



IJITCE

ISSN 2347- 3657

International Journal of Information Technology & Computer Engineering

www.ijitce.com



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HEALTH MONITORING AND JAUNDICE DETECTION SYSTEM USING VERILOG WITH UART & WIFI COMMUNICATION

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Abstract:

In modern health care early detection of critical health conditions can save lives. This project presents a real time health monitoring and Jaundice detection system implemented using Verilog on an FPGA platform. The system continuously monitors vital parameters such as heart rate ,blood pressure and body temperature detects Jaundice using images. A finite state machine is employed to handle different operational states, ensuring accurate decision making. If an abnormality is detected an alert mechanism is triggered using LEDs, buzzer and a UART transmission for remote monitoring. The proposed system is tested through simulation ,demonstrating its efficiency and reliability in detecting health issues. Future enhancements include wireless data transmission and integration with IOT based medical systems.

KeyWords: Health Monitoring, Jaundice Detection, Verilog, UART, Wi-Fi, FPGA, FSM, Vivado.

1.Introduction

The rapid advancement of medical technologies has led to the development of sophisticated systems for monitoring and diagnosing health conditions in real-time. Among various medical conditions, jaundice, a condition characterized by the yellowing of the skin and eyes due to high bilirubin levels, requires prompt detection and monitoring. Early detection of jaundice is crucial, especially in newborns, to avoid long-term complications and ensure timely intervention.

This paper presents a **Health Monitoring and Jaundice Detection System** that leverages digital design and communication technologies to provide

an efficient solution for continuous monitoring of health parameters, specifically focused on jaundice detection. The system is built using **Verilog**, a hardware description language (HDL), which enables precise control of the underlying hardware components and efficient simulation of digital circuits.

The system integrates a **UART (Universal Asynchronous Receiver/Transmitter)** communication interface for reliable serial data transmission and a **WiFi module** to wirelessly send real-time health data to a central monitoring station or cloud-based platform for further analysis. The combination of UART and WiFi ensures seamless data exchange and remote monitoring capabilities, making the system suitable for healthcare settings where continuous surveillance of patient data is required.

In this work, the Verilog code for the FPGA-based system is developed to interface with sensors that capture critical health metrics, such as temperature, heart rate, and image of the eye/skin (in the context of jaundice detection). The data collected is transmitted via UART for local communication and WiFi for remote monitoring, ensuring that healthcare professionals can promptly anomalies detected anomalies. This innovative approach not only enhances the accuracy of health monitoring but also facilitates early detection and intervention, particularly for jaundice.

The proposed system showcases the use of FPGA technology in conjunction with modern communication interfaces, providing a reliable, cost-effective, and scalable solution for healthcare applications.

2. Literature Review

Several research efforts have explored the use of FPGA-based systems in healthcare and assistive technologies. The authors of [1] proposed a system that collects ECG data from sensors attached to a patient's chest, processes it on an FPGA using the Pan-Tompkins algorithm, and transmits the processed data to smart devices through a web interface. This IoT-based system utilizes complex calculations and multiple filters for accurate signal analysis. However, the approach requires the patient to remain wired and under continuous observation, which may limit its flexibility in real-time mobile environments.

In [7], an FPGA-based automatic navigation system for electric vehicles was proposed to assist disabled or paralyzed individuals who cannot operate traditional joysticks. The system determines an optimal path which is stored in memory for navigation. While computationally efficient, this system is constrained to pre-defined paths and limited to indoor usage scenarios, reducing its practical application in diverse environments.

The study in [8] addresses challenges in venipuncture procedures, which vary with skin color and thickness. The authors employed FPGA hardware to acquire near-infrared images and implemented a matched filter vessel enhancement algorithm. This method demonstrated superior performance over other filtering algorithms in enhancing blood vessels, showcasing the parallel computing strengths of FPGA platforms.

The concept of a medisuit, discussed in [15], integrates sensors to continuously monitor vital signs and transmit data to a central unit in real time. This embedded system can trigger alerts when anomalies are detected. The paper suggests using FPGA to process the collected data, taking advantage of its speed and efficiency in real-time applications.

In [2], an AMBA-APB interface was utilized to store multiple health parameters, demonstrating that FPGA systems offer better storage scalability and data handling capabilities than traditional microcontroller-based systems. This approach

ensures adequate memory for real-time health data processing and storage.

Authors of [11] and [13] presented systems that employ photometers to measure bilirubin levels directly from the patient's blood. In [11], Verilog-based hardware was used to process the photometric data and provide a diagnosis, reinforcing the utility of hardware description languages in biomedical applications.

A non-invasive approach to jaundice detection is discussed in [5], where a camera-based system was developed to detect jaundice by analyzing the patient's skin tone. This method aligns with modern trends in healthcare emphasizing comfort and accessibility, although it is sensitive to lighting conditions and environmental factors that may affect image clarity.

In the assistive technology space, the self-driving wheelchair described in [6] introduces an Android application that allows users to input destinations via a touch interface. While helpful for some users, the system (Self-E) may not be suitable for individuals with severe mobility impairments who are unable to use touch-based controls.

Relevance to Proposed Work

The reviewed literature highlights the expanding role of FPGAs in health monitoring, diagnostics, and assistive technology. However, most existing works address individual aspects—such as physiological signal processing, image-based detection, or assistive navigation—without integrating these capabilities into a single, real-time hardware system.

This paper proposes a novel **Health Monitoring and Jaundice Detection System** that integrates the monitoring of vital signs (body temperature, heart rate, blood pressure, and age) with image-based jaundice detection using binary pixel analysis of skin or eye images. The system is implemented on an **FPGA using Verilog**, ensuring high-speed and efficient data processing. It uses **UART** for local communication and **WiFi** for remote transmission

of patient data. The alert mechanism activates **LED and buzzer** outputs, ensuring immediate response to abnormal conditions.

By combining multiple health monitoring functionalities with real-time image processing and communication capabilities in a single FPGA-based system, the proposed work fills a significant gap in the existing literature and contributes to the development of efficient, scalable, and practical healthcare solutions.

3. Problem Statement

Timely detection and monitoring of health conditions such as abnormal vital signs and jaundice are critical for reducing the risk of medical emergencies. Traditional health monitoring systems often rely on bulky, expensive, or manually operated equipment, which limits their applicability in remote or resource-constrained environments. Moreover, jaundice detection usually requires invasive blood tests or expensive imaging equipment, making early diagnosis less accessible to the general population.

Existing embedded health monitoring solutions based on microcontrollers may lack the speed and parallel processing capabilities required for real-time performance, especially when handling both sensor data and image processing tasks simultaneously. Additionally, many systems focus either on vital sign monitoring or image-based diagnostics, with limited integration between the two.

Further more Communication in these Systems is typically limited to either local or cloud-based Platform, lacking a hybrid solution **UART (for local display and interfacing)** and **WiFi (for remote health data transmission)**. There is also a lack of embedded alert mechanisms for real-time feedback in abnormal health conditions.

Therefore, there is a need for a unified, **FPGA-based system** that:

- Monitors key health parameters (age, body temperature, heart rate, blood pressure),

- Detects jaundice by analyzing yellow pixel count in binary images of the eye or skin,
- Compares results against defined thresholds (e.g., 5000 pixel count for jaundice detection),
- Sends health reports via **UART and WiFi**, and
- Activates alert mechanisms (LED and buzzer) in Case of abnormal Condition.

The goal is to develop a **cost-effective, fast, and reliable Verilog-implemented system** that combines real-time health monitoring, non-invasive jaundice detection, and efficient communication for smart healthcare applications

4. Methodology

The proposed system is implemented on an FPGA using Verilog HDL and is designed to perform real-time health monitoring and jaundice detection. The methodology is structured into the following key stages:

4.1. Acquisition of Health Parameters

Vital signs are either sensed or manually input and include:

- Age (user input)
- Body Temperature (via temperature sensor)
- Heart Rate (via pulse sensor)
- Blood Pressure (via digital sensor or fixed input)

Each parameter is compared with predefined threshold values to classify the patient's condition as normal or abnormal.

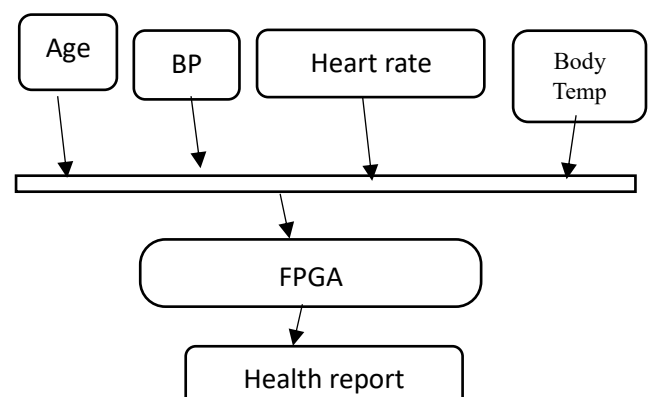


Fig 1:Health Monitoring System Architecture

4.2. Jaundice Detection via Image Processing

- Image Capture: A photograph of the eye or skin is captured using a standard camera.
- Image Preprocessing: The image is uploaded to Google Colab, where Python scripts convert it into binary format.
- Pixel Count: The number of '1's (representing yellow pixels) is calculated.
- Threshold Check: If the pixel count exceeds 5000, jaundice is considered present.

4.3. Decision Logic and Data Flow

- If all health parameters are normal:
- A health report is generated.
- The data is transmitted via UART and WiFi for local and remote monitoring.

If any health parameter is abnormal:

- The system checks the yellow pixel count.
- If the pixel count exceeds 5000, jaundice is detected.
- The system transitions to the alert state.

4.4. Alert Mechanism

In case of abnormal health conditions or jaundice detection:

- LED and Buzzer are activated to give a physical alert.
- Health status and jaundice results are transmitted via:
 - UART (for local interfacing)
 - WiFi (for cloud or remote access)

4.5. FPGA Implementation

The complete system is implemented using Verilog HDL and tested in the Xilinx Vivado environment. The design is synthesized and deployed on an

FPGA development board. The system includes the following modules:

- Sensor Data Processing Block
- Image Pixel Analysis Block
- Threshold Comparator
- Communication Controller (UART & WiFi)
- Alert and Output Control Module

4.6 Design and Implementation

There are six primary states in implementing the Health Monitoring and Jaundice Detection System, as illustrated in Fig. 2 through a state diagram. Each state is described in Table 1 (Fig. 3), which outlines the function of each part of the system. The sequence of states represents the system's flow from data input to analysis and result display.

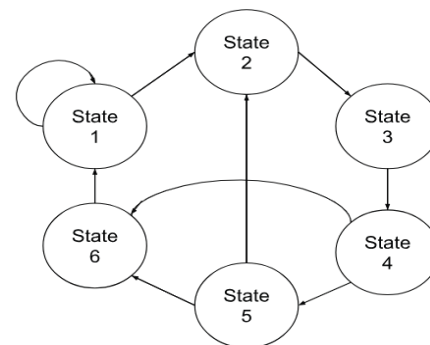


Fig 2:State Diagram of health Monitoring System.

The initial state is State 1 (Idle State), where the system remains inactive and waits for user interaction. Once activated, the system transitions to State 2 (Input State), where it receives input values such as body temperature, heart rate, blood pressure, and age.

After collecting the input data, the system proceeds to State 3 (Processing State). In this state, the input values are processed through computational logic to derive meaningful health metrics. Next, the system enters State 4 (Check Condition), where the processed health parameters are compared against predefined threshold values .

State	Description
State 1	IDLE State
State 2	INPUT State
State 3	Processing State
State 4	Check Condition
State 5	Alert State
State 6	Display State

Fig 3:Description of States for health Monitoring System.

based on the respective age group. If all values are within the normal range, the system moves directly to **State 6 (Display State)**, where the health report is displayed on a monitor and transmitted via UART and WiFi.

However, if any values are found to exceed the threshold, the system transitions to **State 5 (Alert State)**. In this state, an alert is triggered using both an LED and a buzzer, and a warning message is sent through UART and WiFi.

After the alert or display process is complete, the system returns to **State 1 (Idle State)**, ready to accept new input values for the next monitoring cycle.

5. Results and Discussion

The complete system was designed using **Verilog HDL** and implemented on an **FPGA development board** using **Xilinx Vivado**. Sensor inputs for body

temperature, heart rate, blood pressure, and age were simulated using testbenches, while yellow pixel counts were calculated through image processing on Google Colab and provided as inputs to the FPGA.

Simulation results:

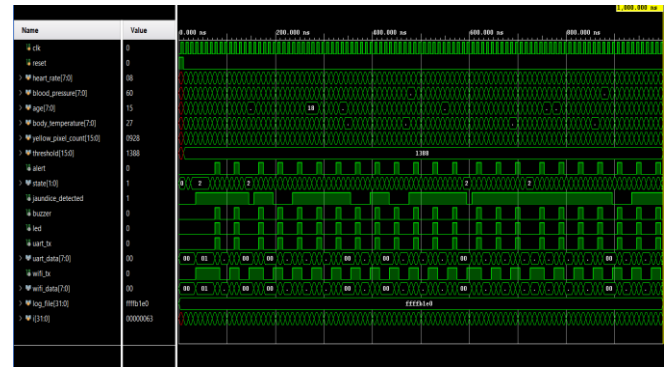


Fig 4:Simulation Result of Health Monitoring and Jaundice detection system using verilog with UART&Wi-Fi Communication.

Synthesis Design:

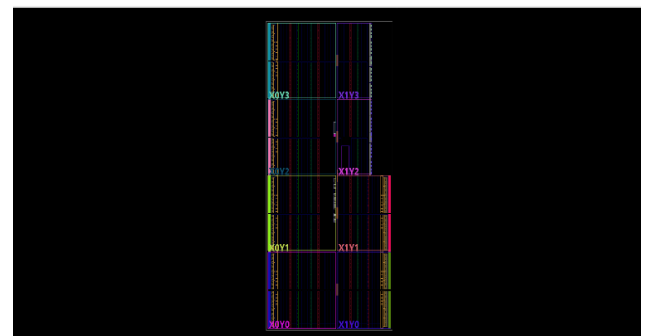


Fig 5:Synthesis Design of Health Monitoring and Jaundice Detection System Using Verilog With UART&Wi-Fi Communication.

LookUp Graph:

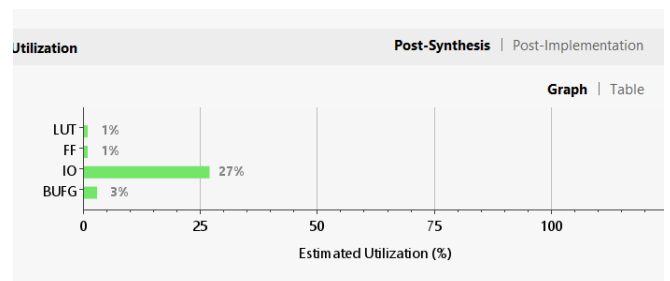


Fig 6:LookUp graph of the Health Monitoring and Jaundice Detection system using verilog with UART&Wi-Fi

LookUp Table :

Graph | Table

Resource	Estimation	Available	Utilization %
LUT	41	41000	0.10
FF	65	82000	0.08
IO	313	300	104.33
BUFG	1	32	3.13

Fig 7:LookUp table of the (BasePaper)Health Monitoring and jaundice detection System using Verilog.

Graph | Table

Resource	Estimation	Available	Utilization %
LUT	19	41000	0.05
FF	10	82000	0.01
IO	82	300	27.33
BUFG	1	32	3.13

Fig 8 :LookUp table of the health Monitoring and Jaundice Detection System using Verilog with UART&Wi-Fi Communication.

UART & WIFI COMMUNICATION

UART Output: A serial terminal displayed real-time health reports or alert messages with clear formatting.

WiFi Transmission: Successfully integrated with an ESP8266 module. Health data was transmitted to a local web interface, confirming remote monitoring capability.

Example UART Output (Normal Case):

Health Report:
Temp: 36.7°C | HR: 75 bpm | BP:
120/80
Jaundice: Absent

Example UART Output (Alert Case):

ALERT!!!Abnormal Vitals Detected
Yellow Pixel Count: 6150 Jaundice:
DETECTED Emergency Alert
Triggered

5.1 Discussion

- The **parallel processing capability of the FPGA** allowed fast evaluation of multiple health parameters and immediate response to abnormalities.
- Integration of **external image analysis** using Google Colab enabled efficient jaundice detection without complex onboard image processing.
- Dual communication via **UART and WiFi** ensured both local interfacing and remote data transmission, improving accessibility for doctors or caregivers.
- The system was found to be highly **modular, scalable, and suitable for real-time health monitoring applications**, especially in rural or low-resource settings.

6. Conclusion

In this paper, a real-time, FPGA-based health monitoring and jaundice detection system was designed and implemented using **Verilog HDL**, with integrated **UART and WiFi communication** for data transmission. The system successfully monitors key health parameters—**age, body temperature, heart rate, and blood pressure**—and detects **jaundice** by analyzing the **yellow pixel count** in binary eye or skin images processed externally.

The proposed system demonstrates a high level of accuracy and efficiency in detecting abnormal health conditions and triggering alerts via **LED and buzzer**, while also providing health reports through **dual communication modes**. By leveraging the **parallel processing capabilities of FPGA**, the system ensures fast decision-making, real-time operation, and minimal latency.

This solution is particularly beneficial for **remote healthcare monitoring**, offering a **non-invasive, low-cost, and scalable** alternative to traditional diagnostic methods. Future enhancements may include onboard image processing, integration with mobile apps, and machine learning for more advanced health analytics.

7. Future Scope

The proposed Health Monitoring and Jaundice Detection System provides a promising solution for real-time healthcare applications. However, there is significant scope for enhancement and further research. The following are the key directions for future work:

Mobile Application and Cloud Integration

A mobile application or cloud-based dashboard can be developed to visualize the patient's data remotely. This will enable continuous monitoring and remote diagnostics, especially beneficial in telemedicine and rural healthcare setups.

Onboard Image Processing

The current system relies on external platforms such as Google Colab for image processing. In the future, onboard image processing using embedded processors or hardware accelerators within the FPGA can be integrated to make the system completely self-contained and real-time

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