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

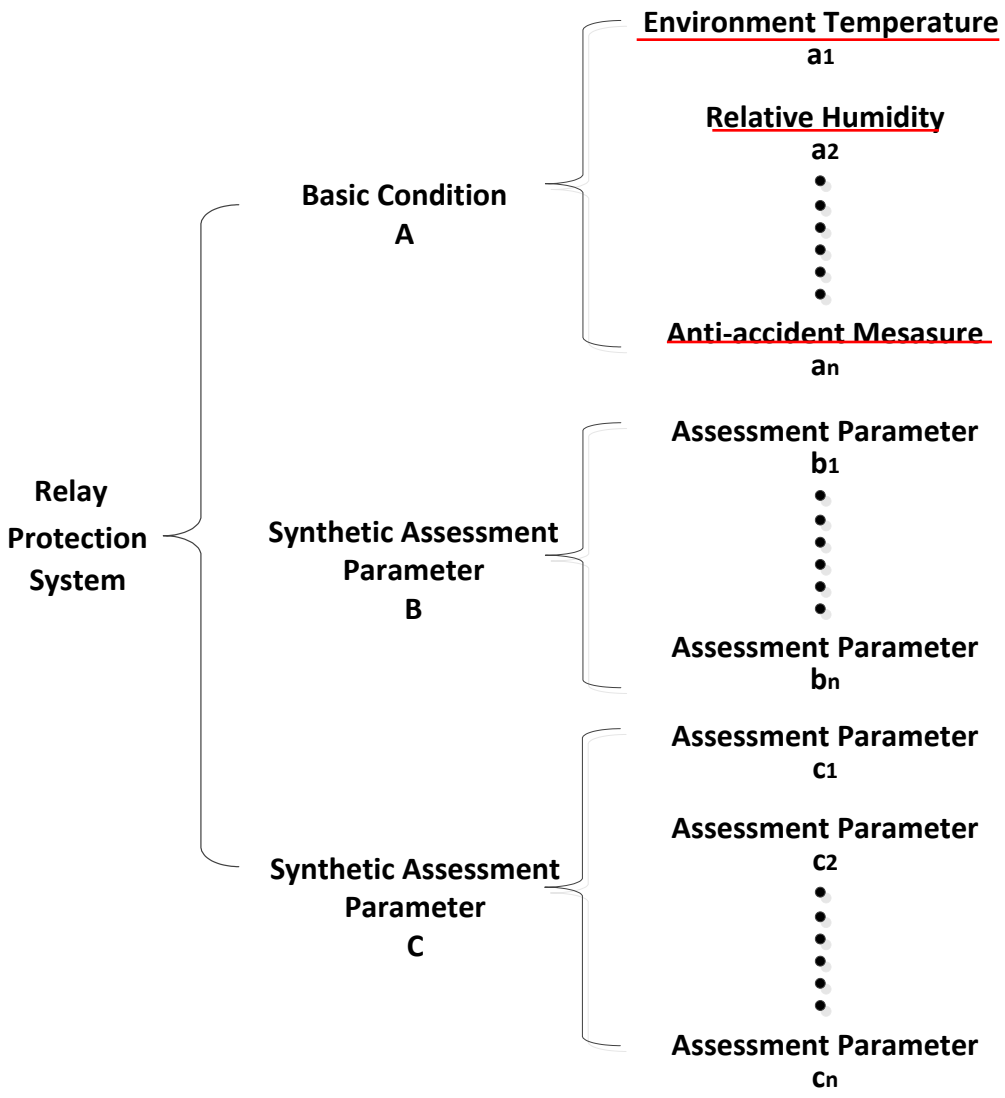
- The weights of assessment parameters are constant.
- The assessment result is not satisfied.

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

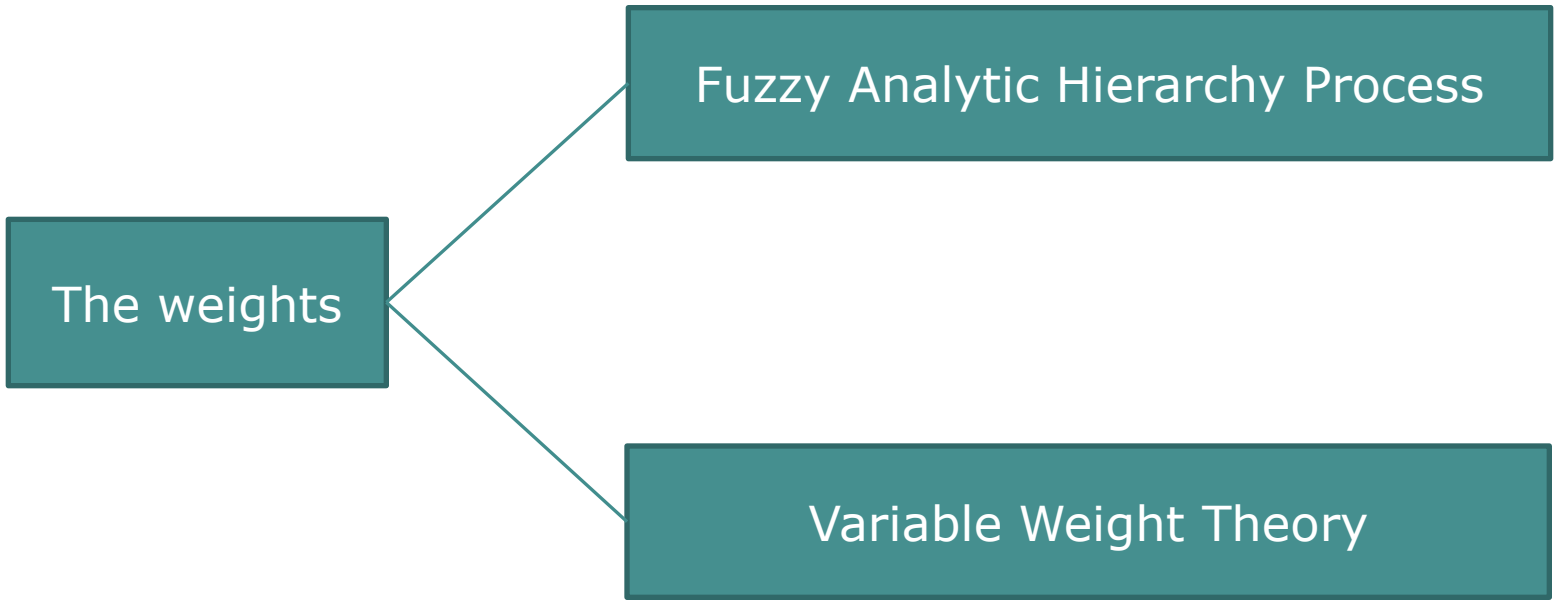
VWFSE - Membership Function

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

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

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

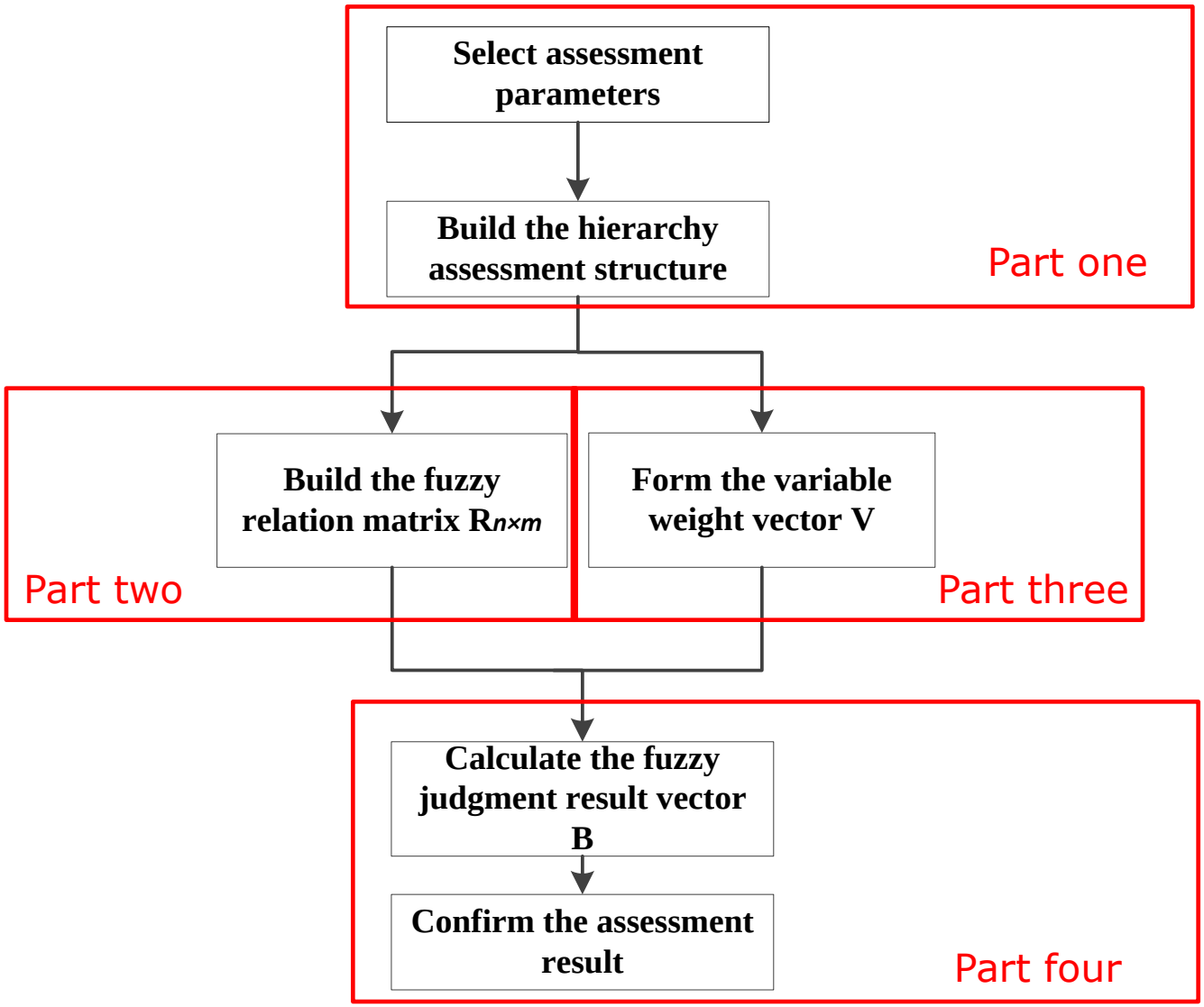
VWFSE-Fuzzy Judgment Result Vector

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

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

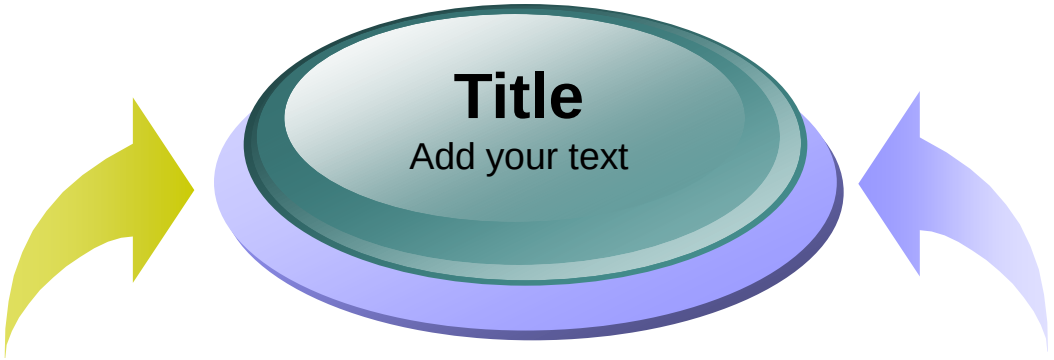
FSE					VWFSE				
	Normal	Caution	Abnormal	Failure		Normal	Caution	Abnormal	Failure
$B = [$	0.393	0.344	0.148	0.116 $]$	$B' = [$	0.235	0.276	0.142	0.346 $]$

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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