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AI POWERED FAULT DETECTION FOR PCB

[1] Dr.S.M.Swamynathan, [2]M.Bala Hari, [3]G.Illamparuthi, [4]R.Manojkumar, [5]D.Meiythiruprakash

[1]Associate Professor/ECE, [2] , [3], [4], [5]Final year students

[1]Electronics and Communication Engineering,

[1]SNS College of Technology, Coimbatore, I*ndia*

Abstract: This research presents a novel approach for real-time fault detection for PCB using AI and Python. The increasing complexity of electronic devices has led to a rising demand for efficient fault detection mechanisms in Printed Circuit Boards (PCBs).The integration of Internet of Things (IoT) technologies with advanced Artificial Intelligence (AI) algorithms presents a promising avenue for addressing this need. This paper proposes a novel approach leveraging Convolutional Neural Networks (CNNs) for the automated detection of faults in PCBs, facilitating real-time monitoring and diagnostics within IoT frameworks. The proposed systembegins by acquiring high-resolution images of PCBs using specialized cameras or sensors, capturing intricate details of the board layout and components. These images serve as input data for the CNN model, which is trained on a comprehensive dataset comprisingvarious types of faults, such as short circuits, open circuits, and component defects. Through extensive training, the CNN learns to discern patterns and anomalies, establishing a robust fault detection framework. Utilizing the inherent ability of CNNs to extract hierarchical features from images, the model accurately identifies and localizes faults within the PCBs. The integration of this AI- based solution within an IoT infrastructure enables seamless connectivity and data transmission, allowing for remote monitoring and analysis. Detected faults trigger immediate alerts or notifications, empowering timely interventions to mitigate potential issues, thereby enhancing the reliability and performance of electronic systems. The effectiveness of the proposed AI-driven fault detection system isvalidated through extensive experiments and evaluations, demonstrating high accuracy and reliability in detecting various types of faults in diverse PCB designs. The integration of CNN-based fault detection within IoT frameworks showcases its potential to revolutionize fault diagnosis in electronic systems, paving the way for more resilient and self-monitoring devices in the era of interconnected smart technologies.

I. INTRODUCTION

Printed Circuit Boards (PCBs) serve as the backbone of modern electronic devices, enabling the interconnection of various components. However, ensuring their flawless functionality poses significant challenges in industries. The purpose of implementing fault detection mechanisms within PCBs is to preemptively identify and rectify issues that may compromise the reliability, performance, and safety of electronic systems. This imperative arises due to the intricate nature of PCBs and the critical role they play in diverse industries, ranging from consumer electronics to aerospace and healthcare. Industries face multifaceted problems when it comes to PCB fault detection. One of the primary challenges is the increasing complexity and miniaturization of electronic components, which intensifies the difficulty in manually inspecting and detecting faults. Traditional inspection methods, reliant on human visual inspection or basic testing, often fall short in identifying latent or minute defects, leading to potential malfunctions in the field. Moreover, the demand for high-volume production further exacerbates the need for rapid and accurate fault detection mechanisms. Implementation of robust fault detection strategies in PCBs is imperative to address these industry challenges. Leveraging advancements in Artificial Intelligence (AI) and Internet of Things (IoT) technologies offers a promising solution. AI-based algorithms, particularly Convolutional Neural Networks (CNNs), present a revolutionary approach by enabling automated, high-precision fault detection. By analyzing intricate details captured through high-resolution imaging, these algorithms can discern patterns and anomalies that might escape human detection. Furthermore, integrating these fault detection systems within IoT frameworks facilitates real-time monitoring, remote diagnostics, and preemptive maintenance, enhancing the overall reliability and operational efficiency of electronic systems.

II. RESEARCH METHODOLOGY

2.1 HARDWARE REQUIREMENTS

- POWER SUPPLY UNIT
- ARDUINO UNO
- NODEMCU
- LIQUID CRYSTAL DISPLAY
- BUZZER

2.2 HARDWARE DESCRIPTION

2.2.1 POWER SUPPLY UNIT

A power supply unit (PSU) is an essential component in electronic devices and systems that converts electrical energy from a source (such as a wall outlet or a battery) into a form suitable for powering the various components within the device. It provides the necessaryvoltage, current, and frequency to ensure stable and reliable operation. This type converts alternating current (AC) from a wall outlet into the direct current (DC) needed by electronic devices. It typically contains a transformer, rectifier, and regulator to achieve this conversion. Power supplies are rated based on their maximum output capacity, which is measured in watts (W). It's crucial to select aPSU with a sufficient wattage to meet the demands of the connected components, ensuring they operate efficiently and without strain.The power supplies often come with various protections, such as overvoltage, overcurrent, and short-circuit protection, to safeguard both the power supply itself and the connected equipment from potential damage.

Power supply units are integral components in a wide range of electronic devices, from computers and laptops to televisions, mobile phones, and industrial machinery. They play a critical role in ensuring reliable and consistent electrical power for the proper functioningof these devices.

2.2.2 ARDUINO UNO

The Arduino Uno has a total of 14 digital input/output pins. Of these, 6 can be used for pulse-width modulation (PWM) output. It has 6 analog input pins that can also be used as digital inputs. These pins are capable of reading analog signals, making them suitable for sensors and other analog devices. The ATmega328P operates at 16 MHz, providing sufficient processing power for a wide rangeof applications. The Arduino Uno can be powered via USB connection, an external power supply, or through the VIN pin using a regulated power source. It features a USB interface that allows it to be connected to a computer for programming and serial communication. This interface also provides power to the board. The board is equipped with a voltage regulator that ensures a stable5V supply for the microcontroller and connected components. The reset button allows you to restart the program execution from thebeginning. The Arduino Uno operates at 5 volts, making it compatible with a wide range of sensors and modules. It is compatible with a vast ecosystem of sensors, shields, and modules, making it versatile and suitable for a wide range of projects.

2.2.3 NODE MCU

Based on the ESP8266 Wi-Fi module, the NodeMCU is a multipurpose microcontroller board intended for Internet of Things (IoT) applications. Its main objective is to combine Wi-Fi capabilities into a small and easily portable platform to enable connectivity and control in a variety of electrical applications. Both novice and expert developers will find the NodeMCU relatively simple to work with as it runs on a firmware based on Lua and can be programmed using the Arduino IDE. Functionally, the NodeMCU integrated Wi-Fi connectivity allows for smooth communication with other devices and the internet. It is equipped with a potent 32-bit microcontroller unit that can run code and issue commands to communicate with other peripherals like actuators and sensors. GPIO (General Purpose Input/Output) pins on the board let users communicate with external.

PIN CONFIGURATION

GPIO Pins (General Purpose Input/Output):

GPIO0 to GPIO15: These pins are multipurpose and can be used for digital input/output, PWM (Pulse Width Modulation) output, I2C, SPI, and more. Some pins have specific functionalities or limitations, so it's essential to refer to the board's pinout diagram or documentation for details.

Power Supply Pins:

VIN: This pin is used to supply voltage to the board. It can typically handle a range of voltages, but it's recommended to provide a stable 5V power source.

3.3V and GND: These pins are for supplying power at 3.3 volts and ground respectively. USB-to-Serial Interface:

TX and RX: These pins are used for serial communication with the computer or other serial devices. TX stands for transmit,

and RX stands for receive.

Reset and Flash Buttons:

RST: This is the reset pin, which, when pulled LOW, resets the microcontroller.

FLASH: Used for putting the board into flashing mode for firmware updates.

Analog Pins:

A0: Some NodeMCU boards have an analog pin labeled as A0, allowing for analog input functionality.

Special Purpose Pins:

D0 (GPIO16): This pin has a special purpose related to deep sleep functionality in the ESP8266.

2.2.4 LIQUID CRYSTAL DISPLAY

A liquid crystal display, often known as an electronic visual display or video display, is a flat panel display that makes advantage of liquid crystals' ability to modulate light. Light is not directly emitted by liquid crystals. A digital clock's seven-segment display,preset words, and numerals are examples of fixed graphics that can be shown or hidden on LCDs. They can also display arbitrary images, like those found on a general-purpose computer display. The only difference between them is that although other displays have larger parts, arbitrary images are composed of many tiny pixels. An LCD is a cheap, tiny display. The dark blob on the rear ofthe board is an integrated controller, which makes it simple to interact with a microcontroller.

Since this controller (HD 44780) is common to many displays, libraries for numerous micro-controllers, like the Arduino, make displaying messages as simple as writing one line of code.

LCDs are utilized in many different applications, such as signage, instrument panels, computer monitors, televisions, and cockpit display in airplanes. They have mostly supplanted cathode ray tube (CRT) displays in consumer electronics, including video players,gaming consoles, clocks, watches, calculators, and phones. In addition to having a larger selection of screen sizes than CRT and plasma displays, they don't experience image burn-in because they don't utilise phosphors. Unfortunately, LCDs might suffer from image persistence.

2..5 BUZZER

A buzzer, sometimes known as a beeper, is a type of electrical signaling device that is commonly seen in cars, home appliances likemicrowaves, and game shows. It typically consists of several switches or sensors that are connected to a control unit that detects whether a button was pressed and which button it was, as well as whether a predetermined amount of time has passed. It then typically turns on a light at the relevant button or control panel and emits a warning sound, which can be either continuous or sporadic, in the form of a beeping or buzzing sound. This device's original electromechanical foundation was the same as that of anelectric bell San the metal gong. These devices frequently served as sounding boards by being fastened to a wall or ceiling.

Another way to use some AC-connected devices was to build a circuit that would generate enough noise from the AC current to power a loudspeaker when connected to an inexpensive 8-ohm speaker. These days, using a ceramic-based piezoelectric sounder—such as a Son alert—that produces a high-pitched tone is more common. These were typically connected to "driver" circuits that pulsed the sound on and off or changed the pitch of the sound. Because it prevents others from signaling when one person "buzzesin," it is sometimes referred to as a "lockout system" in video game shows. Huge buzzer buttons labeled "plungers" can be found on a number of game shows.

The buzzing sound that buzzers produced when they were electromechanical devices running at 50 or 60 cycles on stepped-down AC line voltage is where the word "buzzer" originates. A ring or beep are two additional noises that are frequently used to show that a button has been pressed.

2.3 SOFTWARE REQUIREMENTS

2.3.1 PYTHON IDLEPython Technology:

Python is a high-level, general-purpose programming language that interprets code. It is compatible with several programmingparadigms, such as functional, object-oriented, and procedural programming. Because of its extensive standard library, Pythonis frequently referred to as a "batteries included" language.

Python Programing Language:

Python is a computer language with multiple paradigms. Many of its features allow functional programming as well as aspect-oriented programming (via the use of met objects and meta programming, among other magic ways), and both object-orientedand structured programming are fully supported. Extensions support many different paradigms, such as logic programming and design by contract.

Python packages with a wide range of functionality, including:

- Easy to Learn and Use
- Expressive Language
- Interpreted Language
- Cross-platform Language
- Free and Open Source
- Object-Oriented Language
- Extensible
- Large Standard Library
- GUI Programming Support
- Integrated

Python handles memory by utilizing a cycle-detecting garbage collector in conjunction with reference counting and dynamic typing. Additionally, during program execution, method and variable names are bound via dynamic name resolution, often known as late binding.

The goal of Python was to be highly extendable, rather than having all of its features built into it. Adding programmable interfaces to existing applications has been made possible by its compact modularity, which has led to its popularity.
ABC advocated the opposite strategy, and Van Rossum's frustration led him to envision a compact core language with a hugestandard library and an easily expandable interpreter.The goal of writing Python is to make it simple to read. Although other languages utilize punctuation, English terms are frequently used in its visually simple layout.

It does not utilize curly brackets to separate blocks like many other languages do, and semicolons are not required after statements. Compared to C or Pascal, it features fewer syntactic exceptions and special circumstances.

PROJECT DESCRIPTION

3.1 WORKING OF PROPOSED SYSTEM

The integration of AI-driven fault detection in Model PCBs, specifically focusing on the power supply unit, represents a cutting-edgeapproach. Utilizing cameras for fault identification enables precise diagnostics within the PCB using on the CNN algorithm. The collected data is then transmitted through an IoT network, facilitating remote access to fault information. LCD system enhances accessibility, displaying real-time updates on detected faults. This innovative solution promises proactive maintenance, ensuring efficient fault detection and swift response, ultimately bolstering operational reliability.

A large dataset of images depicting both normal and faulty PCBs is collected. These images showcase various types of faults oranomalies that may occur within the PCB, especially in the power supply unit. The images are preprocessed to ensure uniformity andenhance their suitability for the CNN algorithm. This may involve resizing, normalization, or other techniques to optimize the data. The CNN consists of multiple layers—convolutional layers, pooling layers, and fully connected layers. The convolutional layers helpin detecting various features within the images, like edges, corners, or specific patterns related to faults. The CNN is trained on thedataset, learning to distinguish between normal and faulty PCB images. During training, the network adjusts its internal parameters(weights and biases) by comparing its predictions with the actual known labels, gradually minimizing the error or difference betweenpredicted and actual results. Through the convolutional layers, the CNN validation and testing from the images, identifying patterns specific to faults within the PCB. The trained CNN model is then deployed within the system, where it processes live or incoming images from cameras installed in the production line. It rapidly analyzes these images, identifying and flagging any detected faults within the power supply unit or the PCB.

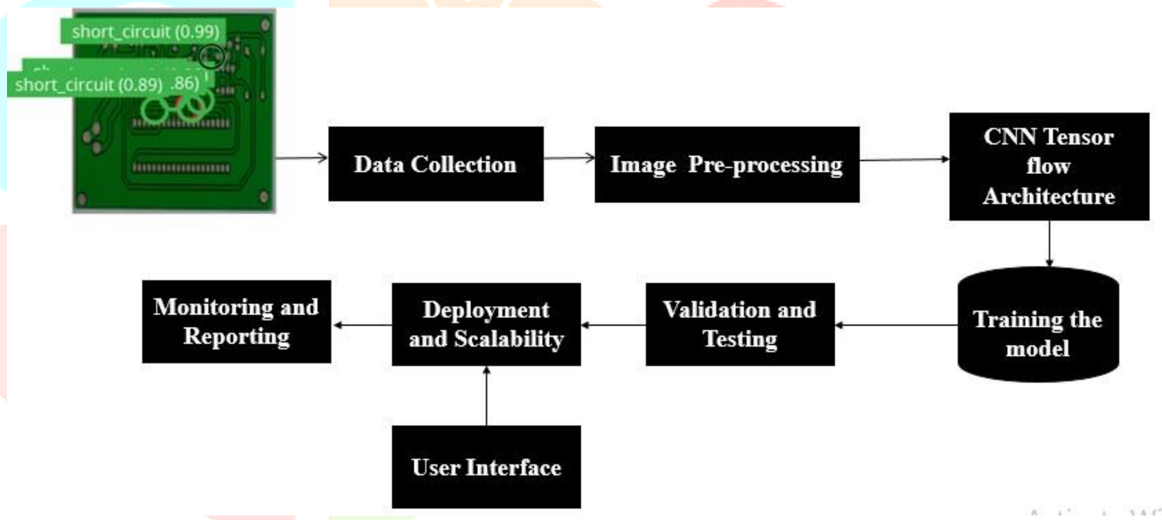

Fig. 3.1 ARCHITECTURE OF PROPOSED SYSTEM

IV. RESULTS AND DISCUSSION

4.1 Results of Descriptive Statics of Study Variables

The integration of AI-driven fault detection in Model PCBs, specifically focusing on the power supply unit, represents a cutting-edgeapproach. Utilizing cameras for fault identification enables precise diagnostics within the PCB using on the CNN algorithm. The collected data is then transmitted through an IoT network, facilitating remote access to fault information. LCD system enhances accessibility, displaying real-time updates on detected faults. This innovative solution promises proactive maintenance, ensuring efficient fault detection and swift response, ultimately bolstering operational reliability.

The results of the PCB fault detection is identified based on the fault which occurs in the PCB. Here the main fault is Track cutwhich is identified by the AI model based on the CNN Algorithm is accurate and can be done lively via web cams and phone cameras. After the error detected an email is sent to the manufacturer .

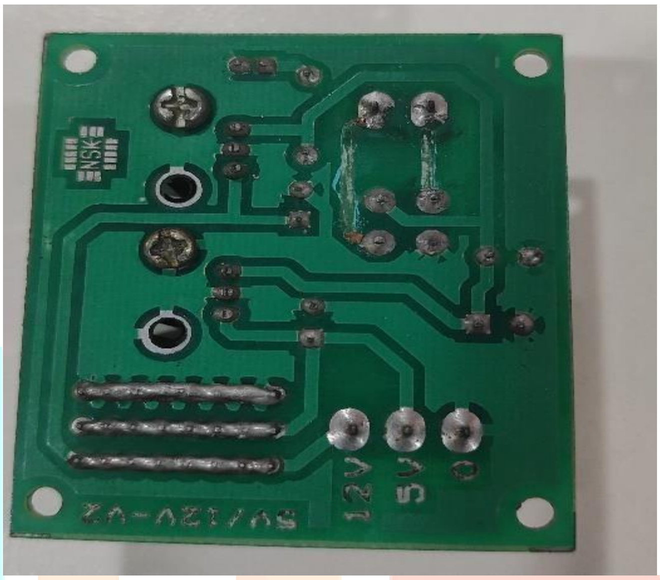

Fig. 4.1 TRACK CUTTED PCB

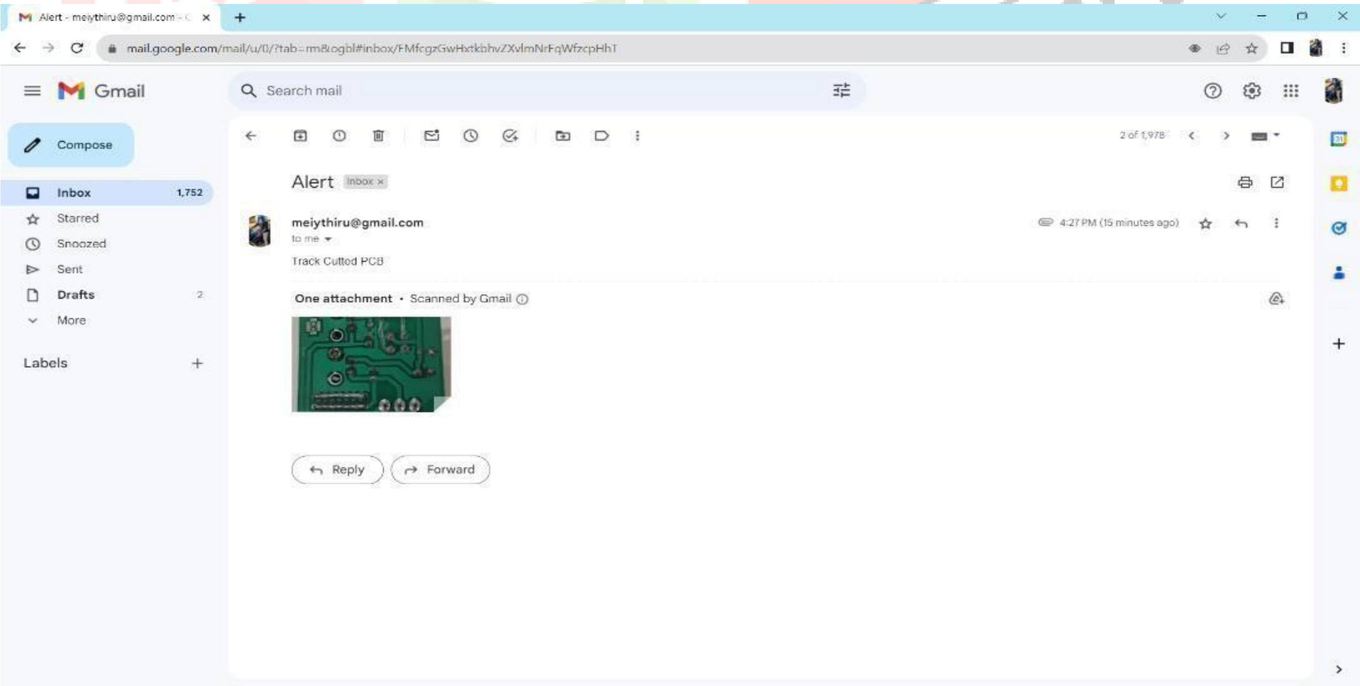

Fig. 4.1 ALERT MAIL

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