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Study of the periodicity in Euro-US Dollar exchange rates using local alignment and random matrixes

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Abstract

The purpose of this study was to detect latent periodicity in the presence of deletions or insertions in the analyzed data, when the points of deletions or insertions are unknown. A mathematical method was developed to search for periodicity in the numerical series, using dynamic programming and random matrices. The developed method was applied to search for periodicity in the Euro/Dollar (Eu/$) exchange rate. Period length equal to 24 and 25 h were found. The reasons for the existence of the periodicity in the financial time series are discussed. The results can find application in computer systems, for the purpose of forecasting exchange rates.

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Keywords: Latent periodicity, dynamic programming, rates, random matrixes, insertions, deletions

1 Introduction

Identification of the cyclic patterns in numeric time series and symbolical sequences may shed structure of different time series. Currently, there are many mathematical methods for studying symbolic sequence periodicity. This is due to the necessity of studying DNA sequences and amino acid sequences of proteins (Hogeweg 2011). To identify periodicities in the time series and symbolical sequences, the methods mainly used are based on the Fourier transform, wavelet transform and dynamic programming, as well as some other method (Stoica P & Moses R 2005; Struzik 2001; Oppenheim et al. 1999; Hamilton 1994; Benson 1999; Granger & M 1967; Stankovic et al. 2005; Marple 1987; Dodin et al. 2000; Jackson et al. 2000; Coward & Drabløs 1998; Rackovsky 1998; Chechetkin & Turygin AYu 1995; Makeev & Tumanyan 1996; Fadiel et al. 2006). Previously, we proposed the method of informational decomposition, which allows the detection of periodicity in both symbolic and numeric sequences; however, the detection was severely impeded by the above approaches (Korotkov et al. 2003). These difficulties emanate from the fact that methods based on Fourier and Wavelet transform, decompose the statistical significance of long periods (larger than the

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size of the analyzed sequence alphabet) for smaller periods with a multiple of the length (Korotkov et al. 2003). Also, these methods are very sensitive to the insertion and deletion of symbols. This leads to the fact that spectral methods cannot detect periodicity at a statistically significant level, even in the presence of a few deletions or insertions.

Dynamic programming, which allows the detection of deletions and insertions in the periods, cannot detect relatively "fuzzy" periodicity. This is due to the fact that this method is based on finding the similarity between pairs of periods in the studied sequence (Benson 1999). However, if a statistically significant similarity is absent between two separate periods, dynamic programming will fail to detect periodicity in the analyzed sequence. The lack of similarity between any two separate periods can be observed for latent periodicity, where the periodicity occurs on the background of random noise (Korotkov et al. 2003). To find such periodicity, the method of informational decomposition was used (Korotkov et al. 2003). This method enabled the discovery of latent periodicity in the DNA sequences of many genes (Korotkov et al. 1997; Chaley et al. 1999) and revealed the latency of amino acid specific for the protein families (Turutina et al. 2006; Korotkov et al. 1999). These results suggest that latent periodicity with insertions and deletions can be detected in sequences of a different nature and in numerical sequences also.

Today, it is known that people, animals and plants have biological rhythms. The manifestation of these rhythms can be observed at all levels of biological organization. The interaction can be observed between the rhythms that affect the internal state of the person and on various social processes. A. Chizhevsky first drew attention to the influence of natural factors on social processes (Chizhevsky 1976) The biological rhythms can also influence currency rates. If the periods in the exchange rates exist, then the various events in public life can affect them. Such events can lead to changes in the data and could be identified as a phase shift of the period. The phase shifts in the sequence could have resulted from deletion or insertion of values with respect to the existing period. Therefore, in order to detect this periodicity, it was necessary to develop a mathematical method for detecting the periodicity of the time series, taking into account the unknown location and unknown number of insertions or deletions, in the presence of large noise. It cannot be done with the help of all known mathematical methods. Previous studies have searched for insertions or deletions (Rastogi et al. 2006), but failed to find a periodicity with large noise (Suvorova et al. 2014). It is right mainly for dynamic programming. Either of these methods works well in the presence of large noise, but fails to find periodicity in the presence of even small amounts of insertions and deletions (Korotkov et al. 2003).

This paper contributed to filling the gap in mathematical methods for periodicity search. A mathematical method was developed to find periodicity in the symbolical sequences, in the presence of insertions and deletions and the big noise. The method was developed using the random matrices of periodicity and the method of dynamic programming. The developed method was applied to search for periodicity in the exchange rate of the Euro to the US Dollar. To search for periodicity, the numerical sequence was converted to a symbolical sequence. The calculations show that there is a periodicity equal to 24 and 25 h in the Euro-Dollar exchange rate. This periodicity of the exchange rate contains a lot of insertions and deletions and could not be detected by previously developed mathematical methods.

2 Methods and Algorithms

To search the periodicity with insertions and deletions, the algorithm shown in Figure 1 was used. As can be seen from the algorithm, firstly, a set of random matrices (Figure1, paragraph 2) with size 20xn was generated, where n is the length of the period, and 20 is the alphabet size of the studied sequence. Then, a local alignment of the studied sequence was built relative to each of the generated random matrices (Figure 1, paragraph 3). Dynamic programming was used to build the local alignment and in determining the similarity function F. Then, the matrices were transformed because