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M.Tech – VLSI Design
21LIV604 Open Lab

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Real Time FPGA - Based Weather Classification System using Offline - Trained Decision Tree Logic

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PROBLEM STATEMENT

Many regions lack reliable internet connectivity and consistent power supply, making it difficult to deploy conventional weather monitoring systems that depend on processors, cloud services, or complex embedded software. To overcome this limitation, this project presents a hardware weather classification system implemented on FPGA.

OBJECTIVES

- To implement a real-time weather classification system that functions completely offline.
- To train a machine learning classifier and extract decision thresholds for hardware realization.
- To utilize a low-cost temperature and humidity sensor (DHT11) for efficient weather classification.

METHODOLOGY

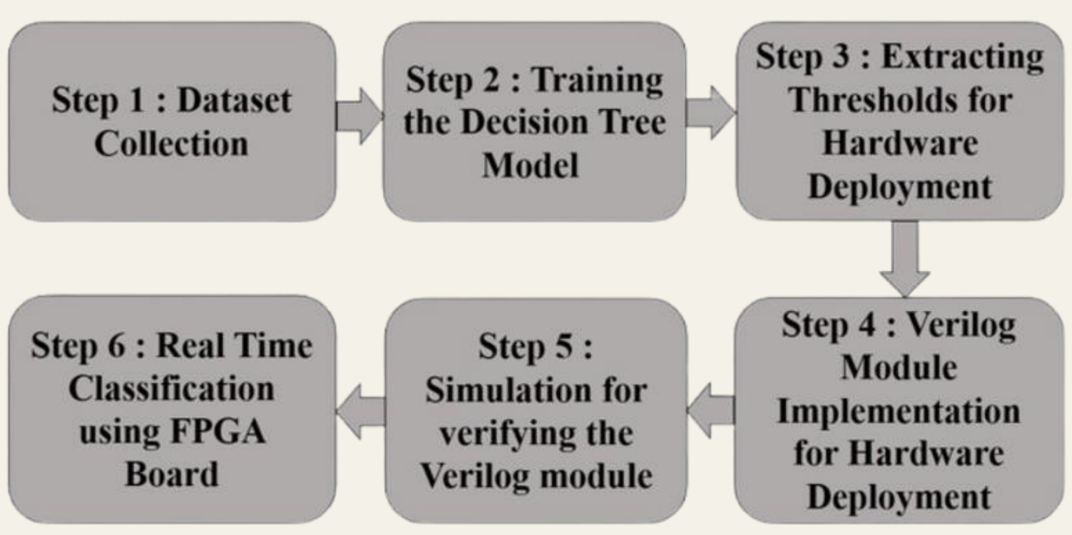

Fig. 1 : Methodology

Step 1. Dataset Collection : Weather data containing temperature and humidity readings is collected and prepared for training.

Step 2. Training the Decision Tree Model : Using Python, Decision Tree model is trained on the dataset to categorize weather conditions such as Clear, overcast, rain partially cloudy, partially cloudy, rain overcast and overcast.

Step 3. Extracting Thresholds for Hardware Deployment : The decision boundaries, the thresholds generated by the trained model are extracted for hardware implementation.

Step 4. Verilog Module Implementation for Hardware Deployment: The extracted thresholds are manually encoded as if-else conditions in Verilog to form the weather classification logic.

Step 5. Simulation for verifying the Verilog Module : The Verilog module is simulated to verify weather classification for various temperature and humidity inputs

Step 6. Real-Time Classification using FPGA Board : The verified design is implemented on the Basys3 FPGA and integrated with the DHT11 sensor. Results are displayed through an LCD display and PuTTY terminal using UART.

CIRCUIT DIAGRAM

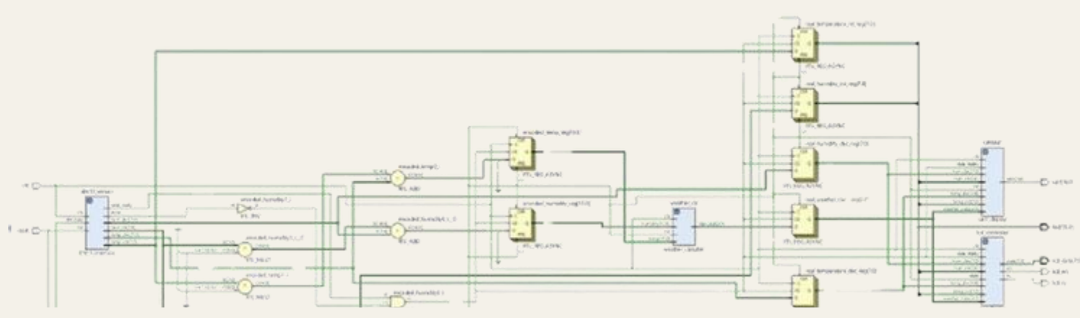

Fig. 2 : RTL Schematic for Real Weather classification System

The RTL schematic consists of four main Verilog modules as shown in Fig.2. The *dht11_interface module* reads the 40-bit data frame from the DHT11 sensor and extracts temperature and humidity values. These values are sent to the *weather_classifier module*, which determines the current weather condition based on the embedded logic. The classified weather, along with temperature and humidity, is then displayed on an LCD via the *lcd_display module* and simultaneously transmitted to a PC through the *uart_display module* for real-time monitoring. This setup enables fully offline, hardware-based weather classification

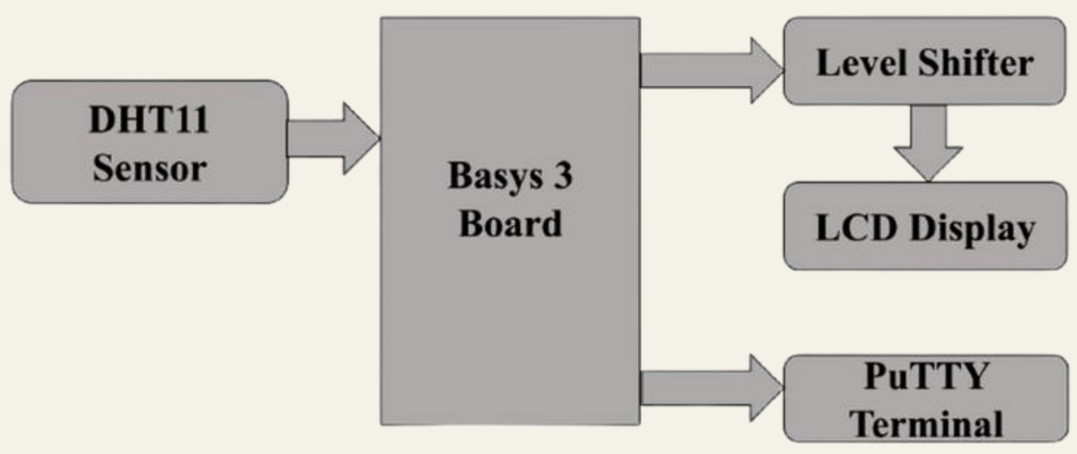

Fig. 3 : Block Diagram for Real Time Classification

Fig. 3 shows the block diagram for Real Time Classification. The DHT11 sensor captures real-time temperature and humidity data, which is processed by the Basys3 FPGA board using classification logic embedded using verilog code. The classified weather information is displayed on an LCD via a level shifter and simultaneously sent to a PC through the PuTTY terminal for real-time monitoring.

SIMULATION RESULT

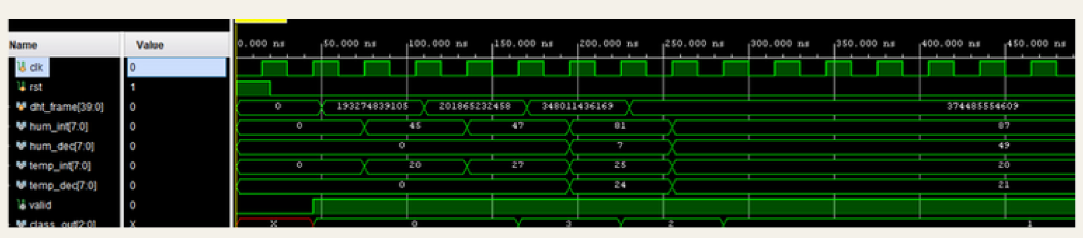

Fig. 4 : Simulation of Weather classification

The simulation shown in Fig.4, verifies the Verilog-based weather classification logic using four input test frames. At first edge of clock, temperature and humidity values are extracted, and at the next clock edge, the classifcation result is displayed. Weather conditions are encoded to allow clear visualization in the waveform.

RESULTS

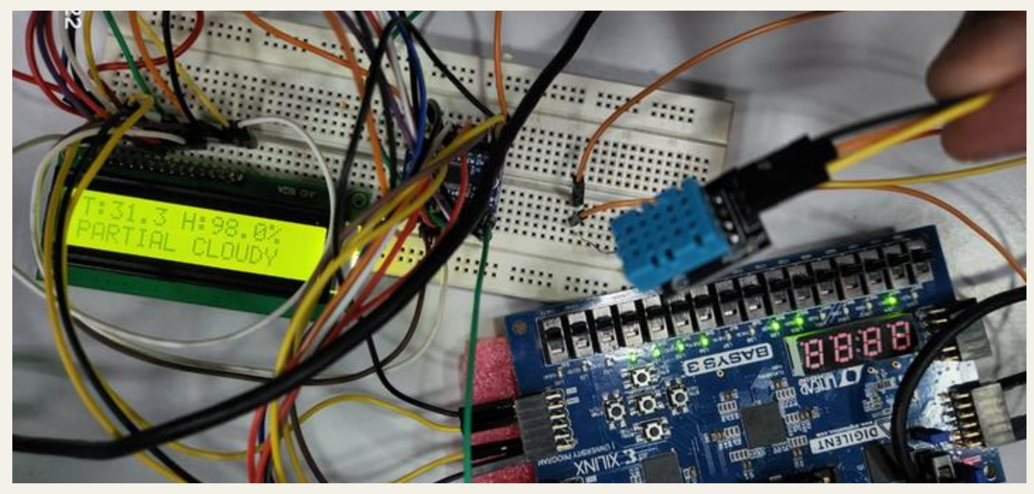

Fig. 5 : Displaying Weather Condition on LCD Display

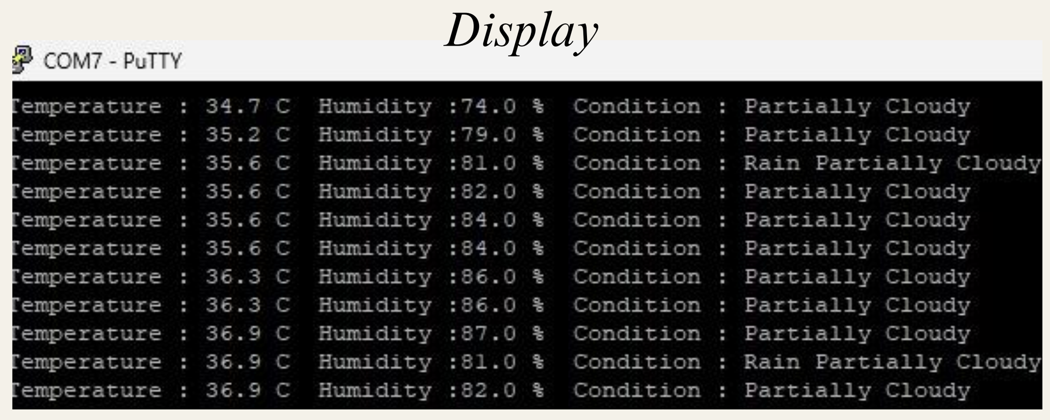

Fig. 6 : Displaying Weather Condition in PuTTY Terminal via UART

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