Intelligent Battery Health Monitoring System

MATLAB EXPO
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Intelligent Battery Health Monitoring

- Agenda

1. Introduction
2. Problem Statement
3. Approach
4. Results
5. Conclusion

Intelligent Battery Health Monitoring

- Introduction

➢ As the electrical vehicle market is growing, research on battery management system has got more attention.

➢ SOH (state of health) of battery is most crucial factor which decides the driving mileage and also the replacement time of the battery

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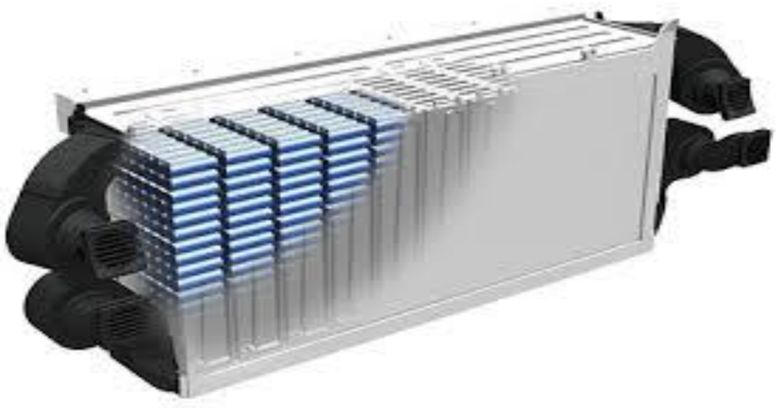
- Problem statement

➢ Battery failure can cause loss in operation, reduce the capacity and in in vehicle it can cause the fatal accident.

➢ To ensure that battery operate within design limits and storage life time, effective battery health monitoring is required.

➢ Monitoring evaluation can also provide the remaining charge information and warn when the limits exceeds.



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- Approach

➢ The proposed system will automatically predict the battery health based on the SOH calculated from battery time capacity.

➢ Multiscale entropy (MSE) and SOH are used as data input and target vector for learning algorithm.

➢ The neuro fuzzy classifier (ANFC), an adaptive network based system in which antecedent parameters are adapted with neural network, is used as a learning algorithm.

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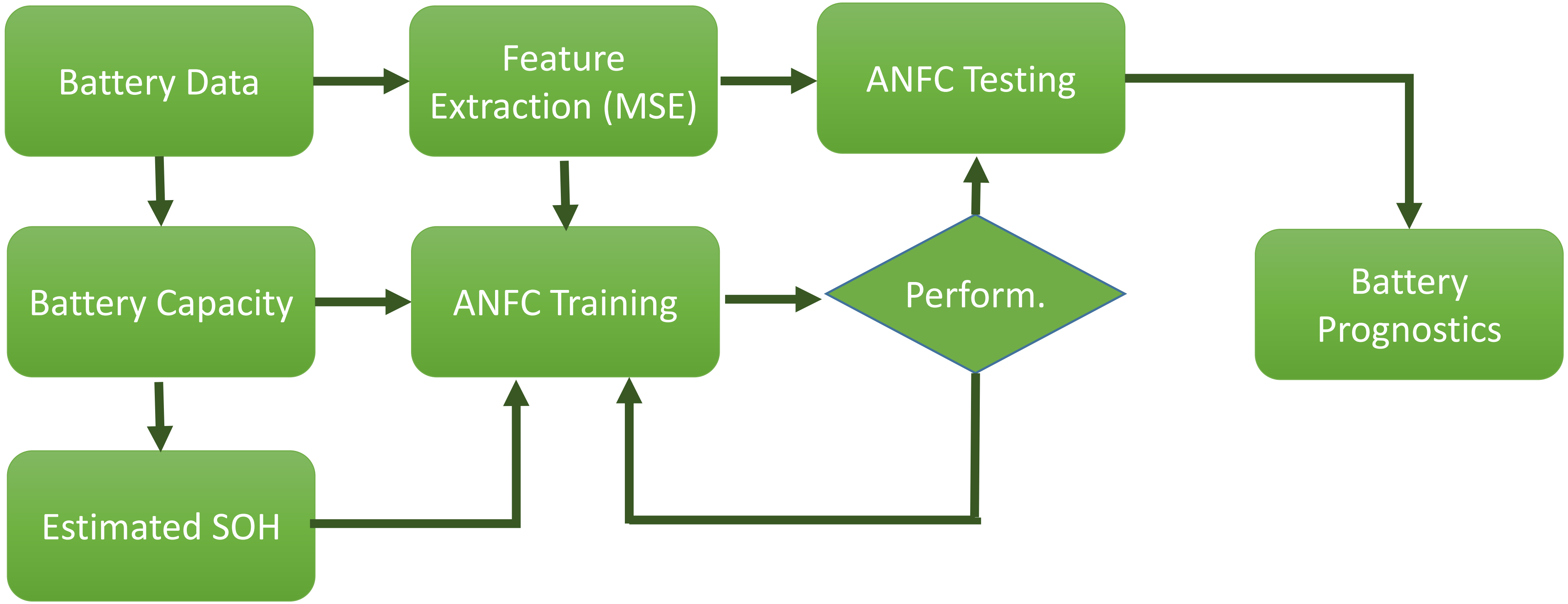
- Approach

➢



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- Experimental setup

- ➢ dataset provided by the data repository of NASA Ames Prognostic center of Excellence (PCoE) is used here for the validation of the proposed system.
- ➢ In the experiment Li-ion batteries go through three different profiles (charge, discharge and impedance) at room temperature.
- ➢ The charge and discharge cycle increase the aging of batteries. While the impedance measurement present the insight into the battery internal parameters that change as aging accelerate.
- ➢ The EOL (end of life criteria) is 30% fade in rated capacity (2Ahr to 1.4 Ahr) for these batteries.

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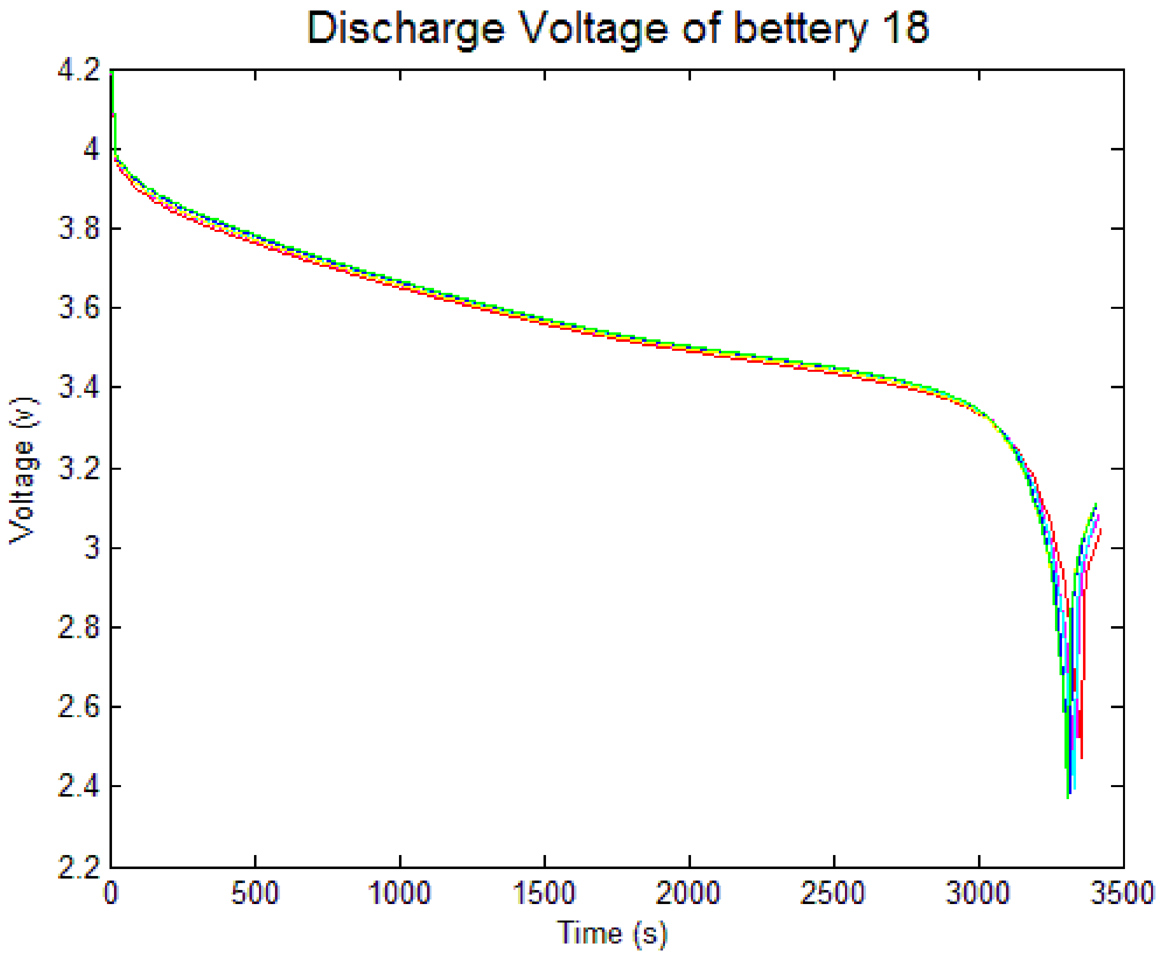
- Experimental setup



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- Experimental setup

➢ discharge voltage shows that cells will not have the same end of discharge at the same cycle index because of variation in depth of discharge and rest period.

➢ This ambiguity shall represent the actual usage

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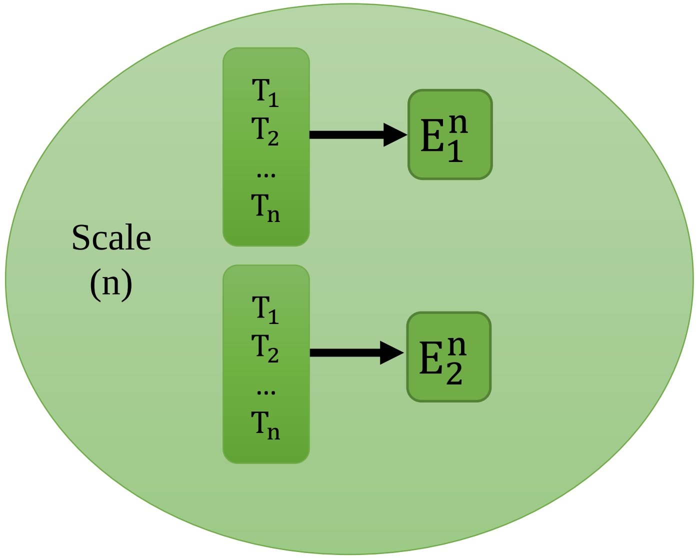
- Multiscale Entropy

➢ Multi scale entropy provides the way to measure complexity over the range of scale.

➢ MSE method incorporate two procedure

1. Construct coarse-grain series



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- Multiscale Entropy

1. Calculate sample Entropy

$$SE= -\ln\left[\frac{x^m(r)}{y^m(r)}\right]$$

Here $x^m(r)$ & $y^m(r)$ represent two sequence will match for m points and m+1 points

➢ MSE is implemented using the MATLAB.

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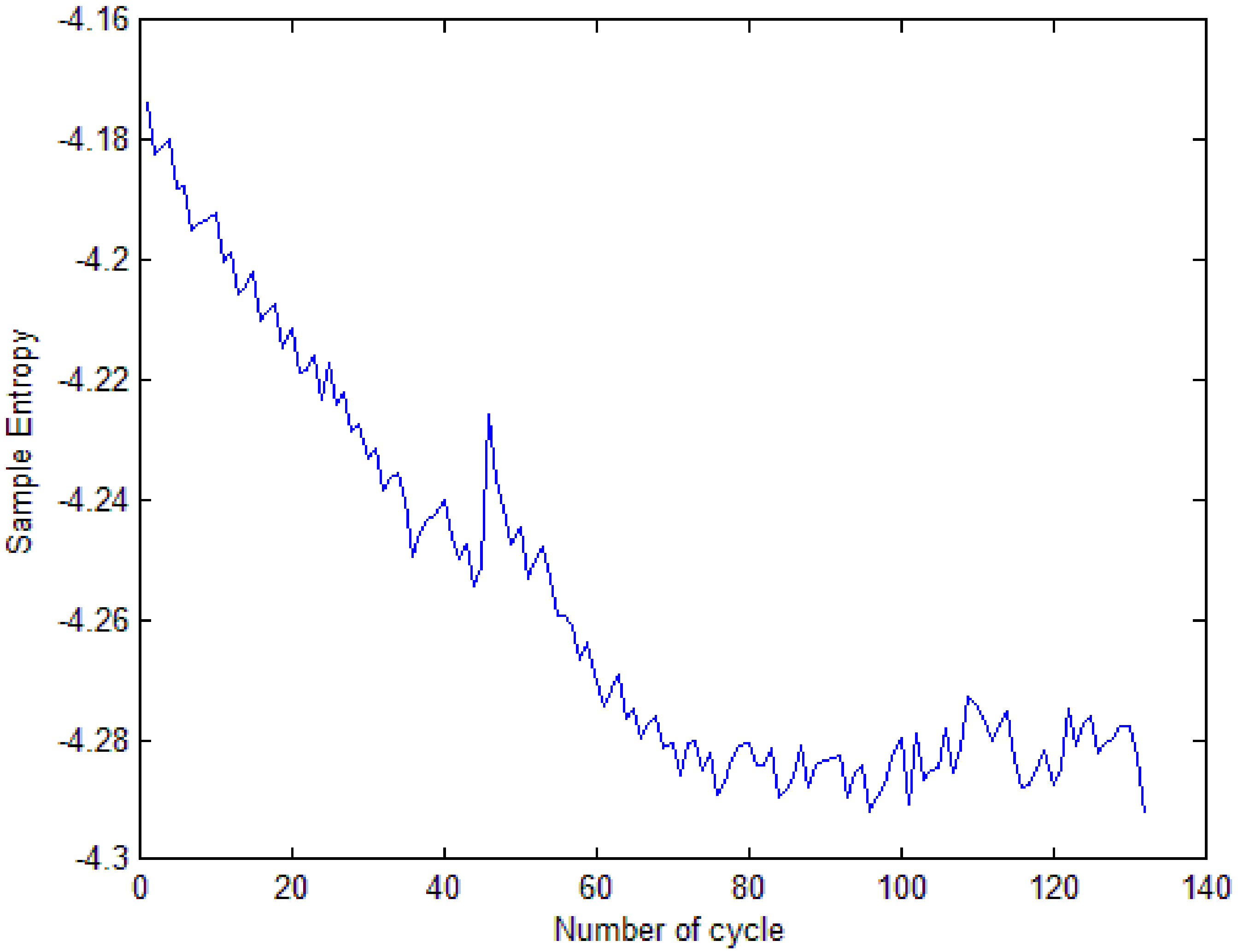

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- During the discharge process the sample entropy value reduce with increase in the cycle.
- This relation can indicate the battery degradation.
- At cycle number 46 sample entropy value is higher than the previous cycle, because of variant in depth of discharge in which voltage and rest period is high.

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- State of health (SOH) estimation

➢ SOH is calculated based on the capacity method, that is ratio between nominal capacity of the present time to the initial time.

➢ $$\mathrm{SOH} = \frac{\text{Capcity at present time}}{\text{Capacity at initial time}}$$

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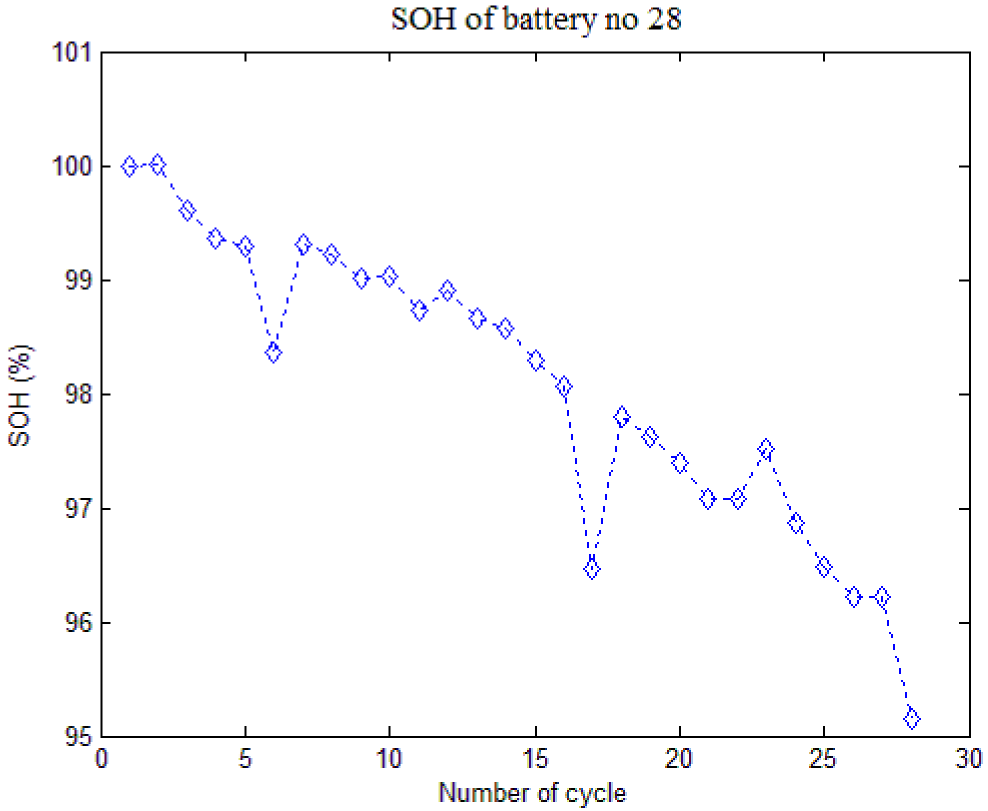
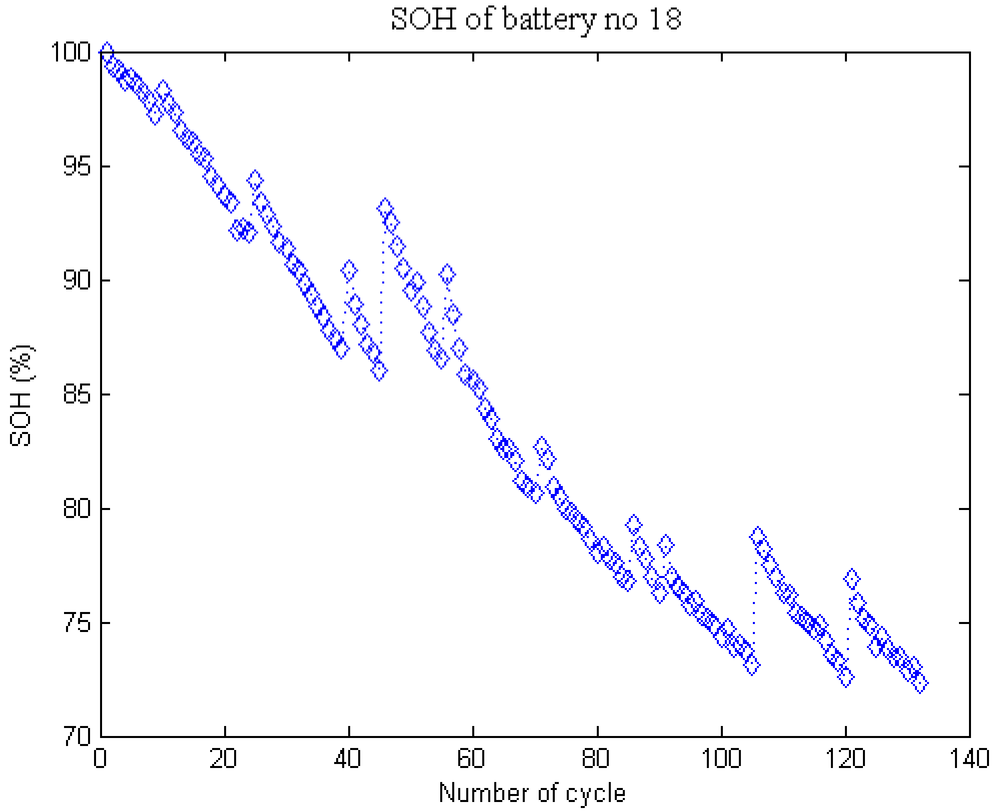
- State of health (SOH) estimation





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- Adaptive Neuro Fuzzy classifier

➢ It is the combined system with fuzzy system qualitative approach and artificial NN adaptive capabilities.

➢ The ANFC explicates a zero order surgeon fuzzy inference model in to the framework of a multilayer artificial neural network (ANN) with adaptive and non-adaptive nodes.

➢ MATLAB ANFIS toolbox is used to implement fuzzy inference system with scaled conjugate gradient algorithm.

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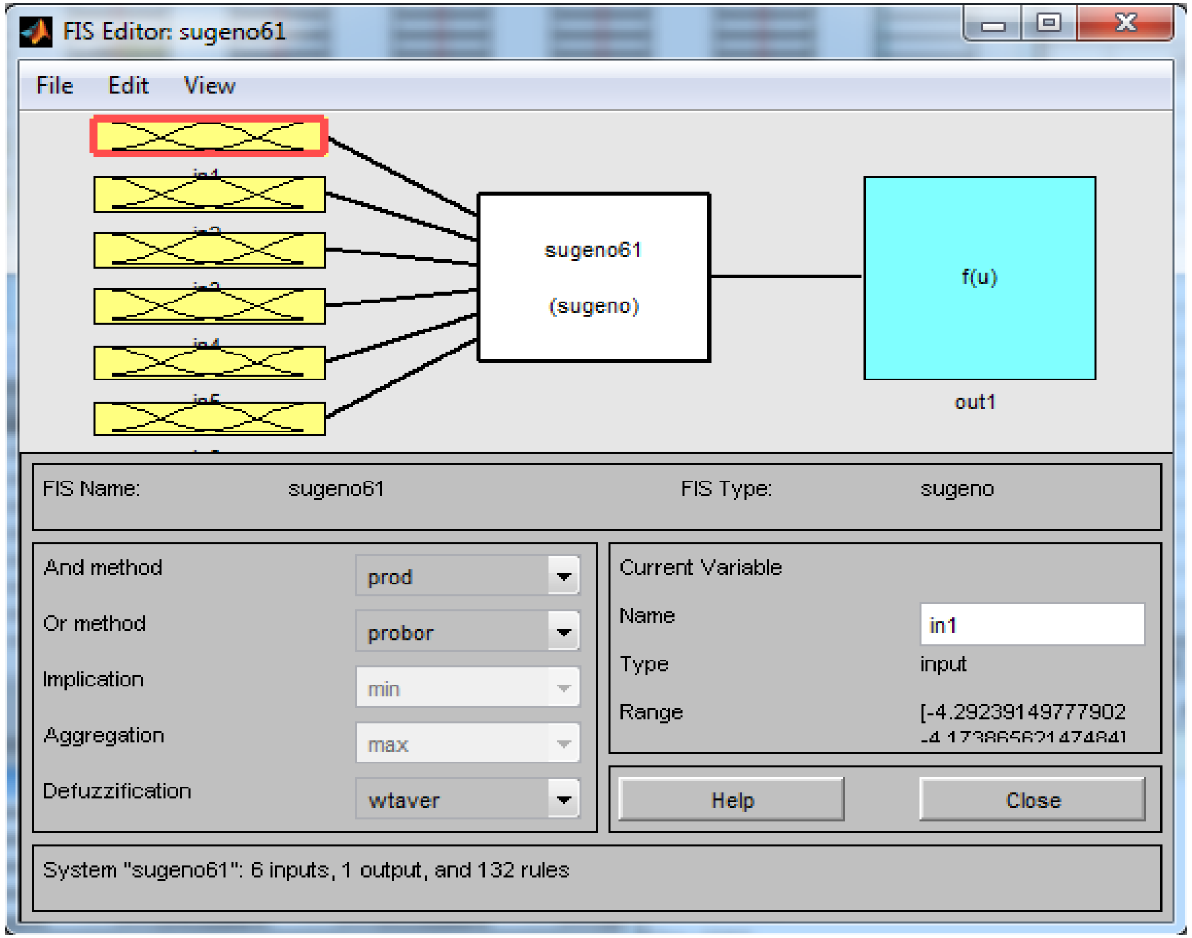
- MATLAB ANFIS toolbox



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- Results

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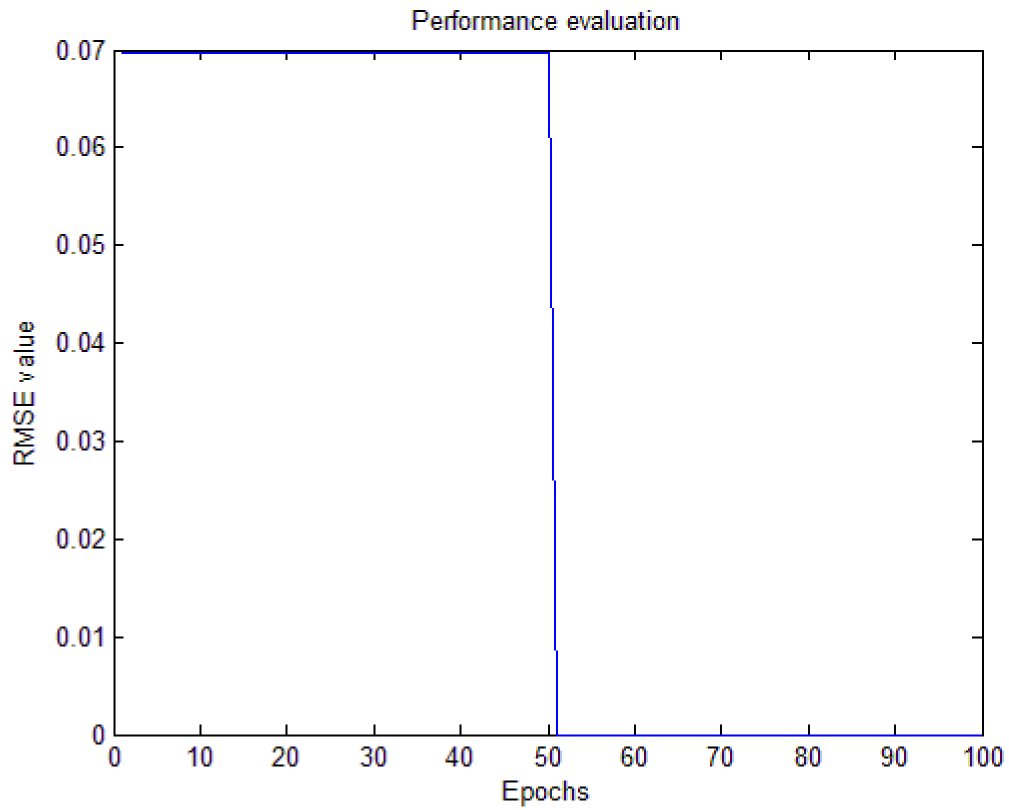

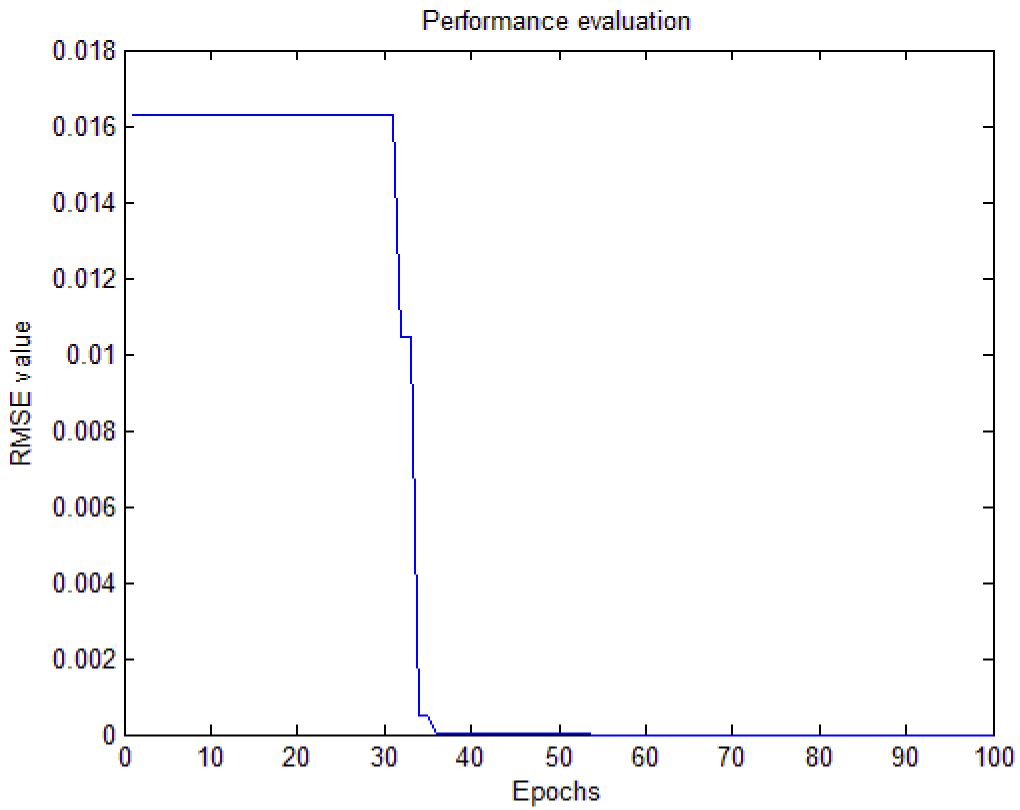

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- Results

➢ Accuracy prediction comparison for battery no. 28 and 18

Battery No	Performance measure	SVM*	RVM*	ANFC
28	RMSE	0.47	5.96*10-5	0.069
18	RMSE	1.43	0.54	4.93 *10-33

* A.Widodo et al. Intelligent prognostics for battery health monitoring based on sample entropy. 2011 (expert system with applications).

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- Results

➢ Accuracy prediction comparison for battery no. 28 and 18

Battery No	Performance measure	SVM*	RVM*	ANFC
28	Accuracy	>95%	95%	96%
18	Accuracy	>95%	>95%	100%

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- Conclusion

➢ MSE provides rich source of feature from the raw battery data, which has the relation with SOH of battery.

➢ Proposed system is applied successfully to use this relation to automatically predict the life of the battery.

➢ This system based on the MSE and ANFC method is plausible and can be used for Li-ion remaining battery life prediction.

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Thank You!!!