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Procedia Computer Science 120 (2017) 446–453

Procedia Computer Science

www.elsevier.com/locate/procedia

9th International Conference on Theory and Application of Soft Computing, Computing with Words and Perception, ICSCCW 2017, 24-25 August 2017, Budapest, Hungary

Positional-binary recognition of cyclic signals by fuzzy analyses of their informative attributes

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Abstract

To increase the validity of positional-binary recognition of cyclic signals it is proposed to use the mathematical apparatof fuzzy sets theory that allows taking into account additional informative attributes of these signals. Recognition of cyclic signals is carried out by comparing their fuzzy interpretations with the corresponding fuzzy interpretations of etalon signals reflecting the time location of the position-binary components.

Peer-review under responsibility of the scientific committee of the 9th International Conference on Theory and application of Soft Computing, Computing with Words and Perception.

*Keywords:*Sycle signal; positional-binary component; fuzzy set; fuzzy similarity measure.

1. Introduction

According to Dedus, (2003), Dvornikov and Saukov (2004), at the present time to improve thevalidityof analysis and recognition of different signals are widely used methods based on different versions of the Fourier transform and wavelet technologies. However, the known deficiencies of Fourier analysis cannot fully ensure the accurate measurement of the characteristics of certain processes, which are displayed by cyclic signals. In particular, by Dreminet al. (2001) to provide the required adequate description of these processes by spectral methods are often required to use a large number of harmonic components, which ultimately reduces to an increase of the dimension of

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1877-0509
Peer-review under responsibility of the scientific committee of the 9th International Conference on Theory and application of Soft Computing, Computing with Words and Perception.
10.1016/j.procs.2017.11.262

attribute space, complicates the process of diagnosis and, thus, does not always produce the desired results.Methods based on wavelet transforms for improving performance time-frequency descriptions of cyclic signals, calculate the parameters of global and local energy spread. However, according to Dvornikov (2004) and Aliev (2007) the procedure for calculating them is a difficult problem and, moreover, even for the same frequency-time transformation the expected and final values of these parameters are different and depend on the type of the cyclic signal.

2. Problem statement

In the PBC-method the duration of PBC is used as informative attribute, and the estimation of adjacency is made by calculation of numerical parameters of adjacency by result of PBC covering of analyzed pairs the signals formed in each position according to Aliev and Nusratov (1998) by Expression:

$$S_w=(\xi_{q(n-1)}+\eta_{q(n-1)})2^{n-1}+(\xi_{q(n-2)}+\eta_{q(n-2)})2^{n-2}+\ldots+(\xi_{q0}+\eta_{q0})2^{0}, \quad (1)$$

where$\xi=\sum p_+$ is total value of PBC durations of binary coverings of recognized and etalon signals, which is formed by transitions $(0\rightarrow1)$; $\eta=\sum p_-$ is total value of PBC durations of binary coverings of recognized and etalon signals, which is formed by transitions $(1\rightarrow0)$; n is quantity of positions in PBC-decomposition.Nevertheless, to increase the validity of the PBC-technology for recognition of cyclic signals, it is necessary to consider additional algorithms that take into account the time location of the PBC in quantitative assessment the proximity of the cyclic signals.

As a test case, there are chosen three etalon signals e_i (i=1÷3) – wattmetrograms for the cycle of bottom-hole pumping, characterizing by three types of defects and, accordingly, three recognizable cyclic signals r_i. Given signals are presented in Fig. 1, andfor cycle at Δt=50 and amplitude 60 at each$q_k=2^k$ position (k=0÷5) their corresponding decompositions on positional-binary components are presented in Fig. 2.

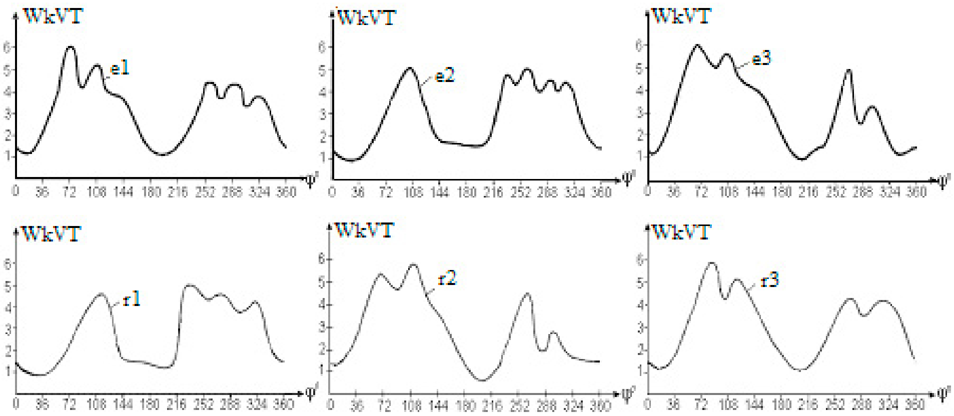

Fig. 1. Wattmetrogramse_i for the cycle of bottom-hole pumping and recognizable cyclic signals r_i.

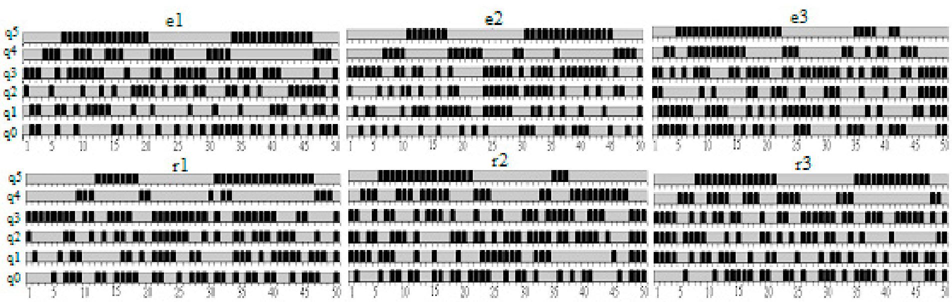

Fig. 2. Decompositions on positional-binary components of etalon signal e_i and recognizable signals r_i (i=1÷3).