing ample processing power for a wide range of applications. It boasts internal RAM for data and instructions, and crucially, it can interface with external flash memory, allowing for larger program storage and data logging. The integrated Wi-Fi supports the 802.11 b/g/n standards, enabling seamless connectivity to existing wireless networks. This eliminates the need for separate Wi-Fi modules, significantly reducing the cost and complexity of IoT projects.

The ESP8266 offers a versatile set of GPIO (General Purpose Input/Output) pins, which can be configured for various functions, including digital input and output, PWM (Pulse Width Modulation), and even I2C and SPI communication through software implementations. It also features a single analog-to-digital converter (ADC) channel, enabling the reading of analog sensor data. This flexibility allows the ESP8266 to interact with a wide array of sensors, actuators, and other peripherals.

What truly propelled the ESP8266 into widespread adoption is its ease of programming. It can be programmed using various development environments, most notably the Arduino IDE. The availability of a well-supported Arduino core for the ESP8266 allows users familiar with the Arduino ecosystem to quickly start building IoT projects using the familiar C++ language and a vast library of existing code. Furthermore, it supports other programming approaches, including Lua scripting through the NodeMCU firmware and MicroPython, catering to different programming preferences and skill levels.

The ESP8266 comes in various module forms, with the ESP-01 being one of the most popular and basic. Other modules, like the ESP-12E, offer more GPIO pins and improved features. Development boards, such as the NodeMCU, integrate the ESP8266 module with a USB interface for easy programming and power, along with convenient pin headers for prototyping.

The impact of the ESP8266 on the IoT ecosystem is undeniable. It has enabled countless innovative projects, from smart home automation and environmental monitoring to industrial control and wearable devices. Its low cost, integrated Wi-Fi, and ease of use have lowered the barrier to entry for creating connected devices, fostering a vibrant and rapidly expanding community of developers and enthusiasts. As technology continues to evolve, the ESP8266 remains a significant and influential component in the world of embedded systems and the Internet of Things.

Figure 3: ESP8266(Micro controller)

MAX30102(Heart Rate sensor):

The MAX30102 is a compact, integrated optical sensor module designed for pulse oximetry and heart-rate monitoring in wearable health and fitness devices. It cleverly combines a red LED, an infrared LED, a photodetector, and associated low-noise electronics into a tiny 14-pin package. This integration simplifies the design process for manufacturers, as it provides a complete system solution with built-in ambient light rejection to enhance measurement accuracy.

Operating with ultra-low power consumption, the MAX30102 is ideal for battery-powered applications. It typically requires a 1.8V power supply for its internal circuitry and a separate 3.3V supply for the LEDs. The sensor communicates with microcontrollers via a standard I2C interface, allowing for easy data retrieval. Furthermore, it offers programmable sample rates and LED current, enabling optimization between power consumption and performance. A software-controlled shutdown mode with near-zero standby current further contributes to energy efficiency.

The MAX30102's ability to deliver fast data output at high sample rates, coupled with robust motion artifact resilience and a high signal-to-noise ratio (SNR), makes it well-suited for dynamic applications like fitness tracking. Its wide operating temperature range of -40°C to +85°C ensures reliable performance in various environmental conditions. Due to its small size, low power consumption, and integrated features, the MAX30102 has become a popular choice for wearable devices, fitness assistants, smartphones, and tablets aiming to incorporate accurate heart rate and blood oxygen saturation (SpO2) monitoring

Figure 4: MAX30102(Heart Rate sensor)

MLX90614(Temperature Sensor):

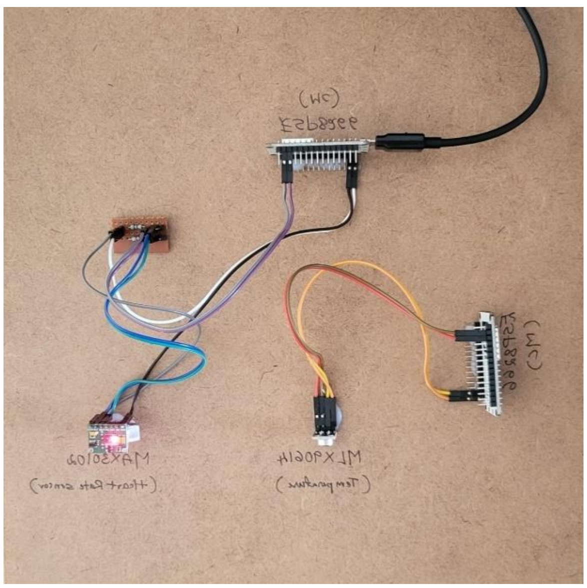
The MLX90614 is a non-contact infrared (IR) temperature sensor capable of measuring the temperature of an object without physical contact. It integrates both an IR-sensitive thermopile detector and a signal conditioning ASIC into a compact TO-39 package. This integration allows for accurate and high-resolution temperature measurements. The sensor operates based on the Stefan-Boltzmann law, which states that all objects emit infrared radiation proportional to their temperature. The MLX90614 detects this emitted radiation to determine the object's temperature.

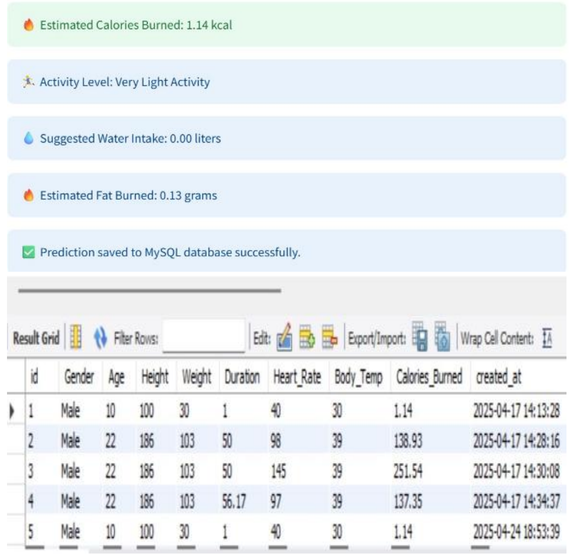
A key feature of the MLX90614 is its factory calibration over a wide temperature range, typically from -40°C to 125°C for the sensor itself and -70°C to 380°C for the object being measured. It boasts a high accuracy of around 0.5°C within a specific temperature range and offers a measurement resolution of 0.02°C. The sensor communicates digitally via an SMBus-compatible I2C interface, allowing for easy integration with microcontrollers and enabling the construction of sensor networks with multiple devices. Additionally, some versions offer a customizable PWM output for continuous temperature readings.

The MLX90614 finds applications in diverse fields, including high-precision non-contact temperature measurements, automotive blind-angle detection, industrial temperature control of moving parts, thermal comfort sensing in air conditioning systems, and even body temperature measurement. Its non-contact nature makes it suitable for measuring the temperature of moving objects or in situations where physical contact is undesirable or impractical. The sensor's small size, low cost, and ease of integration have made it a popular choice for various temperature sensing applications.

Figure 5: MLX90614(Temperature Sensor)

III. RESULT





id	Gender	Age	Height	Weight	Duration	Heart_Rate	Body_Temp	Calories_Burned	created_at
1	Male	10	100	30	1	40	30	1.14	2025-04-17 14:13:28
2	Male	22	186	103	50	98	39	138.93	2025-04-17 14:28:16
3	Male	22	186	103	50	145	39	251.54	2025-04-17 14:30:08
4	Male	22	186	103	56.17	97	39	137.35	2025-04-17 14:34:37
5	Male	10	100	30	1	40	30	1.14	2025-04-24 18:53:39

IV. CONCLUSION

In conclusion, this project successfully demonstrates the feasibility and effectiveness of a real-time calorie burn prediction system by seamlessly integrating IoT sensor technology, machine learning algorithms, and a user-friendly web interface. The real-time acquisition of physiological data, specifically heart rate and body temperature, through the MAX30102 and MLX90614 sensors interfaced with ESP8266 microcontrollers, provides a dynamic and personalized approach to calorie expenditure estimation. By incorporating crucial user-specific parameters such as age, gender, height, weight, and activity duration, the system moves beyond generic estimations, offering more accurate and relevant insights. The selection and implementation of the Random Forest Regression model, known for its robust performance and ability to handle complex datasets, underscores the project's commitment to achieving high prediction accuracy. The deployment of a Streamlit web application, enhanced with a visually appealing dark theme, ensures an intuitive and accessible platform for users to monitor their calorie burn in real-time. Furthermore, the persistent storage of all collected data and prediction results in a MySQL database not only facilitates comprehensive data analysis and future model enhancements but also showcases the system's robust data management capabilities. This holistic approach, effectively blending the strengths of IoT for real-time data collection, machine learning for intelligent prediction, and web technologies for seamless user interaction and data management, highlights the potential of such integrated systems for personalized health and fitness tracking. The promising results obtained from this prototype pave the way for further research and development, potentially leading to more sophisticated wearable devices and personalized wellness applications.

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