ON SOME METHOD OF ANALYSING TIME SERIES*

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We propose a new method of analysing of time series founded on AIP patterns. We tested the method on a time sequence corresponding to laminar phase of intermittency generated by logistic equation.

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Artificial insymmetration patterns (AIP; also known as symmetrized dot patterns), have been introduced to the literature by Pickover [1] as qualitative methods of visualizing correlation functions in the time series of data. To aid the human with interpretation of underlying patterns, the data is mapped in a fashion which artificially induces symmetry into the data set. Such a mapping seems to have remarkable potential for enabling human observers to resolve small differences between virtually identical time series. The AIP transformation is given by

$$\aleph : F(t) = S(r_j, \Theta_{ij}, \Phi_{ij})\,, \tag{1}$$

where S is traditional function of $\boldsymbol{r}$ in radial polar coordinates, while Θ and Φ are two polar angles.

$$r_j = \frac{F_j - L}{H - L}\xi\,, \tag{2}$$

$$\Theta_{ij} = \Theta' + \frac{F_{j+1} - L}{H - L}\xi\,, \tag{3}$$

$$\Phi_{ij} = \Theta' - \frac{F_{j+1} - L}{H - L}\xi\,, \tag{4}$$

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where $j = 1, 2, 3, \ldots, N-1$, $\Theta' = (360°/m)i$, $i = 1, 2, 3, \ldots, m$. Here N is the number of points in the time series, m is the number of symmetric mirrored or conjugate plane reflections, H is the maximum value in the data set, and ξ represents the maximum value used to normalize or scale the data. In practice, good AIP patterns require approximately 200 points to produce reliable characteristics (Figure 1).

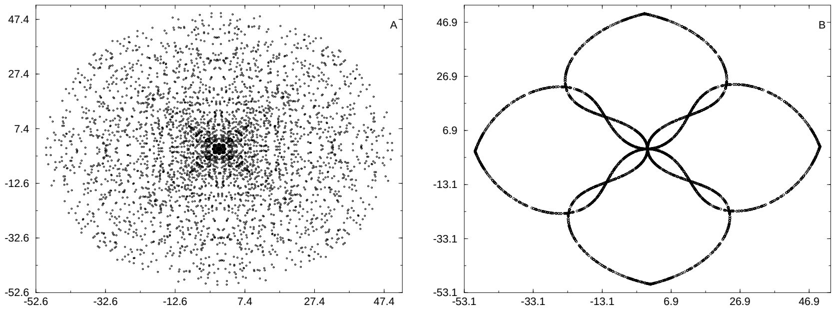

Fig. 1. A — AIP pattern for random noise; B — AIP pattern for logistic map $x_{n+1} = ax_n(1 - x_n)$, with $a = 4.0$, $x_0 = 0.2$.

To diagnose different disturbances in heart rhythm we used the AIP pattern procedure [2] (Figure 2). The AIP patterns are sometimes almost identical for different kinds of arrhythmia. Our aim is to achieve more precise readings of AIP patterns and then in the near future a method of obtaining color patterns. We are convinced that a good quality color AIP pattern may contain more information than a black and white version. Using color patterns would allow more precise readings of characteristics and differentiation of time sequences.

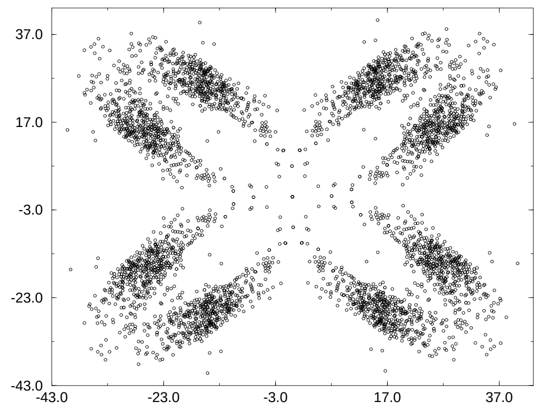

Fig. 2. AIP pattern for a normal heart rhythm.

In this work we employed a method of constructing a histogram corresponding to the AIP pattern generated by the analysed time sequence. We tested this procedure on a time sequence corresponding to laminar phase of intermittency generated by logistic map (Figure 3). Time sequence was divided into two parts and for each of them we produced corresponding AIP pattern. Both patterns are indistinguishable (Figure 4). We made a histogram for each of the patterns (Figure 5), and calculated the difference (Figure 6).

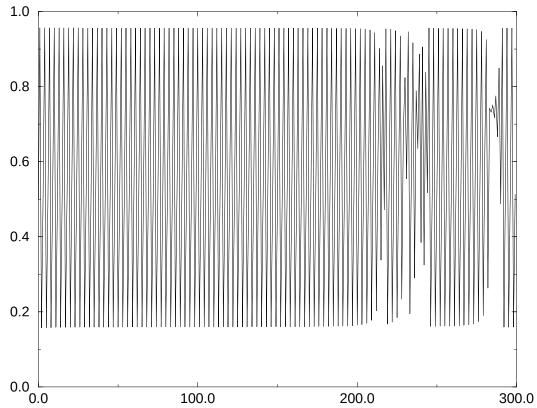

Fig. 3. The time series for logistic map, parameters $a = 3.8284$, $x_0 = 0.5$.

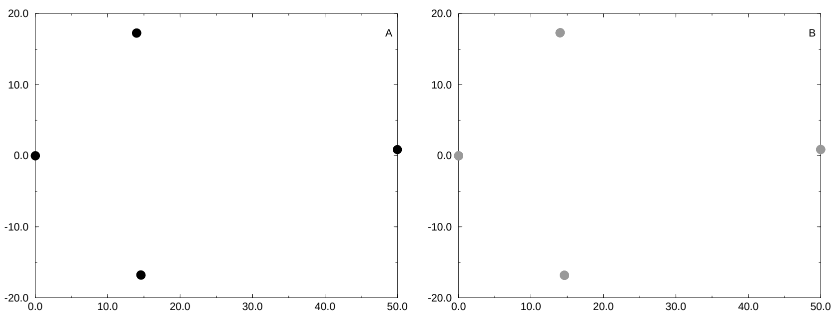

Fig. 4. A — AIP pattern for region 1 ($i \in (50, 100)$); B — AIP pattern for region 2 ($i \in (100, 150)$).

What is the advantage of constructing a histogram for AIP patterns over a method of comparing ordinary histograms made for a time sequence? The AIP algorithm can spot the correlations between different regions (not necessarily neighbouring) of a time sequence (distance between those regions can be determined by choosing appropriate parameters of algorithm), which in some situations could turn out to be advantageous (for instance in heart rhythm analysis, where long distance correlations occur).

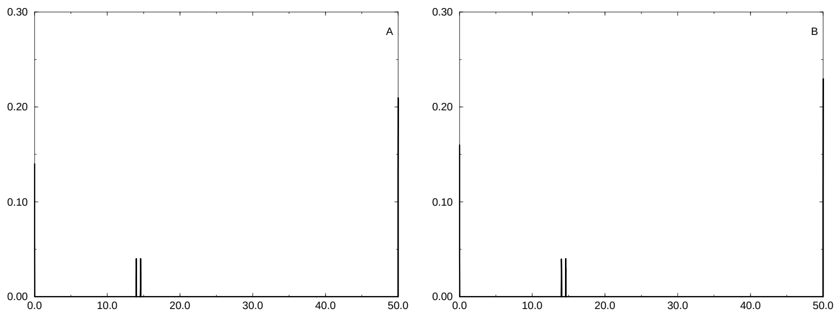

Fig. 5. Histograms for region 1 (A) and 2 (B).

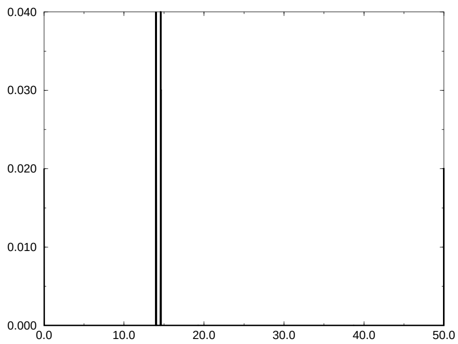

Fig. 6. The difference between the histograms from Figure 5.

We are currently examining the possibility of employing this method in monitoring in real time terms changes taking place in nonstationary time sequences. We aim to achieve means of foreseeing possible serious malfunctions in mechanical systems.

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[2] A. Posiewnik, J. Dabkowski, A new tool for nonlinear analysis of heart rate variability, preprint IFTIA UG 5.