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Particle swarm intelligence tunning of fuzzy geometric protoforms for price patterns recognition and stock trading

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ABSTRACT

A novel approach for detecting patterns in price time series is shown. The proposed system for identifying consolidation phases is based on fuzzy geometric protoforms and classification trees. Promising results of the empirical studies prove that the suggested fuzzy geometric protoforms are very useful for identifying patterns in graphical visualizations of data. Moreover, the architecture of the system enables successful incorporation of genetic optimization what enables capturing various data sets structure and unstable conditions on financial markets.

1. Introduction

While observing price charts of financial instruments (shares, futures contracts, commodities) one can realize that prices tend to form some unique patters before extraordinary market events happen. Investors try to identify such patterns to predict significant price movements, market volatility changes, bull or bear market commencement.

Although the problem of identifying crucial characteristics of the financial time series is so important, there are not too many papers dealing with the price patterns recognition. An interesting method for assessing the predictive power of price patterns was proposed by Savin, Weller, and Zvingelis (2007). Wu, Lin, and Lin (2006) present a stock trading method by combining the filter rule and the decision tree technique. Five trend following (TF) algorithms are presented and compared in Fong, Si, and Tai (2012).

Most of publications try to solve the problem using neural networks (Kara, Boyacioglu, & Baykan, 2011; Kamijo & Tanigawa, 1990; Guo, Liang, & Li, 2007) trained with preprocessed price time series (usually smoothing averages and technical analysis indicators are calculated). Other systems extract patterns with manually established rules comparing some indicators calculated for the fixed time windows. Unfortunately, such systems cannot adapt to changing markets.

In this paper we propose a novel approach for detecting patterns in price time series. Our system utilizes a new concept of so-called fuzzy geometric protoform which seems to be quite effective for modeling patterns.

The paper is organized as follows: In Section 2 we describe typical patterns that appear in technical analysis. In Section 3 we propose a mathematical model of the consolidation phase price pattern. Then in Section 4 we define a fuzzy geometric protoform being the core of our system. Two trend indicators are discussed in Section 5. In Section 6 we present a structure of the consolidation phase detection system while in Section 7 we describe a Particle Swarm Optimization algorithm for intelligent tuning of our system. Finally, in Section 9 we discuss the results of the empirical study.

2. Patterns in technical analysis

Investors usually forecast future price trends basing on information on historical prices and trading volume summarized in the form of charts. In Fig. 1 prices form the so-called price channel while oscillating between two parallel lines called **resistance** (upper line) and **support** (lower line), respectively. An upstroke in late November (we say that there is an upstroke when prices break resistance line) is an indicator of approaching uptrend. On the other hand, when prices came back to the old resistance line in the first week of December, it was the strong negation of the previous signal.

In Fig. 2 prices form a **consolidation phase**. After resistance line break prices elevate in a significant uptrend. Well formed consolidation phase is rather a rare market phenomena. Moreover consolidation phase breakup is one of the strongest technical

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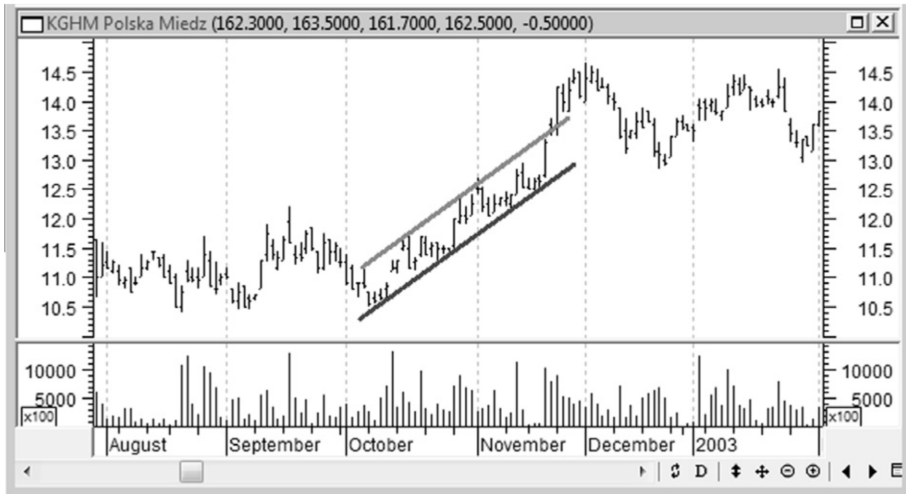

Fig. 1. A price channel and an upstroke in late November.

Fig. 2. A consolidation phase and an upstroke confirmed by a strong uptrend.

analysis indicators. It provides an opportunity to open a position with a high probability of exceeding return and low risk.

There are two most known trading rules connected with the consolidation phase:

- *Upper breakup:* uptrend is expected. We open a long position and place STOP LOSS order in the middle of breakup day price candle. If prices follow uptrend we move our STOP LOSS up to protect the profit.
- *Lower breakup:* downtrend is expected. We open a short position and place STOP LOSS order in the middle of breakup day price candle. If prices follow downtrend we move our STOP LOSS down to protect the profit.

The support and resistance lines in the consolidation phase price pattern form a semi-rectangle of unknown length.

3. The support and resistance lines

Let $\{X_t\}_{t=1}^n$ denote a time series of prices for a given financial instrument (or a part of the longer time series $\{X_t\}_{t\in T}$). To examine patterns that may appear in this time series the following sets will be helpful.

Definition 1. Let d, $d \in \{1,\dots n\}$, denote the length of a subwindow. Then a set $\mathcal{SB}_d \subset \mathbb{R}^2$ given by

$$\mathcal{SB}_d = \{(t, Y_t) : Y_t = \min\{X_i, X_{i+1}, \dots, X_{i+d}\},\ i = 1, \dots, n-d\} \tag{1}$$

is called the d-span **support base** of the time series $\{X_t\}_{t=1}^n$. Similarly, a set $\mathcal{SC}_d \subset \mathbb{R}^2$ given by

$$\mathcal{SC}_d = \{(t, Y_t) : Y_t = \max\{X_i, X_{i+1}, \dots, X_{i+d}\},\ i = 1, \dots, n-d\} \tag{2}$$

is called the d-span **resistance base** of the time series $\{X_t\}_{t=1}^n$.

We also define the truncations of these sets:

Definition 2. Lets t_p, t_0 denote time moments such that $t_p < t_0$. Then

$$\mathcal{SB}_{d|[t_p,t_0]} = \{(t, Y) \in \mathcal{SB}_d : t \in [t_p, t_0]\} \tag{3}$$

$$\mathcal{SC}_{d|[t_p,t_0]} = \{(t, Y) \in \mathcal{SC}_d : t \in [t_p, t_0]\} \tag{4}$$

Further on we utilize the support base and the resistance base to define a price-quadrangle for our time series $\{X_t\}_{t=1}^n$. First of all let us define the support line and the resistance line for the given time interval $[t_p, t_0]$. Please, note, that all concepts discussed above are obtained for a fixed subwindow d.