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Knowledge modeling based on interval-valued fuzzy rough set and similarity inference: prediction of welding distortion

Key words: Knowledge modeling, Interval-valued fuzzy rough set, Similarity-based inference, Welding distortion prediction

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Introduction

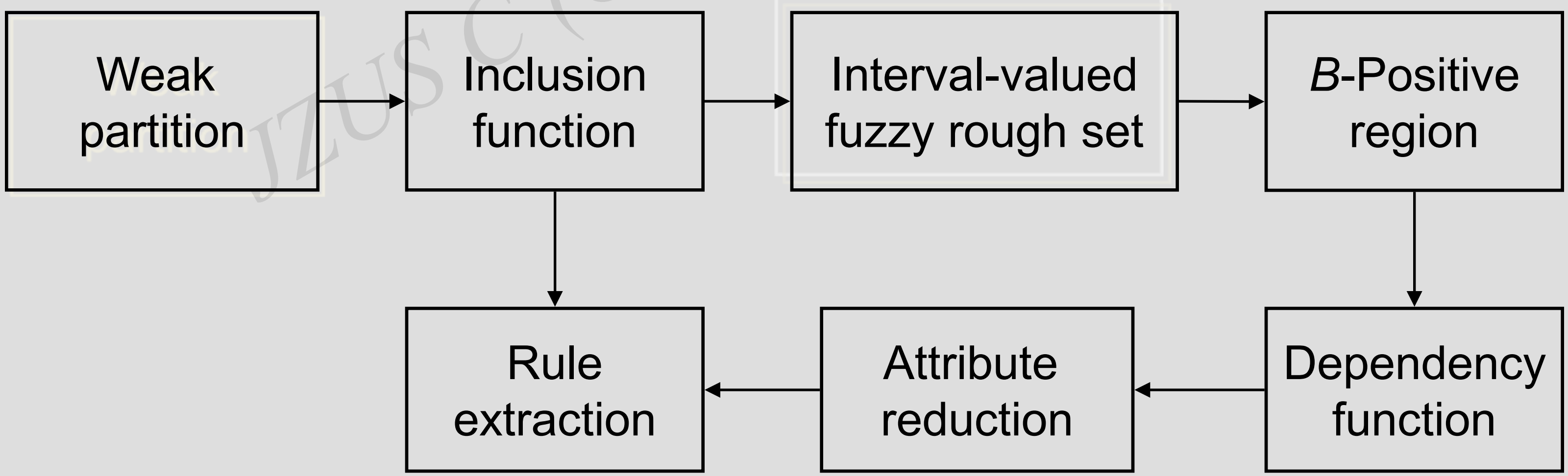
– Knowledge based non-mechanism modeling is a trend to dealing with complex systems. Using interval-valued fuzzy rough set theory, a simplified knowledge model can be extracted from the information system.
– Approximate reasoning is a key to the development of fuzzy systems. We present a novel means of similarity based inference in interval-valued fuzzy environments.
– The proposed method is applied to predict welding distortion of marine structures. Its effectiveness is validated by experimental results.

Framework of our method (I)

The approach of knowledge modeling can be divided into five steps:

- Raw data collection
- Pretreatment of data
- Interval-valued fuzzification of data
- Attribute reduction
- Rule extraction

The technical route of fuzzy knowledge acquisition is summarized as follows:



Framework of our method (II)

An improved similarity inference incorporating the compositional rule of inference contains the following steps:

- Translate rule into interval-valued fuzzy relation $R(A,B)$ using a suitable operator.
- Compute similarity grades $S(A,B)$ between interval-valued fuzzy sets.
- Obtain an induced relation $R(A^*,B)$ by a modification schema.
- Deduce B^* by supremum projection on $R(A^*,B)$.

Given a conditional statement "If *x* is *A* then *y* is *B*" and a case input A^*, an inference result B^* is represented by

$$\begin{cases} \mu'_{B^*}(y) = T(s, I(\inf_x \mu''_A(x), \mu'_B(y))), \\ \mu''_{B^*}(y) = T(s, I(\inf_x \mu'_A(x), \mu''_B(y))). \end{cases}$$

Here T and I are a continuous t-norm and the implicator, respectively.

Application of our method (I)

Procedures of knowledge extraction from the welding distortion information system:

Step 1: Compute inclusion grades of conditional classes in decision classes.

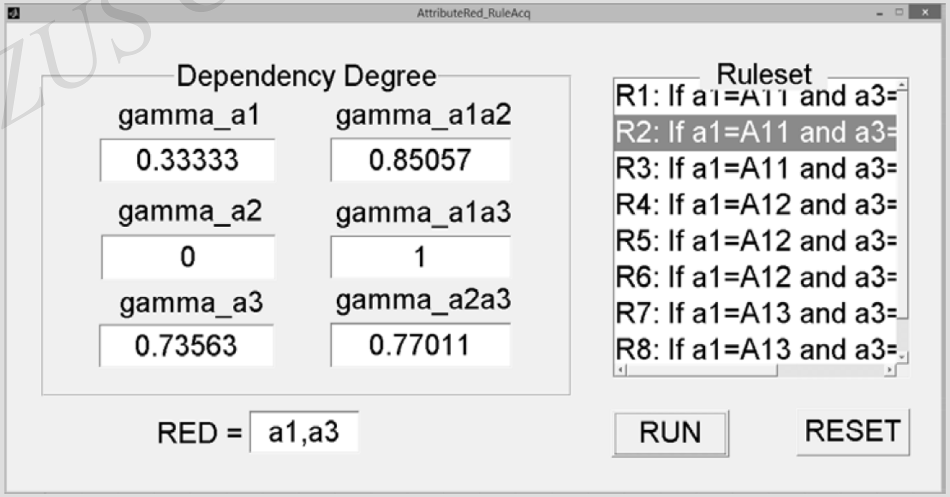
Step 2: Construct the interval-valued fuzzy positive region.

Step 3: Calculate the dependency degree.

Step 4: Implement attribute reduction by the IVFR QuickReduct algorithm.

Step 5: Extract a fuzzy rule set from IVFDT of welding distortion.

Results for dependency degree, reduction, and rule extraction:



Application of our method (II)

Inference steps of welding distortion prediction:

- Input fuzzification
- Translation
- Matching
- Modification
- Projection
- Output defuzzification

Fig. 1: Inference results obtained using the above method

Fig. 2: Errors between prediction values and real values

- Our method (prediction 1)
- CRI algorithm (prediction 2)

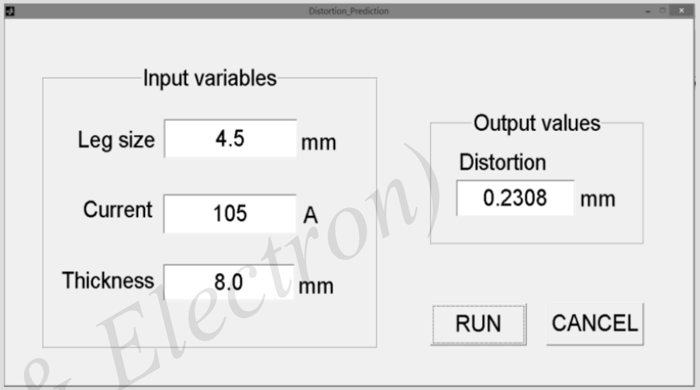


Fig. 1 Running interface for welding deformation prediction

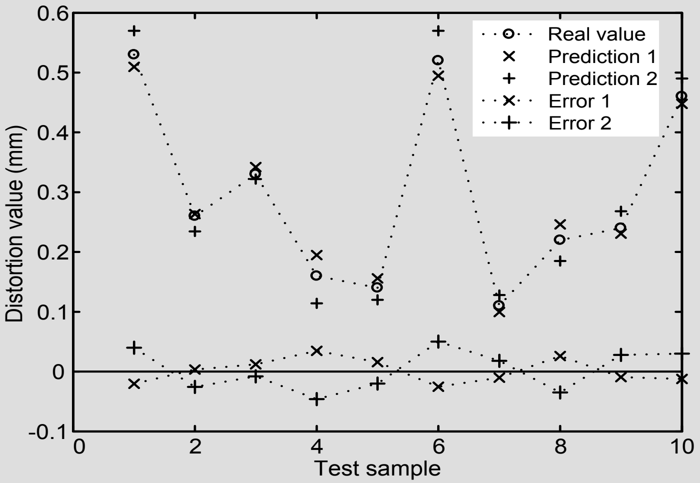


Fig. 2 Predicted values, real values, and errors

Conclusions

– A method of knowledge modeling has been presented to deal with complex process without any priori knowledge

– An approach of similarity-based approximate reasoning is provided to improve the mechanism of inference

– A case study of welding distortion prediction indicates that the proposed methods can achieve high speed and precision to meet the needs of complex process modeling