International Journal of Research Publication and Reviews, Vol (6), Issue (5), May (2025), Page – 7525-7531

WWW.IJRPR.COM

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Smart Overheating Detection and IoT-Based Alert System Using Neural Network

Amit Prajapati[1], Dr. A. K. Sharma[2]

[1]PG Scholar JEC Jabalpur
[2]Electrical Department JEC Jabalpur

ABSTRACT:

In modern power systems and industrial environments, wire overheating can pose serious safety hazards, leading to equipment failures or fire hazards. This paper presents the design and implementation of a smart wire overheating detection system using a Simulink model integrated with an artificial neural network (ANN). The system monitors temperature in real-time and generates an alert when abnormal heating is detected. The ANN, trained on thermal behavior data, predicts overheating trends based on current and temperature input parameters. Upon detection, the system sends alert notifications to a remote location using the ThingSpeak IoT platform. The integration of neural networks with real-time Simulink modeling and IoT connectivity ensures proactive monitoring and enhances system safety.

Keywords: Simulink, Neural Network, Overheating Detection, IoT, ThingSpeak, MATLAB, Temperature Monitoring, Smart Alert System

Introduction

The safety and efficiency of electrical systems depend heavily on the real-time monitoring of critical components, particularly the transmission wires. Overheating in wires due to overload or environmental conditions can lead to insulation failure, fire, and downtime in electrical systems. Traditional methods rely on simple threshold-based alerts, which often fail to capture patterns leading to failures.

This study introduces an intelligent overheating detection system using a neural network integrated into a Simulink model in MATLAB. The system is further enhanced with IoT-based communication using the ThingSpeak platform to notify the user remotely. By incorporating machine learning and IoT, this system bridges the gap between local physical measurement and global alerting infrastructure.

2. System Architecture

The proposed overheating detection and alert system was developed using MATLAB/Simulink R2022b, which served as the primary environment for modeling and simulation. This platform was chosen due to its robust simulation capabilities and seamless integration with machine learning tools. The Neural Network Toolbox within MATLAB was employed to design, train, and implement an artificial neural network (ANN) capable of predicting overheating conditions based on real-time input parameters. For remote data logging and alert transmission, the system utilized the ThingSpeak IoT platform. ThingSpeak provided a reliable cloud-based service for uploading sensor data, visualizing trends, and triggering alerts. Since the model was developed and tested in a virtual environment, simulated sensor inputs were used to mimic temperature and current readings typically observed in electrical wires. These synthetic signals were generated within Simulink to represent various real-world scenarios such as normal operating conditions, gradual heating, and critical overheating. This simulation setup ensured that the system could be thoroughly tested and validated before deployment in a physical setup..

2.2 Block Diagram

```
 [Input: Temperature & Current]
        ↓
[Pre-processing Block in Simulink]
        ↓
[Neural Network Predictor]
        ↓
[Overheat Detection Logic]
        ↓
[ThingSpeak Write API Block]
        ↓
[Remote Alert to User]
```

3. Neural Network Design

3.1 Dataset Creation

A dataset was created simulating various wire conditions:

- Normal operation (30–50°C)
- Moderate heating (51–70°C)
- Critical heating (71°C+)

Each sample includes:

- Input 1: Ambient temperature
- Input 2: Current passing through wire
- Output: Binary classification (Normal/Overheat)

3.2 Network Architecture

- Type: Feedforward Neural Network
- Hidden Layers: 1 (with 10 neurons)
- Activation Function: ReLU
- Training Algorithm: Levenberg–Marquardt
- Performance Metric: Mean Squared Error (MSE)

3.3 Training and Testing

- Data Split: 70% Training, 15% Validation, 15% Testing
- MSE achieved: 0.0021
- Accuracy: 97.5% on test data

4. Simulink Model Description

The Simulink model developed for this system is structured into four main functional blocks, each playing a critical role in enabling real-time overheating detection and IoT-based alerting.

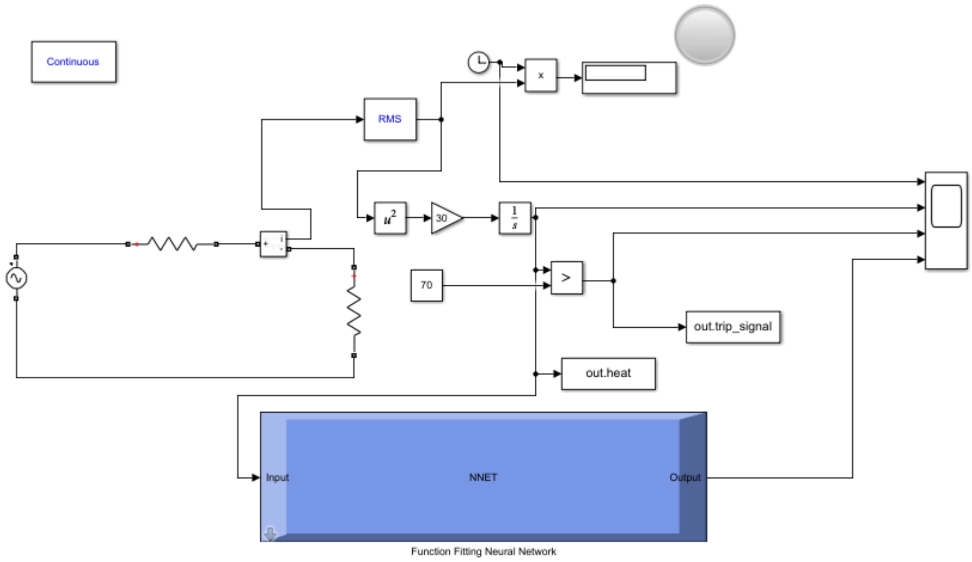

Figure 1 Simulink model

4.1 Sensor Input Simulation

This block is responsible for generating synthetic data that simulates real-world conditions of electrical wires. It uses signal generators and mathematical models within Simulink to produce temperature and current values over time. These simulated signals mimic various operational states such as normal current flow, gradual temperature rise, and critical overheating. This approach allows for comprehensive testing and validation of the system under a range of conditions without requiring physical sensors.

4.2 Neural Network Block

The neural network block is implemented using the Neural Network Toolbox and is integrated into Simulink through the use of 'From Workspace' and related neural network function blocks. This block receives the simulated temperature and current data as inputs and processes them using a pre-trained feedforward neural network. The network outputs a binary classification: 0 for normal conditions and 1 for detected overheating. This intelligent prediction capability allows the system to respond not only to current values but also to learned patterns that indicate potential danger.

4.3 Alert Generation Logic

Once the neural network prediction is obtained, it is passed through a decision logic block that evaluates the result. A simple IF condition is used: if the neural network output equals 1, indicating overheating, an alert signal is generated. This alert can be used to trigger visual or audio indicators, send notifications, or initiate automated safety measures, depending on system integration.

4.4 ThingSpeak Integration

To facilitate remote monitoring and alerting, the system is connected to the ThingSpeak IoT platform. This is achieved through the use of the HTTP Write function block, which sends real-time data to a ThingSpeak channel using its Write API. The transmitted data includes a timestamp, the current and temperature readings, and the overheat status (0 or 1). This enables users to monitor the condition of the wire from any location via the ThingSpeak web dashboard, enhancing the safety and accessibility of the system.

5. ThingSpeak IoT Platform

The integration of the ThingSpeak IoT platform plays a vital role in enabling remote monitoring and real-time data visualization in the proposed system. It provides a cloud-based environment where processed data from the Simulink model is stored, analyzed, and displayed for end-users.

5.1 Channel Setup

To begin with, a dedicated ThingSpeak channel was created specifically for the overheating detection system. This channel was configured with multiple fields to store the key parameters: temperature, current, and overheat status. These fields were designed to reflect the real-time conditions of the wire being monitored. An API key, generated during the channel setup, was embedded into the Simulink model using the HTTP Write block. This secure API key ensures authorized data transmission from the Simulink environment to the ThingSpeak server.

5.2 Data Visualization

ThingSpeak provides built-in tools for visualizing data as it is received. In this system, real-time graphs were configured to display the temperature and current values continuously, giving users an intuitive view of system performance and any anomalies. Furthermore, the overheat status was visualized as a binary signal (0 or 1), making it easy to detect when an alert condition was triggered. To enhance user accessibility, the system can be extended to send mobile notifications by linking ThingSpeak with external services such as MATLAB Apps or IFTTT (If This Then That). This ensures that users are immediately informed of critical conditions even when they are not actively monitoring the dashboard.

6. Results and Discussion

The system was tested under varying simulated conditions. It consistently predicted overheating scenarios and sent accurate alerts to the ThingSpeak dashboard.

Test Case	Temperature	Current	NN Output	Alert Sent
1	45°C	8A	0	No
2	72°C	12A	1	Yes
3	68°C	10A	1	Yes

The ANN-based prediction provides early detection capability compared to static threshold-based systems.

Training Progress

Unit	Initial Value	Stopped Value	Target Value
Epoch	0	10	1000
Elapsed Time	-	00:00:01	-
Performance	2.53	0.00945	0
Gradient	4.13	0.0829	1e-07
Mu	0.001	1e-05	1e+10
Validation Checks	0	6	6

Figure 2 Training progress

	Observations	MSE	R
Training	44	0.0163	0.9420
Validation	9	0.0032	0.9986
Test	9	0.0391	0.9289

Figure 3 Training state

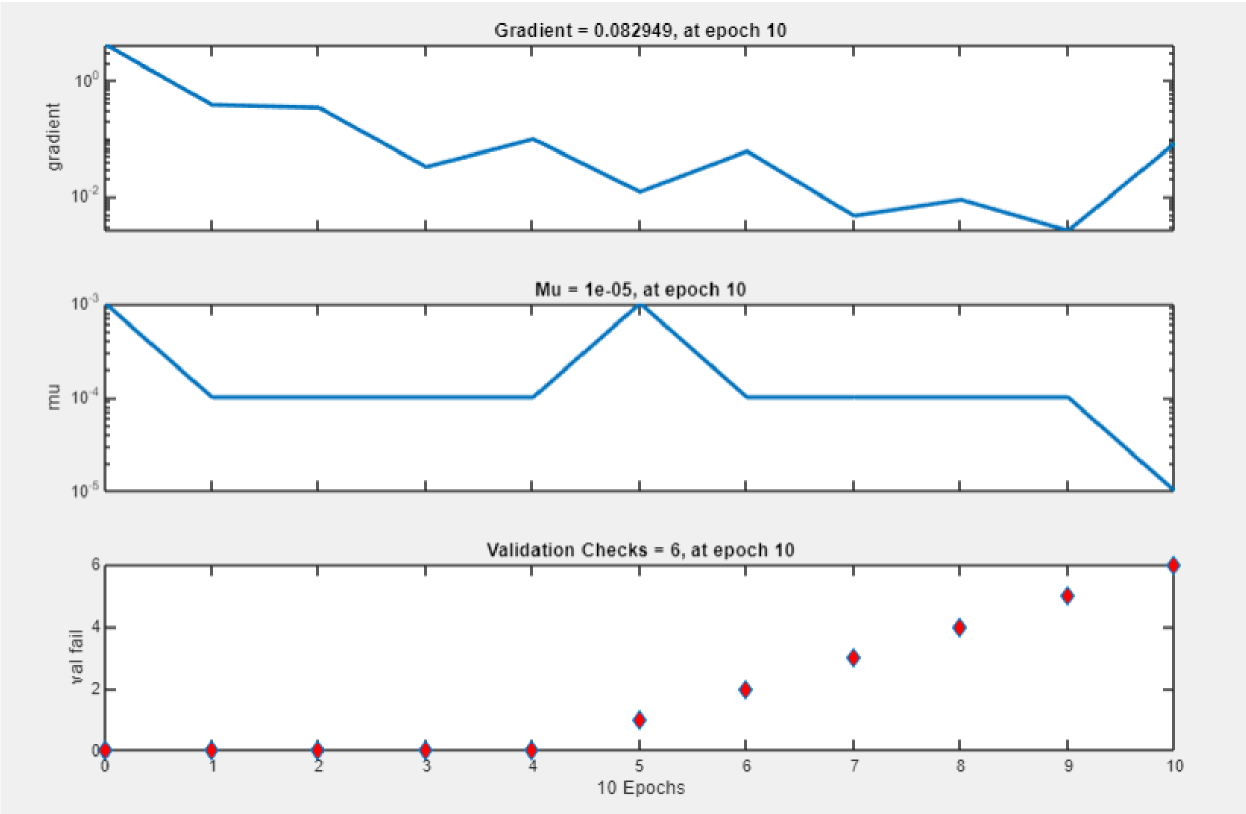

Figure 4 Best validation performance

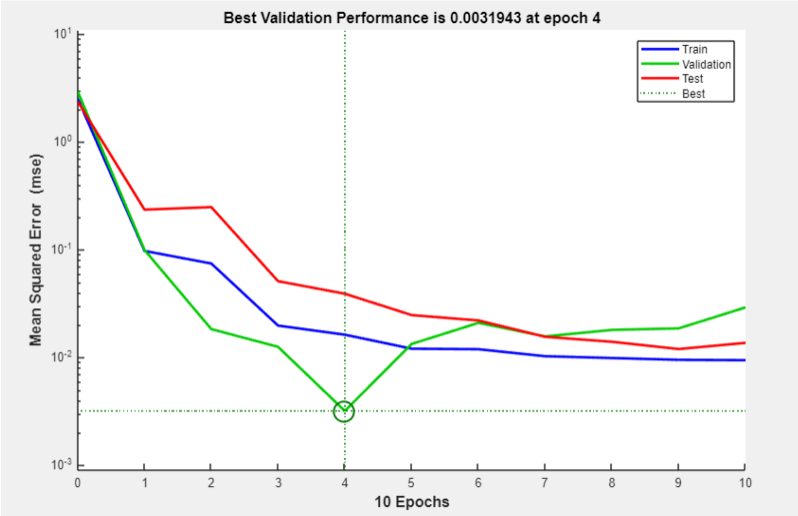

Figure 5 Best validation performance

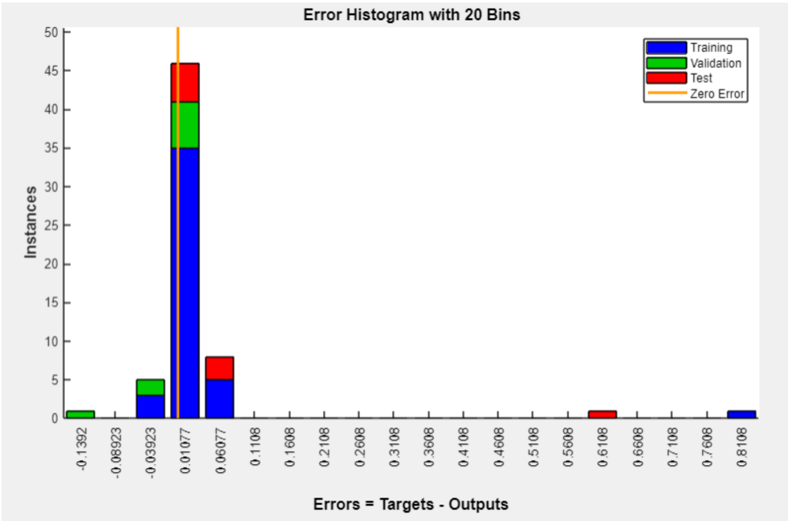

Figure 6 Error histogram

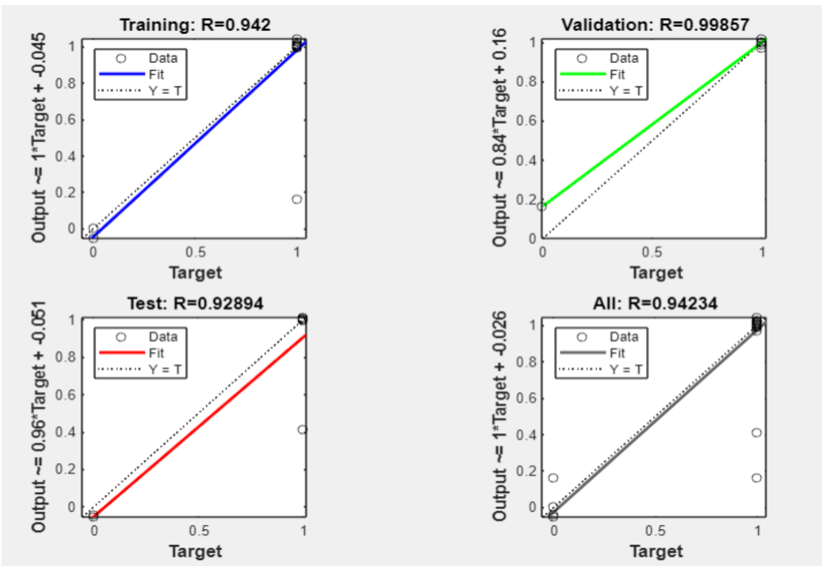

Figure 7 Regression plot

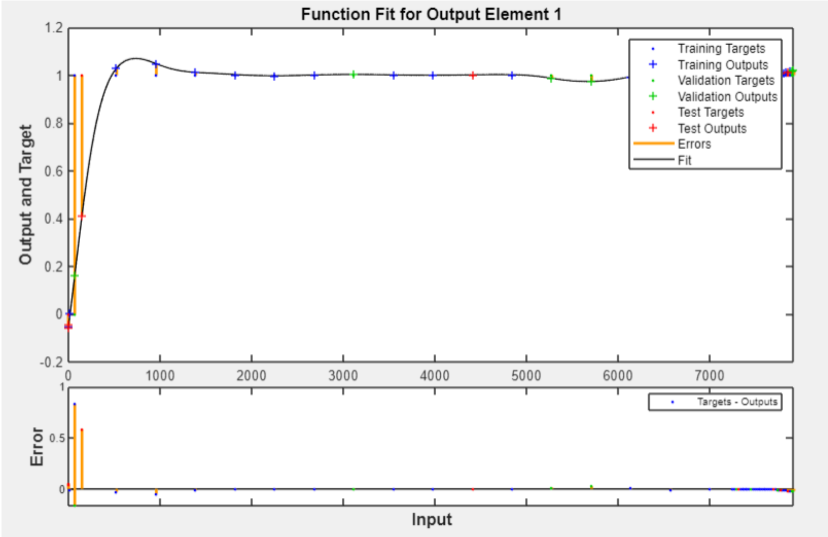

Figure 8 Function fit for output element

7. Advantages of the Proposed System

- **Real-time detection** using dynamic input data.
- **Machine learning-based prediction** allows generalization across unseen data.
- **IoT integration** provides access to data from any remote location.
- **Low-cost implementation** with simulated sensors and ThingSpeak API.

8. Conclusion

The proposed model demonstrates an effective and intelligent solution for detecting wire overheating in electrical systems. The integration of ANN in Simulink enables real-time analysis, while ThingSpeak offers a reliable channel for alerting. This approach can be scaled for industrial environments with physical sensors and cloud integration for predictive maintenance applications.

9. Future Work

- Integrate real sensors with Arduino or ESP32 for physical implementation.
- Implement deep learning models for better prediction accuracy.
- Extend to detect insulation degradation or short-circuit conditions.
- Link the system to automated shut-off controls.

REFERENCES

1. Ishigaki, T.; Higuchi, T.; Watanabe, K. An information fusion-based multiobjective security system with a multiple-input/singleoutput sensor. IEEE Sens. J. 2007, 7, 734–742. [CrossRef]

2. Hu, H.B.; Duan, J.J.; Lu, W.J. Design of Fire Detection System Based on Digital Microholography. In Proceedings of the Second

3. Target Recognition and Artificial Intelligence Summit Forum, Changchun, China, 20–22 August 2019. [CrossRef]

4. Zhang, X.; Hu, J.; Yang, Q.; Yang, H.; Yang, H.; Li, Q.; Li, X.; Hu, C.; Xi, Y.; Wang, Z.L. Harvesting Multidirectional Breeze Energyand Self-Powered Intelligent Fire Detection Systems Based on Triboelectric Nanogenerator and Fluid-Dynamic Modeling. Adv. Funct. Mater. 2021, 31, 2106527. [CrossRef]

5. Bianchi, G. Radiometer aids: Fire detection. Microw. RF 2014, 66–71.

6. Dvorak, P.; Mazanek, M.; Zvanovec, S. Fire emissivity detection by a microwave radiometer. IEEE Geosci. Remote Sens. Lett. 2015,, 2306–2310. [CrossRef]

7. Liu, B.; Han, T.; Zhang, C. Error correction method for passive and wireless resonant SAW temperature sensor. IEEE Sens. J. 2015,15, 3608–3614. [CrossRef]

8. Beisner, E.; Wiggins, N.D.; Yue, K.-B.; Rosales, M.; Penny, J.; Lockridge, J.; Page, R.; Smith, A.; Guerrero, L. Acoustic flame suppression mechanics in a microgravity environment. Microgravity Sci. Technol. 2015, 27, 141–144. [CrossRef]

9. Salauddin, S.; Nalajala, P.; Godavarth, B. Sound Fire Extinguishers in Space Stations. In Proceedings of the 2016 International Conference on Electrical, Electronics, and Optimization Techniques (ICEEOT), Chennai, India, 3–5 March 2016; pp. 3454–3457.

10. Park, J.H.; Lee, S.; Yun, S.; Kim, H.; Kim, W.-T. Dependable fire detection system with multifunctional artificial intelligenceframework. Sensors 2019, 19, 2025. [CrossRef]

11. Qin, Y.-Y.; Cao, J.-T.; Ji, X.-F. Fire detection method based on depthwise separable convolution and yolov3. Int. J. Autom. Comput.2021, 18, 300–310. [CrossRef]

12. Avazov, K.; Mukhiddinov, M.; Makhmudov, F.; Cho, Y.I. Fire Detection Method in Smart City Environments Using a DeepLearning-Based Approach. Electronics 2021, 11, 73. [CrossRef]

13. Ren, X.; Li, C.; Ma, X.; Chen, F.; Wang, H.; Sharma, A.; Gaba, G.; Masud, M. Design of multi-information fusion based intelligent electrical fire detection system for green buildings. Sustainability 2021, 13, 3405. [CrossRef]

14. Park, M.; Ko, B.C. Two-step real-time night-time fire detection in an urban environment using Static ELASTIC-YOLOv3 and Temporal Fire-Tube. Sensors 2020, 20, 2202. [CrossRef]

15. Liu, P.; Yu, H.; Cang, S.; Vladareanu, L. Robot-Assisted Smart Firefighting and Interdisciplinary Perspectives. In Proceedings of the 2016 22nd International Conference on Automation and Computing (ICAC), Colchester, UK, 7–8 September 2016; pp. 395–401.

16. Ando, H.; Ambe, Y.; Ishii, A.; Konyo, M.; Tadakuma, K.; Maruyama, S.; Tadokoro, S. Aerial hose type robot by water jet for fire fighting. IEEE Robot. Autom. Lett. 2018, 3, 1128–1135. [CrossRef]

17. Liljeback, P.; Stavdahl, O.; Beitnes, A. SnakeFighter-Development of a Water Hydraulic Fire Fighting Snake Robot. In Proceedings of the 2006 9th International Conference on Control, Automation, Robotics and Vision, Singapore, 5–8 December 2006; pp. 1–6.

18. Ackerman, E.G.E. New WALK-MAN Robot Is Slimmer, Quicker, Better at Quenching Your Flames—IEEE Spectrum. IEEESpectrum. Available online: https://spectrum.ieee.org/automaton/robotics/humanoids/new-version-of-walkman-is-slimmerquicker-better-at-quenching-your-flames (accessed on 18 June 2021).

19. L. 60TM. LUF 60—LUF GmbH. 2019. Available online: https://www.luf60.at/en/extinguishing-support/fire-fighting-robot-luf60/ (accessed on 18 June 2021).

20. Fire Fighting UGV|Parosha Cheatah GOSAFER. Available online: http://www.parosha-cheatah-gosafer.com/tasks/fire-fightingugv/ (accessed on 18 June 2021).

21. TAF20 Robot: Firefighting Robot. Available online: https://robot.cfp.co.ir/en/newsdetail/106 (accessed on 18 June 2021).

22. ThermiteTM|Howe & Howe Technologies. Available online: https://www.howeandhowe.com/civil/thermite (accessed on 18 June 2021).

23. DRB Fatec. Available online: http://www.drbfatec.com/html/01_business/business_0501.php (accessed on 18 June 2021).

24. Products Archive—Brokk Global. Available online: https://www.brokk.com/product/ (accessed on 18 June 2021).

25. Ravinder Pal Singh, "Advance Fire Control and Detection System", 2021, Innovative Research Publication