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Machine Learning-Based Automated Motherboard Cleaning and Circuit Analysis System Using Raspberry Pi

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Abstract
Laptops, personal computers, and other computing systems contain numerous intricate and compact components that are often difficult to clean. Without regular maintenance and servicing, the performance of these systems can deteriorate significantly. The proposed mechanism aims to provide an efficient and hassle-free method for cleaning such intricate parts.This system includes a detachable garbage collection unit that is easy to attach and remove for convenience. Stepper motors will drive the motion of a brush handle across the motherboard, allowing precise and automated cleaning. Additionally, the mechanism can incorporate air blowers or isopropyl alcohol sprayers to remove dust and residue, followed by brushing for thorough cleaning.By automating the maintenance process, this mechanism promotes timely upkeep, enhances performance, and extends the lifespan of computer systems eliminating the user's dependence on technicians or service centers. Furthermore, by integrating machine learning techniques such as Convolutional Neural Networks (CNNs), the system can analyze thermal images of the motherboard to generate heat maps, thereby monitoring and measuring heat flow across circuits for better performance management.

Keywords: ***Raspberry Pi, Dust removal, Machine Learning, Layers, Motors, Convolution Neural Network, Motherboard cleaner, Heat map.***

1.Introduction
The computer motherboard serves as the central printed circuit board (PCB) that interconnects and coordinates all major hardware components of a computer system. It acts as the primary platform linking the processor (CPU), memory (RAM), storage devices (HDD/SSD), and graphics card, facilitating smooth communication between them. Often referred to by other names such as System Board, Mainboard, Logic Board, Planar Board, or Printed Wiring Board (PWB), the motherboard forms the foundation of every personal computer(1).
Depending on the design of the computer, the motherboard is typically located at the base or along the side of the chassis. It contains numerous printed circuits and conductive pathways that transmit power and data signals among various components. Essentially, every part of the PC either directly or indirectly relies on the motherboard for connectivity and operation.
The type and quality of the motherboard significantly influence a system's performance, speed, stability, and expandability. It is often described as the "heart" or "backbone" of a computer because it integrates all subsystems into one cohesive unit. By enabling communication between components such as RAM, ROM, storage drives, and peripheral devices, the motherboard ensures that the computer functions efficiently and reliably(2).
However, when the motherboard develops faults such as electrical shorts, component failures, or excessive dust accumulation it can lead to system instability or complete hardware failure. Factors contributing to motherboard damage can include overheating, power surges, moisture exposure, physical stress, and improper cleaning or maintenance. Recognizing and addressing these causes early can help prevent irreversible damage and prolong the lifespan of the computer system.
Dust is one of the most common household allergens and, besides making electronic devices appear dirty, it can cause serious internal problems in computers(3). While a layer of dust on the exterior may only affect appearance,

the buildup of dust inside a computer can lead to significant damage. Preventing the accumulation of dust and dirt within the system is essential, as it can permanently harm certain components and lead to hardware failure.

Excessive dust can result in various heat-related issues. When dust gathers on internal components such as memory modules, it acts as an insulating layer, trapping heat and preventing the system's cooling fans from efficiently dissipating it. Additionally, dust clogging the computer's air intake or exhaust vents restricts airflow, stopping cool air from entering and hot air from escaping. Dust accumulation on cooling fan blades also increases friction, leading to noise, reduced efficiency, and uneven fan operation.

The motherboard of the computer is a crucial component that has a significant impact on the other components that cannot be installed. However, some PC enthusiasts are afraid to even touch a motherboard, much less try to replace one, due to the reputation that they are difficult to fix.(4)Rarely, they may even experience motherboard problems with a new computer(5). These issues may manifest as unexpected system reboots, failure to start, or frequent crashes displaying error messages such as fatal exceptions, illegal operations, or general protection faults. Fortunately, many of the common motherboard-related problems users encounter can be identified and resolved with relative ease. More consciousness and patience are needed to solve the fault in the motherboard's circuit Therefore we developed a solution by incorporating machine learning techniques that could be able to generate heatmaps that will help to identify the heat flow in the circuit and fault analysis using a pc analyzer will help to identify and diagnose the fault in the motherboard. This will help to overcome these difficulties and to identify the faults and other short circuits, power outages, and faults in the motherboard.(6)

An overheating computer can experience reduced performance as the processor's thermal protection mechanisms activate to prevent damage. This may lead to system instability and, over time, premature hardware failure. Additionally, dust accumulation can further worsen these issues. It is also important to note that laptop screens and desktop LCD monitors have delicate surfaces that can be easily scratched or damaged by dust particles or improper cleaning materials such as rough cloths.

2. Methodology and Design

The proposed mechanism employs stepper motors to control and move the brush handle precisely across the motherboard for effective cleaning. Alternatively, the system can use air blowers or isopropyl alcohol, which is sprayed onto the board and then gently wiped using the brush to remove dust and residue. This automated cleaning process enables regular maintenance without requiring the user to depend on technicians or service centers, ensuring improved performance and an extended lifespan for computer systems(7).

In addition, a camera integrated with a Raspberry Pi 4 programmed in Python will capture images of the motherboard. Using these images, a machine learning algorithm will analyze the circuits to detect potential faults or damage, allowing for efficient and intelligent system diagnostics.

2.1 Major Components

TABLE 1 Components and its purpose

Name	Purpose and Rating
Raspberry Pi	Raspberry pi 4 is used in this system. It uses 5V USB power supply.
Motor Driver	To deliver high power to the motor using a low-voltage control signal from the control system.
Servo Motor	Servo Motor is used to rotate parts of a machine with high efficiency and with great precision.
Stepper Motor	It has rated voltage and current.
12V DC Fan	DC fans have motors that rely on permanent magnets in order to attract and repel a rotor around the axis using electronic switching.
Raspberry Pi Camera	It provides high sensitivity and low noise image capture in an lightweight design.
PC Analyzer	It has excellent ability for diagnosing errors.
Isopropyl Alcohol Sprayer	It is a major component which is used as cleaners.

2.2 System Design

An ML-based motherboard cleaning mechanism utilizing a Raspberry Pi integrates computer vision and automation to efficiently detect and remove dirt and debris from electronic components. In this system, the Raspberry Pi captures images of the motherboard using its camera module. Through computer vision techniques, the mechanism identifies areas with accumulated dust or debris(8). Machine learning algorithms then compute the most efficient cleaning path for a robotic arm or brush to follow, ensuring thorough and precise cleaning.

The machine learning model is trained on a dataset containing images of motherboards with varying degrees of contamination. This enables the system to accurately recognize and target dirt in real-world conditions, improving its effectiveness over time. The Raspberry Pi serves as the central processing unit, communicating with external devices through standard interfaces such as HDMI, USB, and Ethernet. In IoT-based applications, it uses the networking socket interface to transmit and receive data, functioning as both a client and server in a networked environment.

The setup also includes advanced interfacing capabilities with sensors and actuators. The Raspberry Pi camera module, accessed via the camera library, captures high-resolution images for analysis, while servos and other components are controlled using pulse width modulation (PWM) signals. Two NEMA 17 stepper motors are employed one to control motion along the X-axis and the other along the Y-axis. A dedicated motor driver regulates their operation, with the motors capable of reaching speeds up to 2000 rpm(9).

Additionally, a convolutional neural network (CNN) is used to predict and visualize heat flow across the motherboard. By analyzing images captured by the Raspberry Pi camera, the CNN generates a detailed heat map that highlights thermal patterns and potential overheating zones. This enables proactive maintenance and enhances the overall reliability and performance of the computer system.

2.3 Block Diagram

The Block Diagram of the proposed model is shown in figure 1

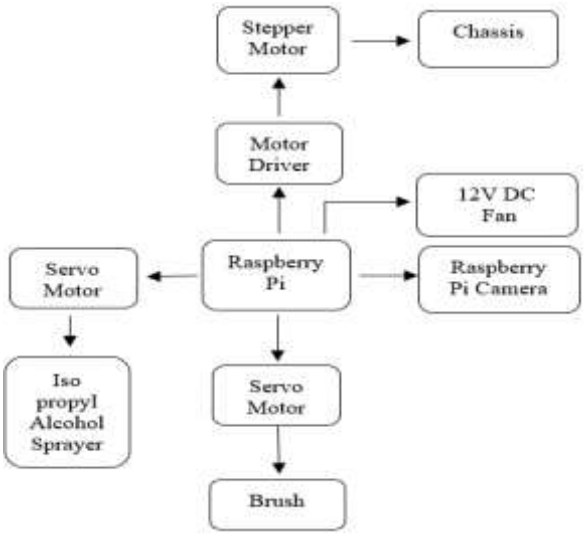

FIGURE 1 Block Diagram

2.4 Circuit Diagram of Motherboard cleaner

This system uses a few other components as supporting components. The motherboard's surface is dusted off using a 12 V fan. Figure 2 displays the suggested motherboard cleaner's full circuit diagram.

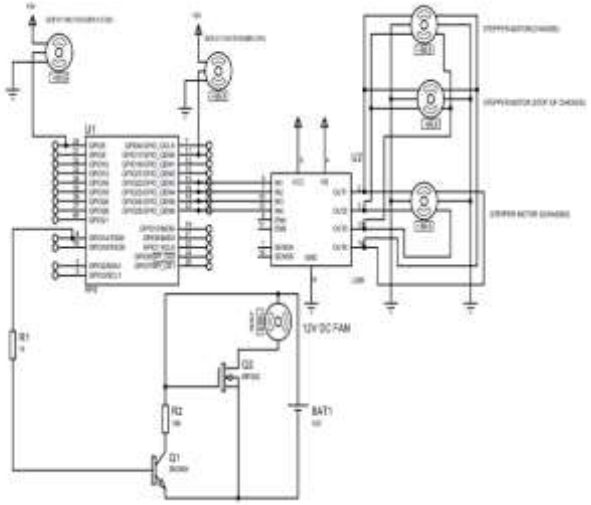

FIGURE 2 Circuit Diagram of Motherboard cleaner

The operational logic of the motherboard cleaning system is illustrated through the flowchart shown in Figure 3

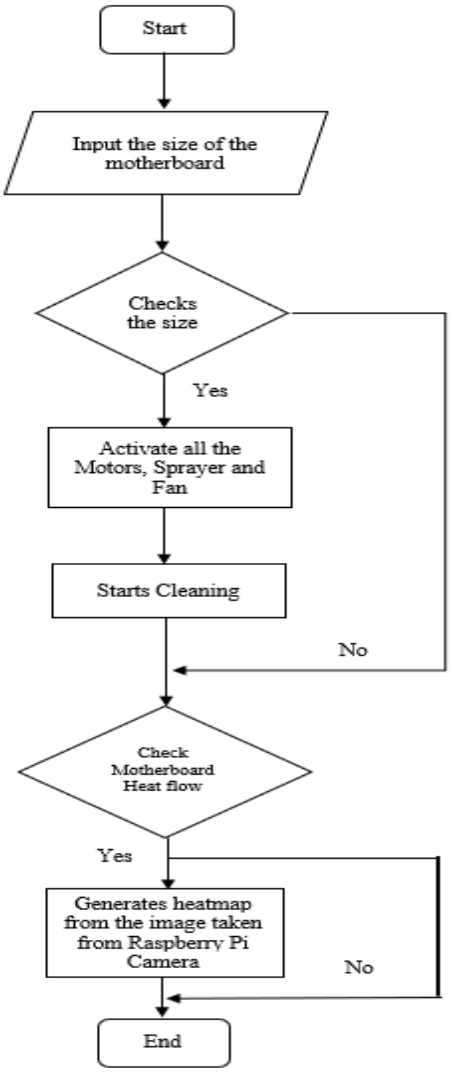

FIGURE 3 Flow Chart

2.5 Heatmaps

A heatmap is a visual representation of data in which different values are illustrated using a color-coding scheme. While heatmaps are widely applied in various types of data analytics most notably to analyze user behavior they

can also be effectively used to visualize thermal patterns and circuit behavior on a motherboard. In this model, heatmaps are utilized to display the distribution of heat flow across different components of the motherboard, providing valuable insights into thermal performance and potential overheating zones, as illustrated in Figure 4(b)(10).For a heatmap to yield accurate and meaningful results, a substantial amount of data is required. Conducting heatmap analysis with an insufficient dataset is similar to prematurely concluding A/B testing without adequate samples or conversions, as shown in Figure 4(a). Since heatmaps are designed to reveal patterns and trends, collecting enough data ensures that anomalies or outliers do not distort the overall thermal representation. Certain motherboard components, such as transistors and processors, must operate within specific temperature thresholds to maintain performance and prevent damage(11). This model employs heatmap analysis to detect and monitor excessive heat levels in integrated circuits, enabling the early prediction and prevention of potential faults thereby improving system reliability and longevity.

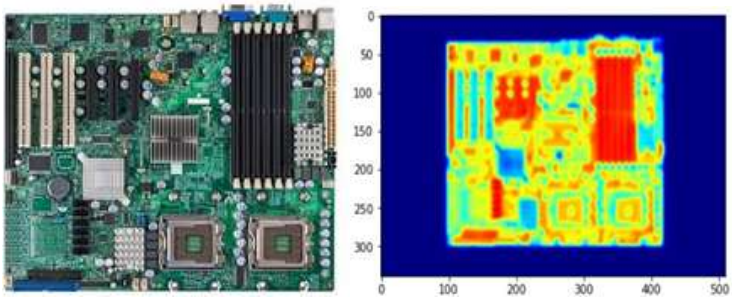

FIGURE 4(a) Normal Image of Motherboard **FIGURE 4(b)** Heat map of Motherboard

2.6 Convolution Neural Networks (CNN)

Among various deep neural network architectures, Convolutional Neural Networks (CNNs) have demonstrated remarkable effectiveness in predictive modeling and pattern recognition tasks. CNNs are a class of feed-forward neural networks composed of multiple layers primarily convolutional, pooling, and fully connected layers arranged to simulate the hierarchical visual processing found in mammalian vision systems. In CNNs, convolutional and max-pooling layers are typically alternated to capture both complex and simple visual patterns at different abstraction levels.

CNNs have been successfully applied across diverse domains such as computer vision, natural language processing, and bioinformatics(12). Modern CNN-based methods are capable of accurately classifying high-quality, static images with well-defined features. In this study, CNNs are utilized to detect and map circuit patterns on motherboards, generating corresponding heatmaps to visualize electrical and thermal characteristics.

The optimal network configuration in our experiment included the following structure and parameters, selected through 5-fold cross-validation to ensure robust hyperparameter tuning and minimize cross-validation error:

- Input Layer: The input layer receives images with a resolution of 64×64 pixels and three color channels (RGB). These inputs are processed and passed to the convolutional layers for feature extraction.
- Convolutional Layers: Three convolutional layers are employed, each applying a set of learnable filters to the input images to extract relevant features. Each filter produces a feature map in the output. To improve convergence and training efficiency, Batch Normalization is applied after each convolutional operation, followed by the Rectified Linear Unit (ReLU) activation function for non-linearity.
- Max-Pooling Layers: Each convolutional layer is followed by a max-pooling layer, which reduces the spatial dimensions of the feature maps. This down-sampling process helps retain essential features while minimizing computational load and overfitting.
- Fully Connected Layers: After feature extraction, the output is passed to three fully connected layers that integrate learned features and determine the final classification scores. A SoftMax classifier at the final layer outputs the probability distribution across categories(13). To prevent overfitting, a Dropout rate of 0.5 is applied, effectively regularizing the network.

The CNN model is trained using categorical cross-entropy loss, allowing it to learn from labeled motherboard images. It identifies both local features such as fine circuit patterns and global relationships across different regions of the image. Through this layered learning approach, the CNN effectively classifies and analyzes motherboard circuit images, providing accurate heatmap visualizations that support diagnostic and predictive analysis.

3.Hardware Implementation and Results

The proposed motherboard cleaning system combines both automated and manually controlled operations. It features a simple yet effective architectural design centered around the Raspberry Pi module. A 12.5W Raspberry Pi unit is utilized in this setup, delivering an output voltage of 5V under open-circuit conditions. The motor driver, responsible for powering and controlling the cleaning mechanism, is configured to operate at an output voltage of 12V, ensuring sufficient torque and efficiency for precise movement during the cleaning process(14). While the stepper motor on top of the brush moves in the direction of right to left, the two stepper motors on the right and left side of the chassis are programmed to move the brush in the direction of top to bottom. Stepper motors are connected with the Motor driver. A Motor Driver is mainly used for control the direction and speed of the motors. Each Motor Drivers are connected with the adapter for power supply. Raspberry Pi is also connected with the adapter.

A servo motor is used for spinning the brush in order to clean the motherboard. When the user wants to clean the motherboard with iso-propyl alcohol, a sprayer with iso-propyl alcohol is fixed behind the brush. It is used to spray 90% pure iso propyl alcohol for cleaning of the motherboard. 90% pure iso propyl alcohol is used to avoid any possibilities of short circuit while cleaning the motherboard in order to dry the iso-propyl alcohol and remove the dust that has gathered in the motherboard a 12V DC fan is also fixed behind the brush. These two devices will have same movement applied for the brush. Brush mounted on the head of the servo motor will be used to wipe the dust off the motherboard. These also will be moved in all four directions. Chassis is the whole mechanical structure that holds the mechanism. The chassis will be mounted with all the above components and will help everything work in confluence. When the Stepper Motors and Servo Motor are run through the help of the machine learning.

The Raspberry Pi camera is used for view the board while cleaning the mother board. It helps to prevent the board from the small damages. DC fan is mainly used for dry the mother board After, the spray of Iso Propyl Alcohol. The mother board is placed and fixed at the correct position for cleaning operation(15). The upper body of the chassis moves with the help of the Stepper Motor and the Stepper Motor connects with a wheel and with the help of the belts. The experimental setup and movements are given in the fig.5

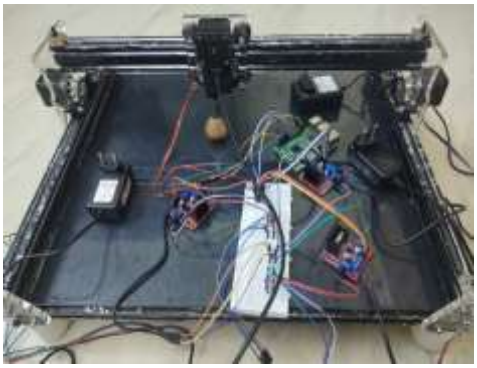

FIGURE 5 Experimental Setup

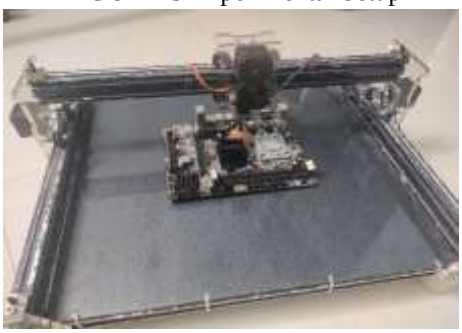

FIGURE 5(a)

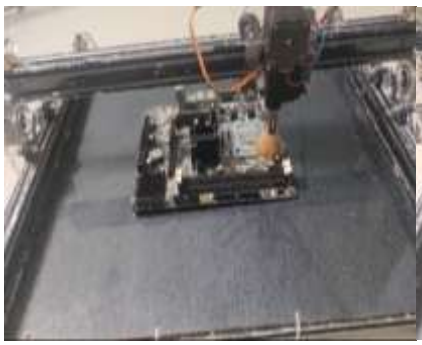
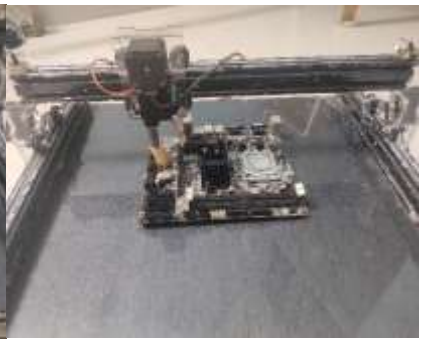

FIGURE 5(b) **FIGURE 5(c)**

Figure 5(a), 5(b), 5(c) depicts the motor movement and mechanism of the proposed motherboard cleaner.
This figure 6(a) depicts a motherboard that has been used for roughly two months and has been cleaned by the proposed mechanism shown in 6(b).


FIGURE 6(a) **FIGURE 6(b)**

Experimental results confirm that the proposed solar panel cleaning system operates efficiently and achieves the desired performance levels(16). Performance comparison of the proposed motherboard cleaning mechanism vs Convection method is shown in Table. 2

TABLE 2 Conventional Method vs Proposed Method

Parameter	**Conventional Method**	**Proposed Method**
Time Consumed	30-40 minutes	Less than 10 Minutes
Windage loss in Motherboard	Very High	Very low
Possibilities of Damage	High	Less
Precision	Less Precise	More Precise

4.Conclusion

This journal presents a system designed to significantly reduce the effort required to clean a motherboard while minimizing the risk of faults or damage. The proposed mechanism features two modes of cleaning, both supported by a sturdy chassis. The chassis provides the necessary mechanical stability, housing and supporting the entire cleaning assembly, and enabling precise movement and operation.
Compared to conventional cleaning methods, the automated mechanism offers a substantial improvement in efficiency and safety. Traditional manual cleaning typically takes 30 to 40 minutes to complete a single motherboard, whereas the proposed automated system can achieve the same task in approximately 10 minutes. Manual cleaning methods are inefficient and risk-prone, as applying inconsistent or excessive pressure by hand can lead to component damage or even cascading system failures.

In contrast, the proposed system is pre-programmed to apply a consistent and optimal amount of pressure during cleaning, effectively eliminating the risk of physical damage. This not only ensures the safety of delicate motherboard components but also minimizes windage losses caused by irregular brush contact. The controlled pressure and uniform brush strokes result in a more precise and consistent cleaning process, reaching intricate areas and corners that are difficult to clean manually.

Additionally, conventional cleaning methods lack the capability to detect heat flow or circuit-related issues. The proposed model addresses this limitation by incorporating a heat and fault detection system capable of identifying which motherboard components generate excess heat and locating both major and minor defects. The detected issues are then displayed to the user, facilitating timely diagnosis and repair.

Overall, the proposed system provides a faster, safer, and more efficient alternative to traditional manual cleaning methods, ensuring both improved performance and prolonged lifespan of computer motherboards.

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Conflicts of interest

The authors have no conflicts of interest to declare

References

1. Tomljanović J, Turina T, Krelja Kurelović E. Motherboard and user experience. International Conference on Information & Communication Technology Electronics & Microelectronics (MIPRO). 2020;1(1):1–6.
2. Aravind G, Vasan G, Gowtham Kumar TSB, Naresh Balaji R, Saravana Ilango G. A control strategy for an autonomous robotic vacuum cleaner for solar panels. Texas Instruments India Educators' Conference (TIIEC). 2014;1(1):1–8.
3. Dumanwar A, Ghangare A, Mithe A, Parashar S, Chaudhari NV. Rooftop solar panel cleaning system using Internet of Things (IoT). International Journal of Scientific Research in Science, Engineering and Technology (IJSRSET). 2019;1(1):1–6.
4. McClintock D, Cunningham L, Petropoulos T. Motherboard testing using the PCI-bus. Proceedings International Test Conference (IEEE). 2000;1(1):1–5.
5. Du P, Yu Y, Gan E, Li B. Finite element modeling for computer motherboard modal analysis. IEEE International Conference on Mechatronics & Automation. 2005;1(1):1–4.
6. Yu Y, Du P, Gan E. Structural robustness study of a computer motherboard. IEEE International Conference on Industrial Technology. 2006;1(1):1–5.
7. Yu L, Wang X, Liu H, Wang H. Study and implementation of a motherboard measurement system for DVD recorders based on virtual instrument technology. 9th International Conference on Electronic Measurement & Instruments (IEEE). 2009;1(1):1–6.
8. Altıntaş M, Arslan S. The study of dust removal using electrostatic cleaning system for solar panels. Renewable Energy Conference Proceedings. 2019;1(1):1–7.
9. Khalil K, Eldash O, Kumar A, Bayoumi M. Machine learning-based approach for hardware faults prediction. IEEE Transactions on Circuits and Systems I: Regular Papers. 2020;67(11):3814–3825.
10. Nowroz AN, Woods G, Reda S. Power mapping of integrated circuits using AC-based thermography. IEEE Transactions on Very Large-Scale Integration (VLSI) Systems. 2013;21(8):1486–1494.
11. Bruno P, Calimeri F. Using heatmaps for deep learning-based disease classification. IEEE Conference on Computational Intelligence in Bioinformatics and Computational Biology (CIBCB). 2019;1(1):1–5.
12. Lin W, Chu H, Wu J, Sheng B, Chen Z. A heat-map-based algorithm for recognizing group activities in videos. IEEE Transactions on Circuits and Systems for Video Technology. 2013;23(9):1499–1512.
13. Viton F, Dequen G, Guérin JL, Elbattah M. Heatmaps for visual explainability of CNN-based predictions for multivariate time series with application to healthcare. IEEE International Conference on Healthcare Informatics (ICHI). 2020;1(1):1–6.
14. Klemme F, Amrouch H. Machine learning for circuit aging estimation under workload dependency. IEEE International Test Conference (ITC). 2021;1(1):1–7.
15. Jagtap SV, Rao YS. GPU accelerated circuit analysis using machine learning-based parallel computing model. Springer Nature Switzerland AG. 2020;1(1):1–8.
16. Sabri N, Mukim M, Ibrahim Z, Hasan N, Ibrahim S. Computer motherboard component recognition using texture and shape features. 9th IEEE Control and System Graduate Research Colloquium (ICSGRC). 2018;1(1):1–4.