# Relay Protection Condition Assessment Based on Variable Weight Fuzzy Synthetic Evaluation

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# Introduction

## A method

Variable Weight Fuzzy Synthetic Evaluation (VWFSE)

It is used for relay protection condition assessment.

It is a improved method of fuzzy synthetic evaluation (FSE).

# Contents

# Methods

## Fuzzy Synthetic Evaluation

A considerable ambiguity and uncertainty relationship between the condition of relay protections and their assessment parameters.

Expert Assessment Model

Intelligent Technologies

Fuzzy Theory

# Fuzzy Synthetic Evaluation (FSE)

## FSE

- It is a common method for condition assessment and is getting more and more attention.
- FSE is designed to group raw data into several different categories according to membership functions.

## Deficiency

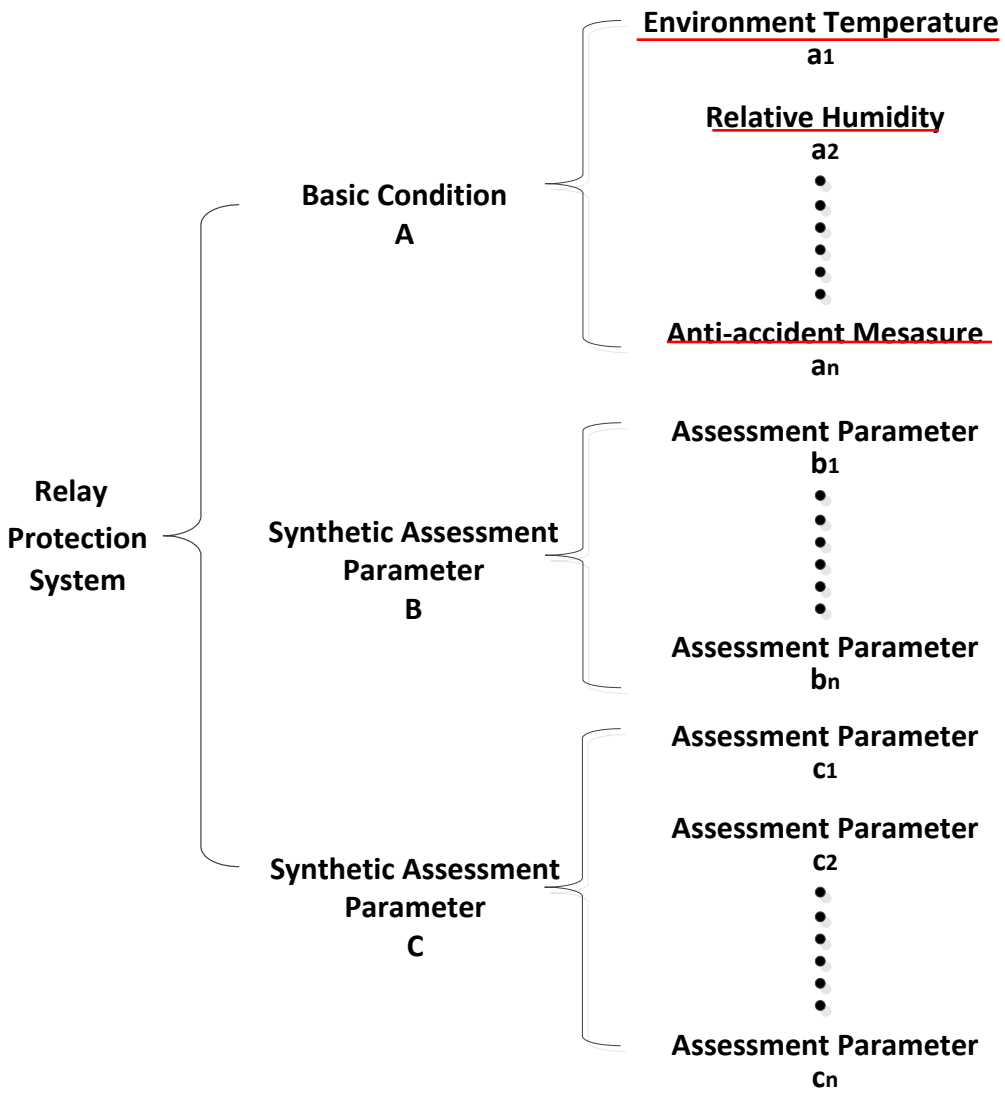
- The weights of assessment parameters are constant.
- The assessment result is not satisfied.

# Variable Weight Fuzzy Synthetic Evaluation (VWFSE)

## The Key Point of VWFSE

1. Build o… …valuation System
2. Membership …unction
3. Determining Weights
4. Fuzzy Judgment Result Vector

# VWFSE-Hierarchy Assessment Structure



## Fuzzy Distribution Method

Relative Humidity

| Normal Condition | Caution Condition | Abnormal Condition | Failure Condition |
|---|---|---|---|
| $\begin{cases} 1 & x \le 0.75 \\ \frac{0.95-x}{0.2} & 0.75 < x \le 0.95 \\ 0 & 0.95 < x \end{cases}$ | $\begin{cases} 0 & x \le 0 \\ \frac{x}{0.75} & 0 < x \le 0.75 \\ 1 & 0.75 < x \le 0.85 \\ \frac{0.95-x}{0.1} & 0.85 < x \le 0.95 \\ 0 & 0.95 < x \end{cases}$ | $\begin{cases} 0 & x \le 0 \\ \frac{x}{0.85} & 0 < x \le 0.85 \\ 1 & 0.85 < x \le 0.95 \\ \frac{1-x}{0.05} & 0.95 < x \le 1 \\ 0 & 1 < x \end{cases}$ | $\begin{cases} 0 & x \le 0.75 \\ \frac{x-0.75}{0.2} & 0.75 < x \le 0.95 \\ 1 & 0.95 < x \end{cases}$ |

trapezoid distribution

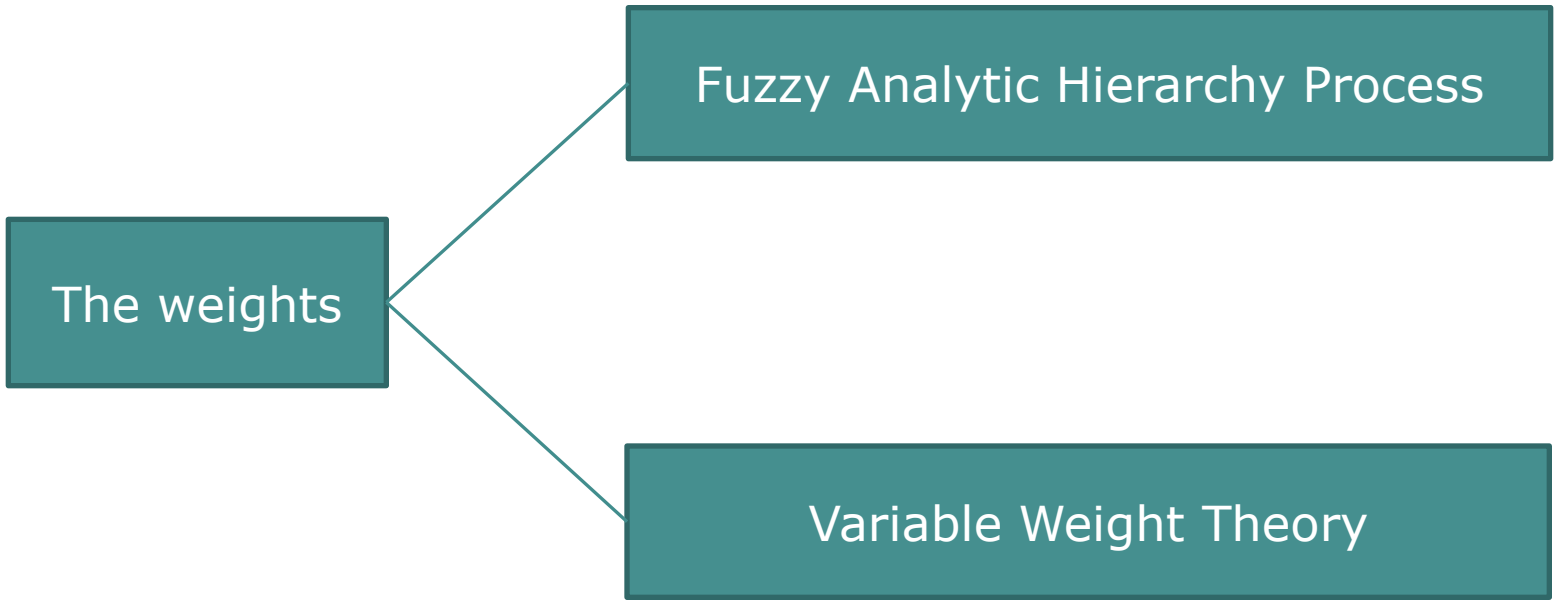
# VWFSE - Membership Function

Fuzzy relation matrixes $R_{n\times m}$

$$R_{n\times m} = \begin{bmatrix} r_{11} & \cdots & \cdots & r_{1m} \\ \vdots & \ddots & & \vdots \\ \vdots & & \ddots & \vdots \\ r_{n1} & \cdots & \cdots & r_{nm} \end{bmatrix}$$

where $r_{nm}$ is the value of membership function.

# VWFSE – Determining Weights



# VWFSE – Determining Weights

**Fuzzy Consistent Judgment Matrix**

$$J_{n\times n}=\begin{bmatrix} j_{11} & j_{12} & \cdots & j_{1n} \\ \vdots & \ddots & & \vdots \\ \vdots & & \ddots & \vdots \\ j_{nn} & \cdots & \cdots & j_{nn} \end{bmatrix}$$

**Constant Weights**

$$w_i=\frac{1}{n}-\frac{1}{2a}+\frac{1}{na}\sum_{k=1}^{n} j_{ik} \qquad a=\frac{(n-1)}{2} \qquad (1)$$

**Variable Weights**

$$X_i=\frac{C_a-C_i}{C_a-C_p} \qquad (2)$$

$$v_i=\frac{w_i}{x_i}\Big/\sum_{p=1}^{n}\frac{w_p}{x_p} \qquad (3)$$

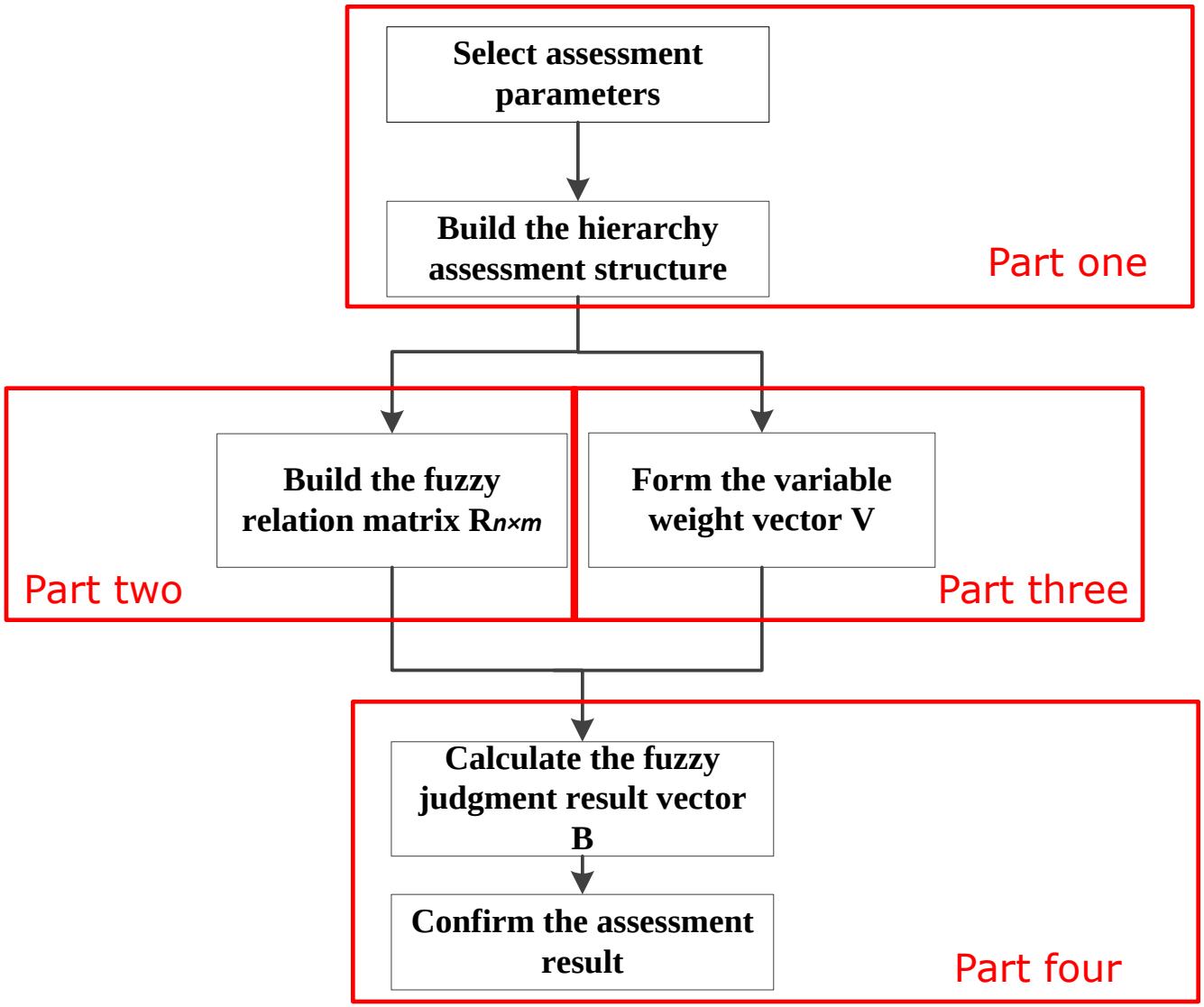
# VWFSE-Fuzzy Judgment Result Vector

$$B = V \circ R_{n \times m} \qquad (4)$$

where $\circ$ denotes the fuzzy operator.

Weighted averaging operator

# VWFSE - The Procedure



# Case Study

| Assessment parameters | | Value |
|---|---|---|
| Relay protection device | Environment Temperature | 42℃ |
| | Relative Humidity | 86% |
| | Familial Defects | Once and repaired |
| | Operating Life | 3 years |
| | Anti-accident Measure | All done |
| | Beyond Periodical Inspection Period | Half a year |
| | Software Fault Condition | 10 times |
| | Module Fault Condition | Twice |
| | Communication Equipment Fault Condition | Once |
| | Power Supply Operating Life | 3 years |
| Secondary circuit | Operating Environment | 59℃ |
| | Operation Box Familial Defects | Once and unrepaired |
| | Circuit Anti-accident Measure | All done |
| | Circuit Infrared Temperature | 13℃ beyond environment temperature |
| | Circuit Fault Condition | Twice |
| | Insulation Resistance | 0.9MΩ |
| | Corrosion | 5% |
| | Blocking | Twice in cable holes |
| Channel condition | The Value of Differential Current | 0.5 times smaller than normal range |
| | The error rate of Optical Fiber Channel | 0.5 times smaller than alarm value |
| | The interruption of Optical Fiber Channel | None |

# Case Study

## The Weights Comparison Table

| FSE | VWFSE |
|---|---|
| $W_{A1}=[0.14,0.16,0.26,0.12,0.22,0.1]$ | $V_{A1}=[0.147,0.502,0.136,0.071,0.092,0.05]$ |
| $W_{A2}=[0.267,0.4,0.2,0.133]$ | $V_{A2}=[1,0,0,0]$ |
| $W_{B1}=[0.158,0.358,0.292,0.192]$ | $V_{B1}=[0.195,0.467,0.19,0.147]$ |
| $W_{B2}=[0.342,0.308,0.208,0.142]$ | $V_{B2}=[0.142,0.719,0.052,0.088]$ |

# Case Study

## Fuzzy Relation Matrix Table

| FSE | VWFSE |
|---|---|
| $R_{A2}=\begin{bmatrix} 0 & 0 & 0 & 1 \\ 0.57 & 0.779 & 0.105 & 0 \\ 0.018 & 0.368 & 1 & 0.632 \\ 0.816 & 1 & 0.20369 & 0 \end{bmatrix}$ | $R'_{A2}=\begin{bmatrix} 0 & 0 & 0 & 1 \\ 0.57 & 0.779 & 0.105 & 0 \\ 0.018 & 0.368 & 1 & 0.632 \\ 0.816 & 1 & 0.20369 & 0 \end{bmatrix}$ |
| $R_{B1}=\begin{bmatrix} 0.209 & 1 & 0.822 & 0.088 \\ 0.287 & 1 & 0.007 & 0 \\ 1 & 0.449 & 0.086 & 0 \\ 1 & 0.8 & 0.3 & 0.071 \end{bmatrix}$ | $R'_{B1}=\begin{bmatrix} 0.209 & 1 & 0.822 & 0.088 \\ 0.287 & 1 & 0.007 & 0 \\ 1 & 0.449 & 0.086 & 0 \\ 1 & 0.8 & 0.3 & 0.071 \end{bmatrix}$ |
| $R_{B2}=\begin{bmatrix} 0.939 & 0.57 & 0.047 & 0.061 \\ 0.25 & 0.833 & 1 & 0.667 \\ 1 & 0 & 0 & 0 \\ 0.135 & 0.939 & 1 & 0.895 \end{bmatrix}$ | $R'_{B2}=\begin{bmatrix} 0.939 & 0.57 & 0.047 & 0.061 \\ 0.25 & 0.833 & 1 & 0.667 \\ 1 & 0 & 0 & 0 \\ 0.135 & 0.939 & 1 & 0.895 \end{bmatrix}$ |

# Case Study

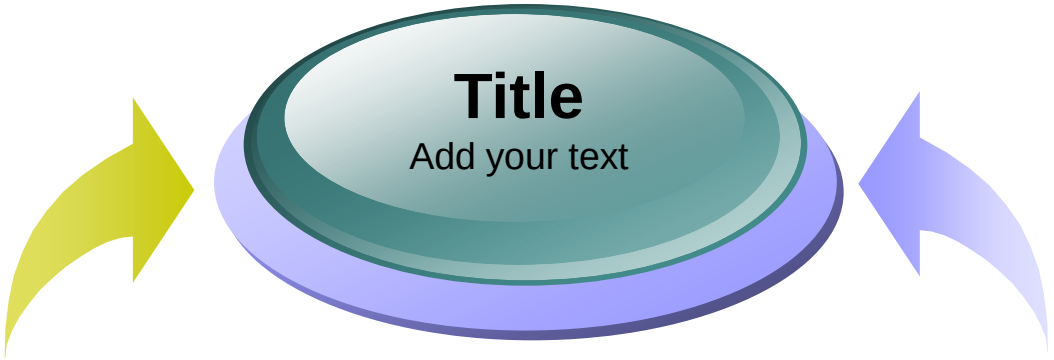
| FSE | | | | | VWFSE | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Normal | Caution | Abnormal | Failure | | Normal | Caution | Abnormal | Failure |
| $B = [$ | 0.393 | 0.344 | 0.148 | 0.116 $]$ | $B' = [$ | 0.235 | 0.276 | 0.142 | 0.346 $]$ |

# Conclusion

VWFSE

- VWFSE is proposed
- variable weights are the main feature
- solves the deficiency of FSE ‘s
- result is more objectively and accurately
- the example proves the effectiveness

# Conclusion




**Parameters**

- More teleindication information
- Running condition data of power grids

**Structure**

Improve the hierarchy assessment structure

# *Welcome Criticism !*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