# A NEW FUZZY GRANULAR TECHNIQUE FOR THE CONDITION MONITORING OF ELECTRICAL HOTSPOTS BASED ON INFRARED THERMOGRAPHY

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## PRODUCT BACKGROUND

- In Malaysia, more than 46% of the total causes of fires in buildings are because of the failure of electrical distribution (Ref: http://www.bomba.gov.my)
- Infrared thermography technology is currently being used in various applications, including fault diagnosis in electrical equipment.
- Thermal abnormalities are diagnosed by identifying and classifying the hotspot conditions of electrical components.
- The proposed intelligent system is applied to automatically realize and formulate the conditions of the thermal abnormalities. On the basis of the priority level, the hotspot conditions are categorized as normal, warning, and critical.

## APPLICATION/ BENEFITS

**INTELLIGENT DEFECT ANALYSIS TOOL**

→ It outperforms the existing intelligent methods !
→ Thus, allowing predictive and preventive diagnosis to maintain the reliable and uninterrupted operation of the power system.

| Recommended class | Classifier | Classification accuracy (%) |
|---|---|---|
| Defect and Normal (No. of rules = 2) | Proposed Method | 92.3 |
| | ANFIS | 87.9 |
| | SVM | 88.1 |
| | MLP with LM | 73.2 |
| | kNN (k = 3) | 88.1 |
| | kNN (k = 5) | 86.5 |
| | kNN (k = 7) | 88.9 |
| | kNN (k = 9) | 87.3 |
| Critical, warning and normal (No. of rules = 4) | Proposed Method | 80.0 |
| | ANFIS | 62.7 |
| | SVM | N/A* |
| | MLP with LM | 64.4 |
| | kNN (k = 3) | 64.8 |
| | kNN (k = 5) | 66.4 |
| | kNN (k = 7) | 66.4 |
| | kNN (k = 9) | 64.8 |

*Function *svmtrain()* for SVM does not support more than two classes.

## PATENT

PATENT FILLING STATUS:
Invention disclosure submitted on 20 March 2018

## COLLABORATION

Invitation letter shows their interest for potential commercialization of this invention.
Name: Techno Plast Consultancy, Dhaka, Bangladesh

## MARKETABILITY

This technique for the direct monitoring of actual operating conditions. Potential ~
1) Industries related to the electrical and electronics business, for example, member of TEEAM or Tenaga Nasional.

2) Industry and Home: Reduction of energy loss.

3) Home Electrical Equipment: Prevent from the gross overloads, excessive thermal insulation, stray currents, ground faults, and overvoltage.
4) Industry and Home: Reduced maintenance cost.

## PUBLICATIONS


1. Md. Manjur Ahmed et al. (2015). Recursive construction of output-context fuzzy systems for the condition monitoring of electrical hotspots based on infrared thermography. Engineering Applications of Artificial Intelligence (Q1 in Computer Science Area).
2. Md. Manjur Ahmed and Nor Ashidi Mat Isa (2017). Knowledge Base to Fuzzy Information Granule: A Review from the Interpretability-Accuracy Perspective. Applied Soft Computing (Q1 Journal in Computer Science Area).
3. Md. Manjur Ahmed and Nor Ashidi Mat Isa (2015). Evolving output-context fuzzy system for effective rule base. Expert Systems with Applications (Q1 in Computer Science Area).


## ACHIEVEMENTS

- **GOLD MEDAL,** CREATION, INNOVATION, TECHNOLOGY & RESEARCH EXPOSITION, 2018, UMP
- **KEYNOTE SPEAKER**, KHULNA UNIVERSITY OF ENGINEERING AND TECHNOLOGY (KUET), BANGLADESH, 7th FEBRUARY 2017
- **SANGGAR SANJUNG AWARD 2015 (**JOURNAL PUBLICATION**)**, UNIVERSITI SAINS MALAYSIA (USM), MALAYSIA**.** AWARDED ON 2017

## SIGNIFICANCE OF THE PROPOSED SELF-ADAPTIVE FUZZY GRANULAR ALGORITHM

**1)** It automatically observes the prominent distinction point on the output domain using the following equations:

$$\sigma_{init}^{t} = \sigma_{init}^{t-1} - \sigma_{evolve}\ ,\ \&\ \mathrm{BNR_t} = \frac{(\mathrm{NR_t} - \mathrm{NR_{t-1}})^2}{\mathrm{NR_t}}$$

Here, $\sigma_{init}^{t}$ is the self-adaptive evolving parameter, $\sigma_{evolve}$ is taken arbitrarily and BNR index indicating the balanced number of rules.
**2)** The evolving is fully online, does not follow a predefined threshold.
**3)** It uses BNR index to identify the overfitting situation and thus termination occur.

## THERMOGRAPHIC DIAGNOSTIC OF ELECTRICAL COMPONENTS

### 1) Hotspot detection

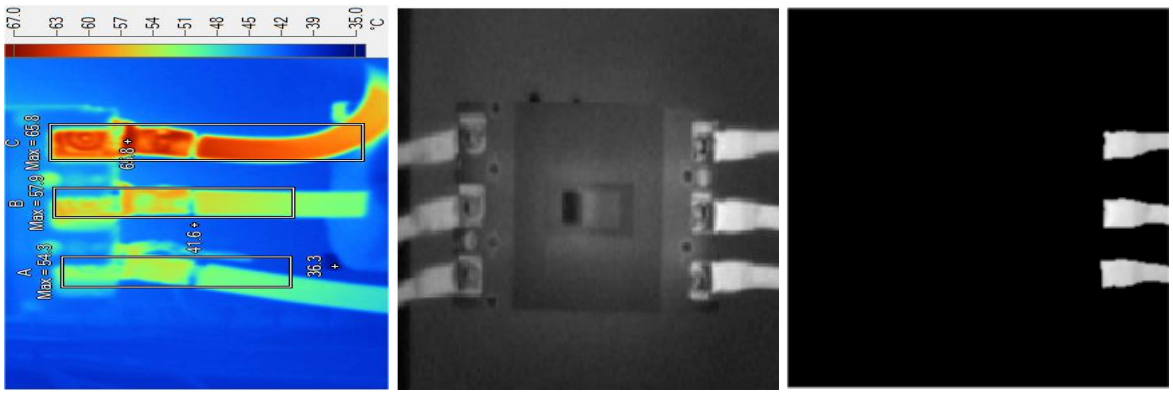


Figure 1: Typical load imbalance problem: (a) thermal image that is showing three different conditions, (b) grayscale image, (c) segmented image.

### 2) Automatic feature extraction

A total of six intensity features were computed by using the pixel intensity. The features are maximum intensity, minimum intensity, average intensity, median intensity, standard deviation, and variance of intensity values.

### 3) Condition monitoring of hotspots: proposed fuzzy granular approach

Table 1: Evolving process of the proposed fuzzy granular system to obtain an effective rulebase. Here, $\sigma_{init}^{t}$ is the self-adaptive evolving parameter.

| $\sigma_{init}^{t}$ | No. of rules | Training error in RMSE | BNR | $\sigma_{init}^{t}$ | No. of rules | Training error in RMSE | BNR |
|---|---|---|---|---|---|---|---|
| **7.5** | 1 | 18.3974 | 0 | **4.5** | 2 | 4.3824 | 0 |
| **7.0** | 2 | 4.4896 | 0.5 | **4.0** | 2 | 4.3824 | 0 |
| **6.5** | 2 | 4.3824, minimum | 0 | **3.5** | 2 | 4.3824 | 0 |
| **6.0** | 2 | 4.3824 | 0 | **3.0** | 2 | 4.3824 | 0 |
| **5.5** | 2 | 4.3824 | 0 | **2.5** | 4 | 3.2737 | 1.0, termination |
| **5.0** | 2 | 4.3824 | 0 | | | | |

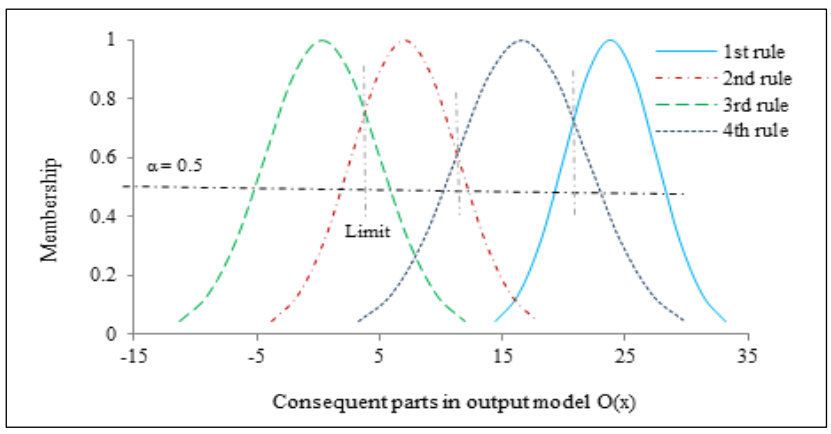


Figure 2: Four distinct points Δ(℃)={0.3, 7.1, 16.6, 23.8} as the center of consequent parts (or output contexts) shows the semantic interpretability.

| Class | $\Delta T$(℃) | Recommended actions |
|---|---|---|
| **Critical** | $\Delta T > 10.8$, Priority 1 | Major discrepancy; repair immediately |
| **Warning** | $3.8 < \Delta T \leq 10.8$, Priority 2 | Probable deficiency; repair as time permits |
| **Normal** | $\Delta T \leq 3.8$, Priority 3 | Minor overheating; warrants investigation |

Table 2: Classification of the electrical components conditions realized by the proposed intelligent system when the number of rules are 4 and $\sigma_{init}^{t} = 2.5$