Determinación de la factibilidad de la detección de estrategias de operación en el mercado de divisas colombiano utilizando la información del libro de órdenes.

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Determining feasibility of trading strategies detection using Order Book Information from the Colombian currency market

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Financial Markets

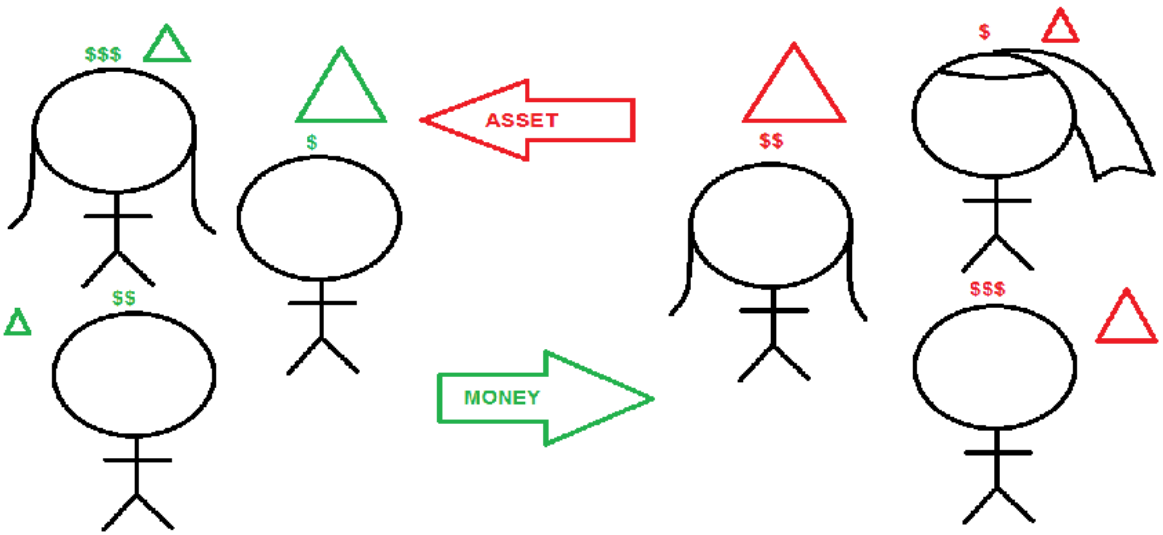


Figure: Market need vs. Available information (Candlestick figure taken from a).

Timescale Aggregations

(a) Candlesticks for one month.

(b) Candlesticks for five days.

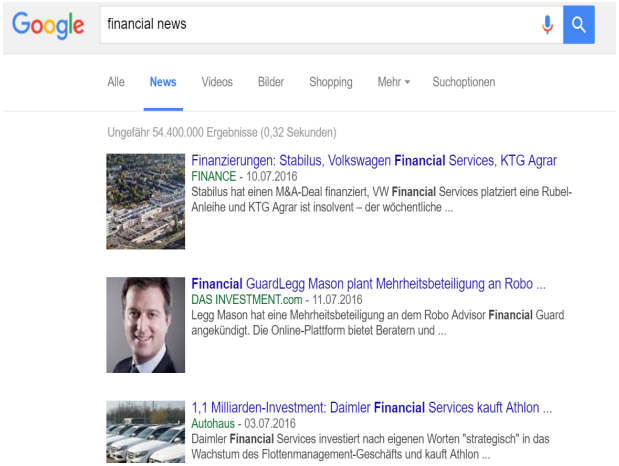
(c) Candlesticks for one day.

(d) Candlesticks for one hour.

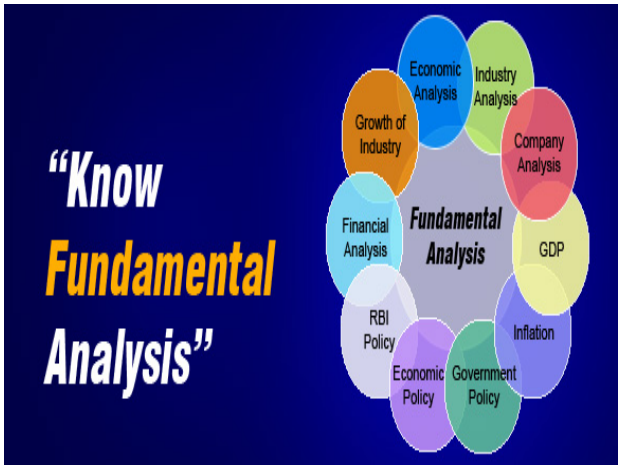
Figure: Apple Inc. Candlesticks charts retrieved from Yahoo Finance (July 13th, 2016).

Alternative Prediction Sources

(a) World trends.



(b) News (Retrieved from google.de).



(c) Fundamental Analysis.

(d) Social Networks.

Figure: Other kind of prediction sources.

Limit Order book Information

Hypothesis: the use LOB dynamics information will produce more effective trading strategies.

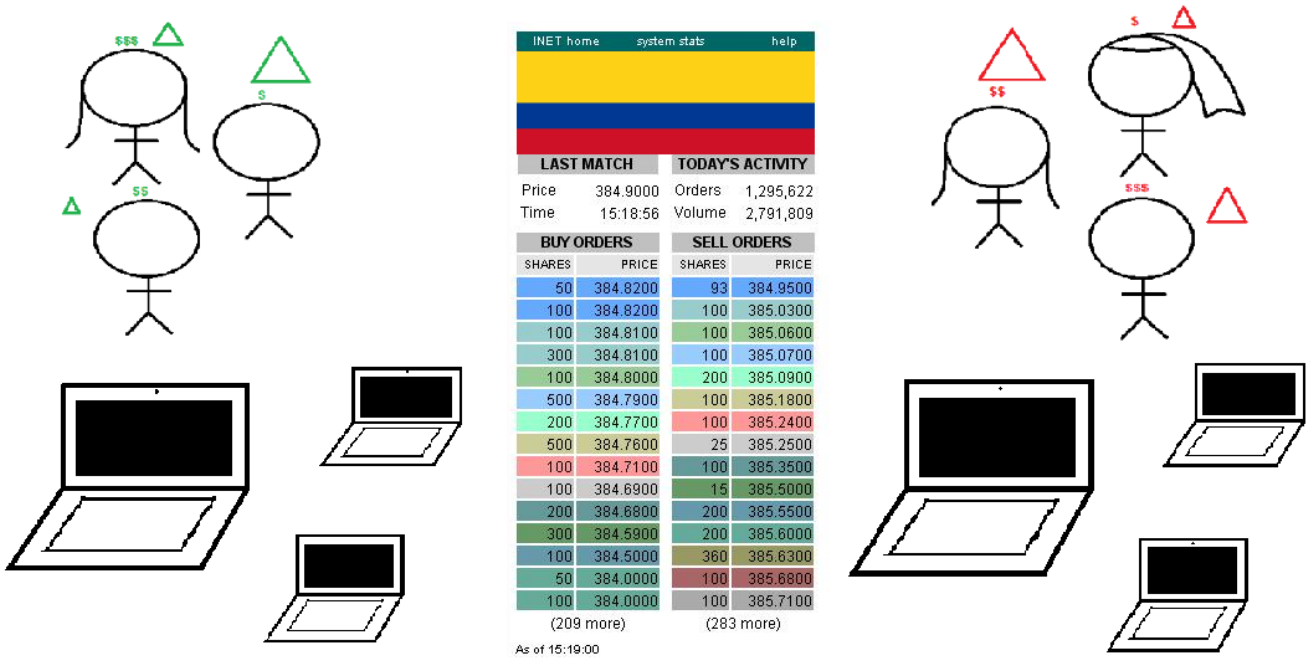
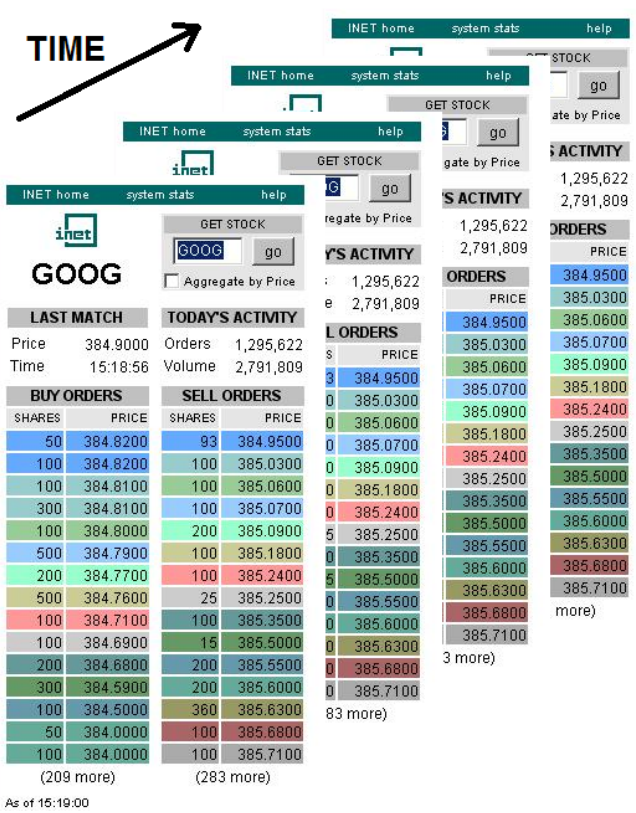


Figure: Broker's exclusive source of information.Images taken from [11]

Limit Order book Dynamics

A more powerful tool:



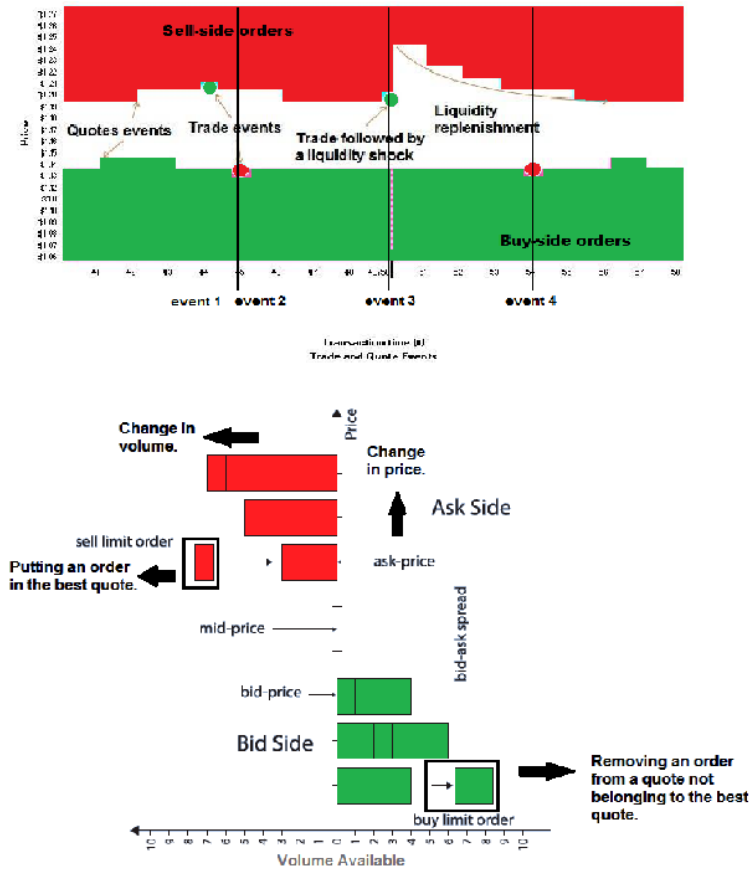


Figure: Order Book Dynamics. Images taken from [11]

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Forex Markets

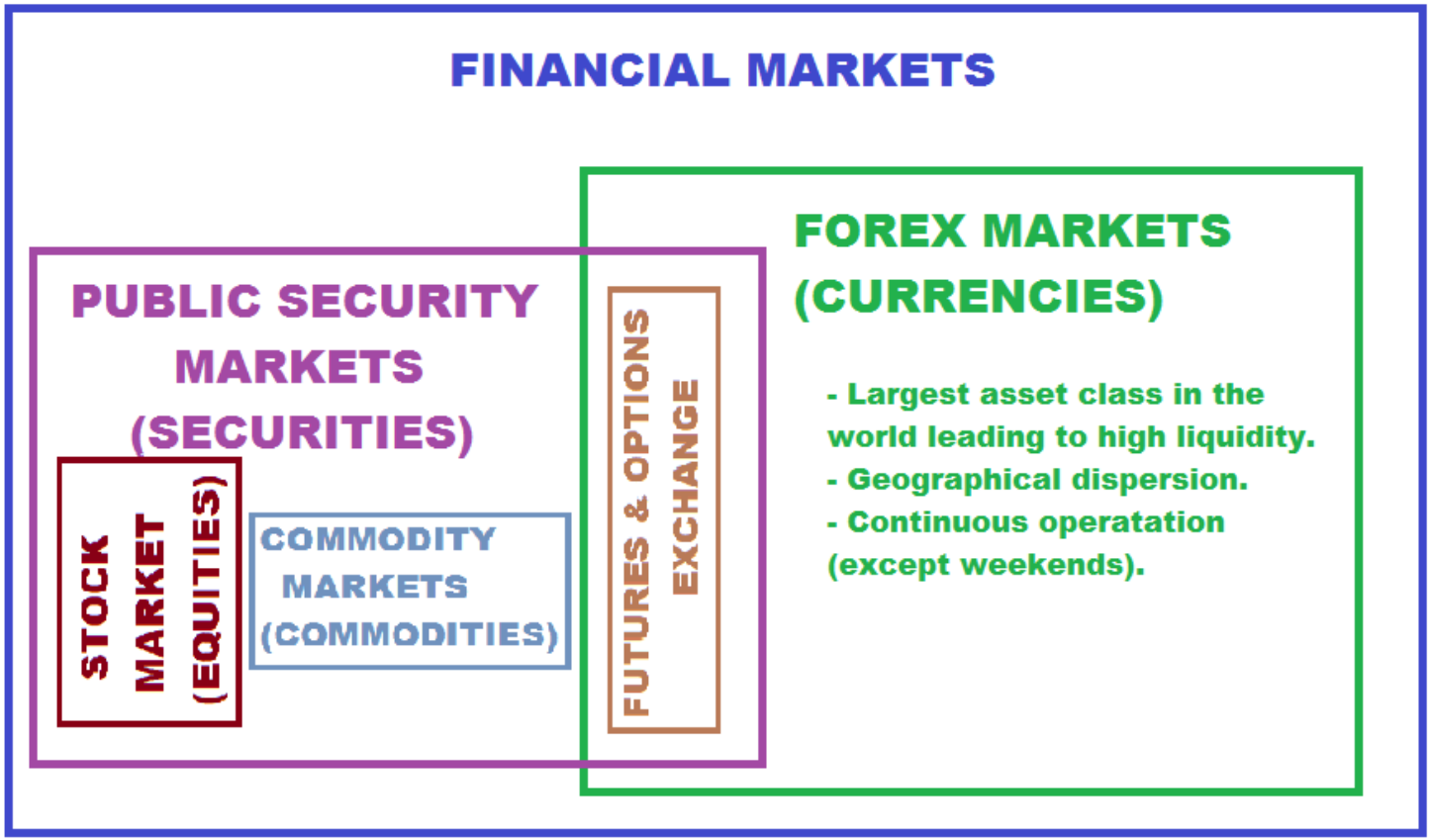

Figure: FX markets experienced a growth rate of 32.5 % in the last three years, with the United States Dollar as the most traded currency[50]. This information presents the USD behavior analysis as a still interesting research area.

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Colombian Bulk Forex Market

- Dollar buy and sell transactions are spot contracts, i.e. the transaction and its fulfillment are made on the same day. A trader buying dollars through SET-FX, receives and pays the product the same day. This market operates on workdays between 8:00 a.m. and 1:00 p.m.
- SET ICAP FX S.A. manages the trading platform SET-FX which is supported by the strategic alliance between its shareholders the Colombia Stock Exchange and SIF ICAP Mexico, the latter, a subsidiary of the Mexican Stock Exchange and ICAP PLC in London.

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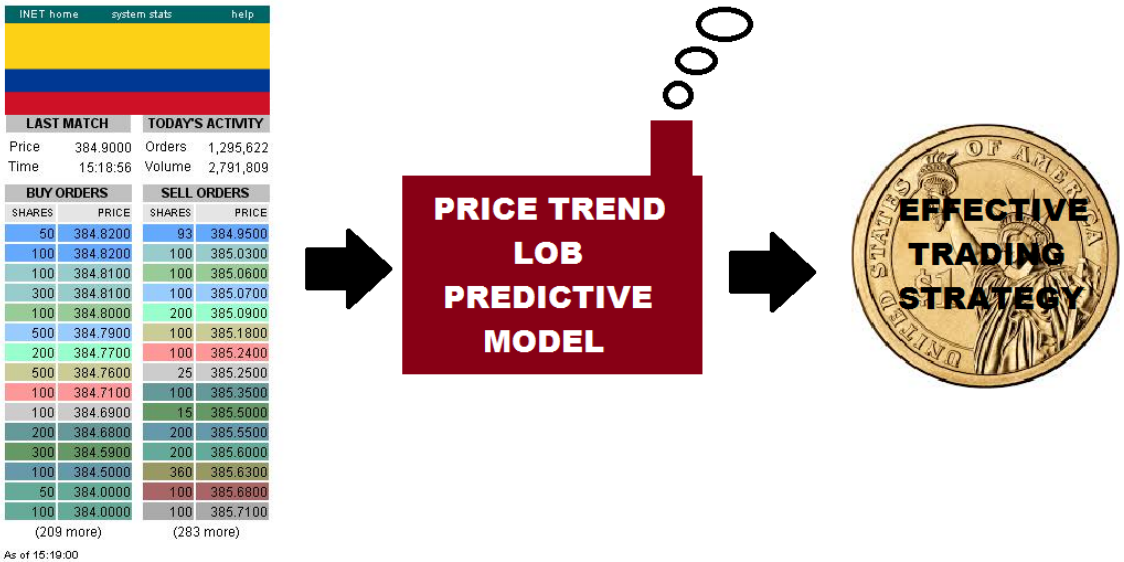
Main goal

To study trading strategies using order book information from the Colombian Forex Market and its potential in the construction of predicting models.



Proposed visualization

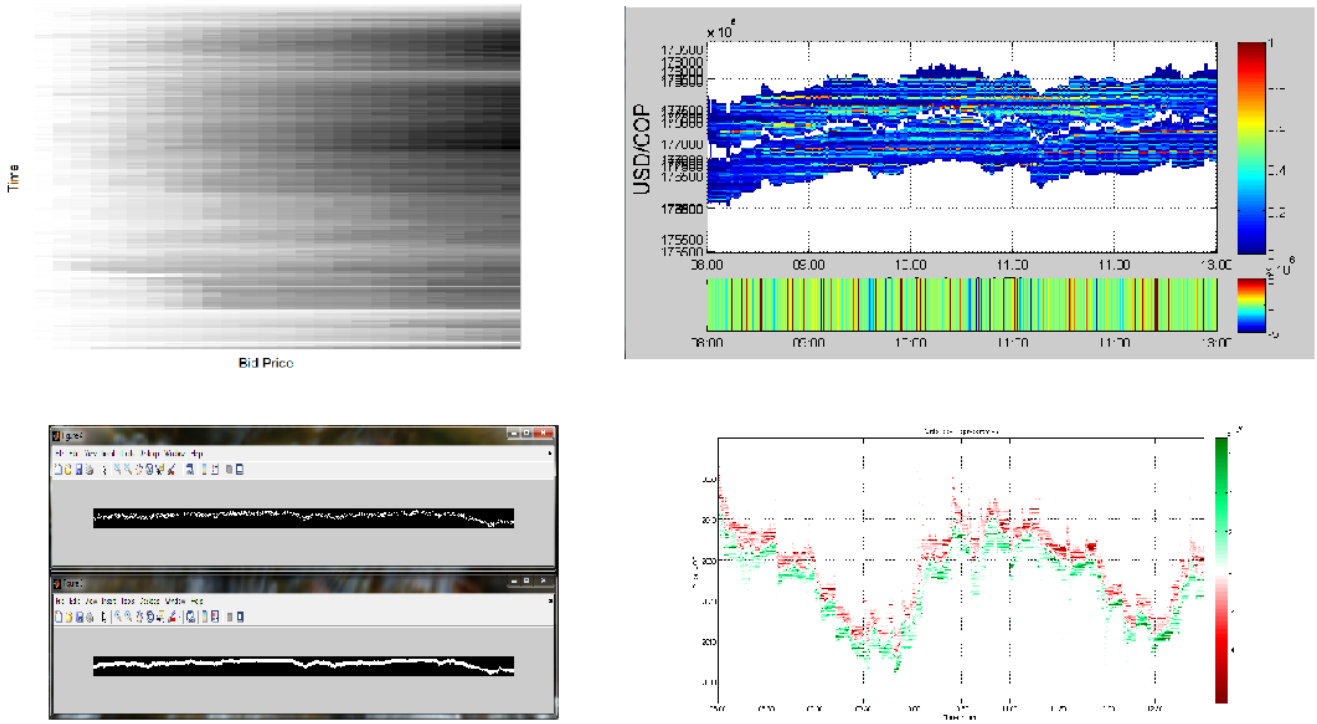


Figure: Evolution of the proposed visualization.

Similar tools

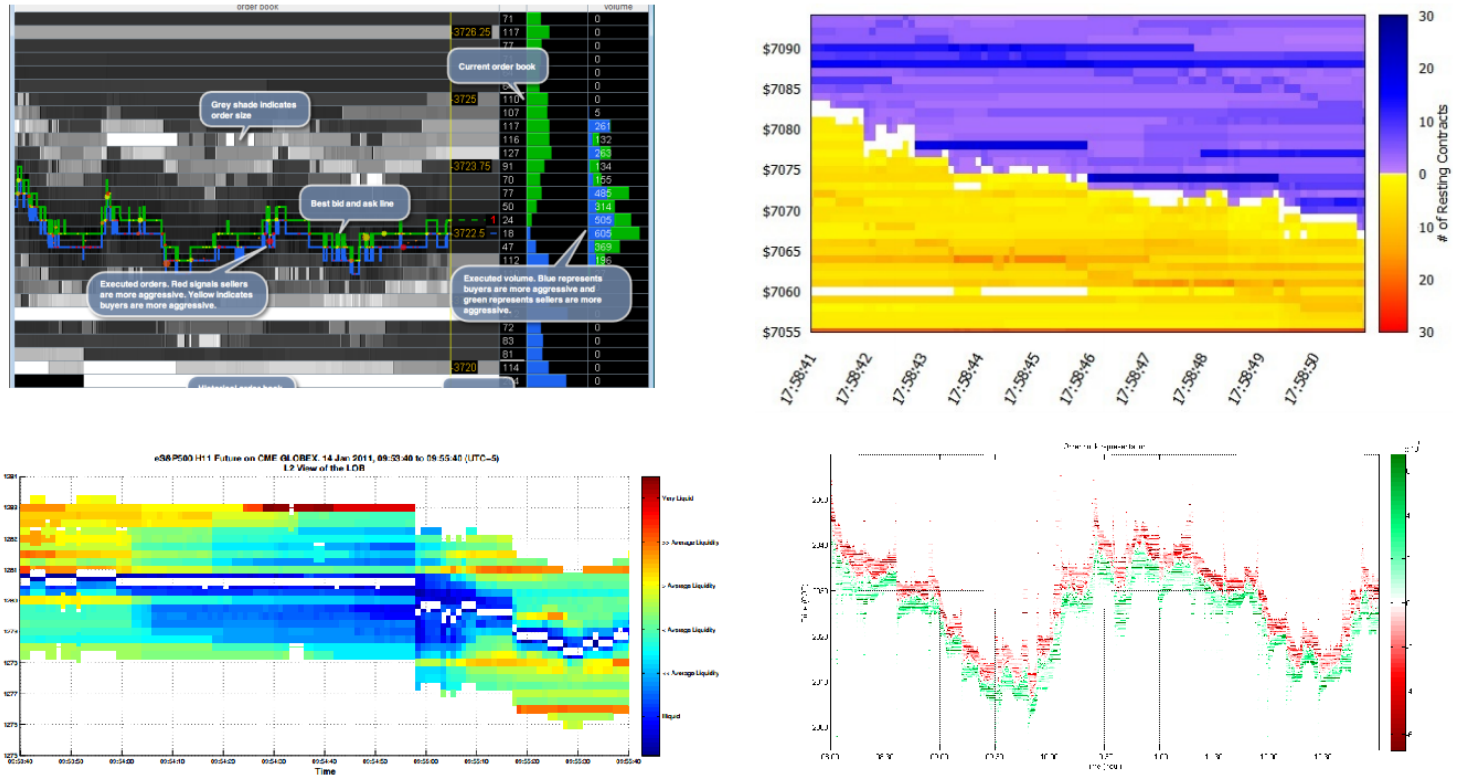


Figure: Similar visualization tools [5],[55],[9],[11].

Dataset description

- Experiments were conducted using real tick data of foreign exchange rate USDCOP from March to May of 2012.
- LOB provides information about time, price and volume for every request in the market; this information was summarized every minute, in a price range of 120 COP in the best quotes, using a 20 cents mark up.
- Volumes were quantized in levels of USD 250,000, which is the minimum trading volume for this market. The maximum volume observed for a particular order during the analyzed period was 43.5 USD millions. The maximum price observed was 1,862.6 COP and the minimum was 1,742.2 COP.

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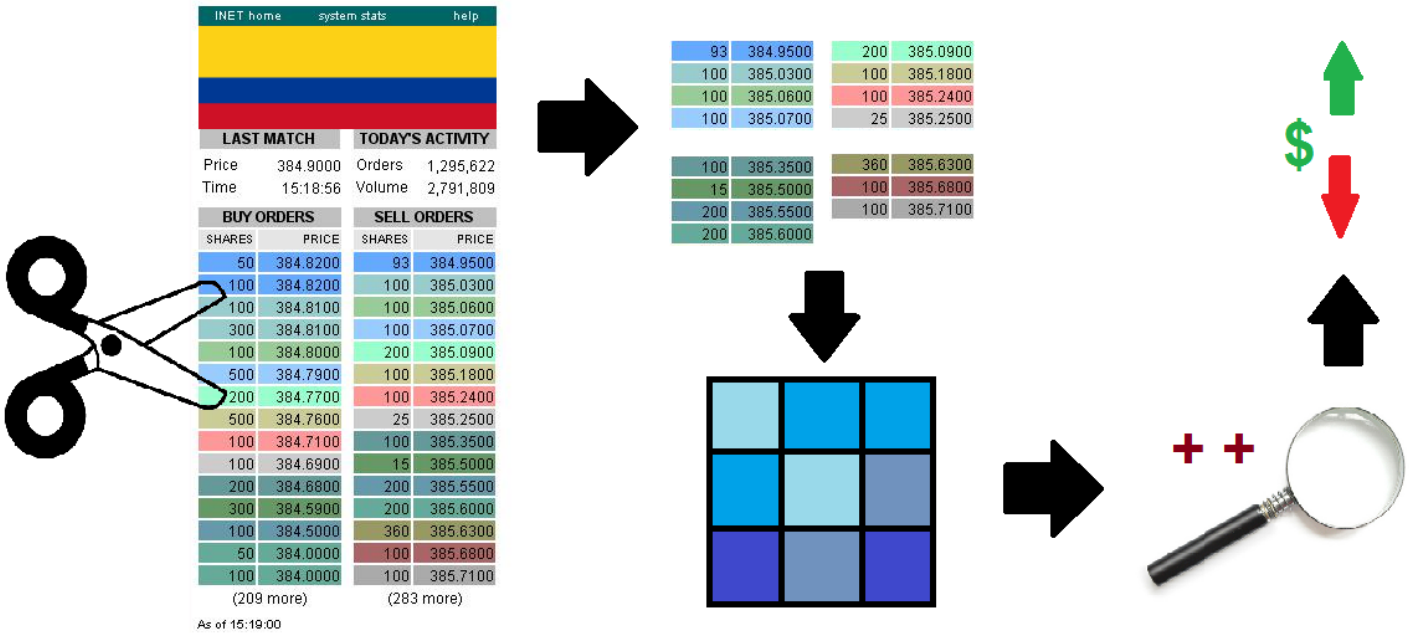
Heatmap based approach



Detection of trading strategies

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Wavelets

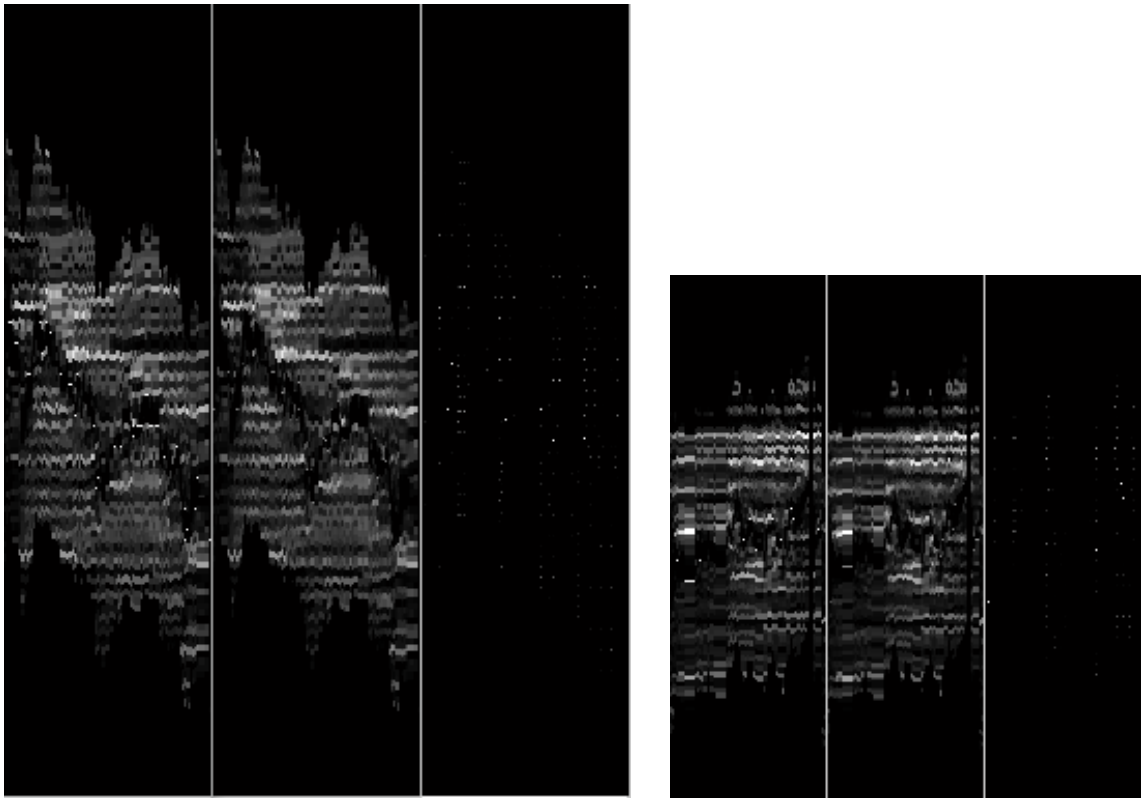

Figure: Result of the application of Haar wavelet transform over an image.

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With the aim of exploring different resolution levels, the subsets were compressed in four stages using Haar Wavelet Transform. Both sets of coefficients were employed independently. This was a preprocessing step and later the same procedure for the heatmap based approach was followed.

Figure: Effect on the image's size of using Haar Wavelet transform.

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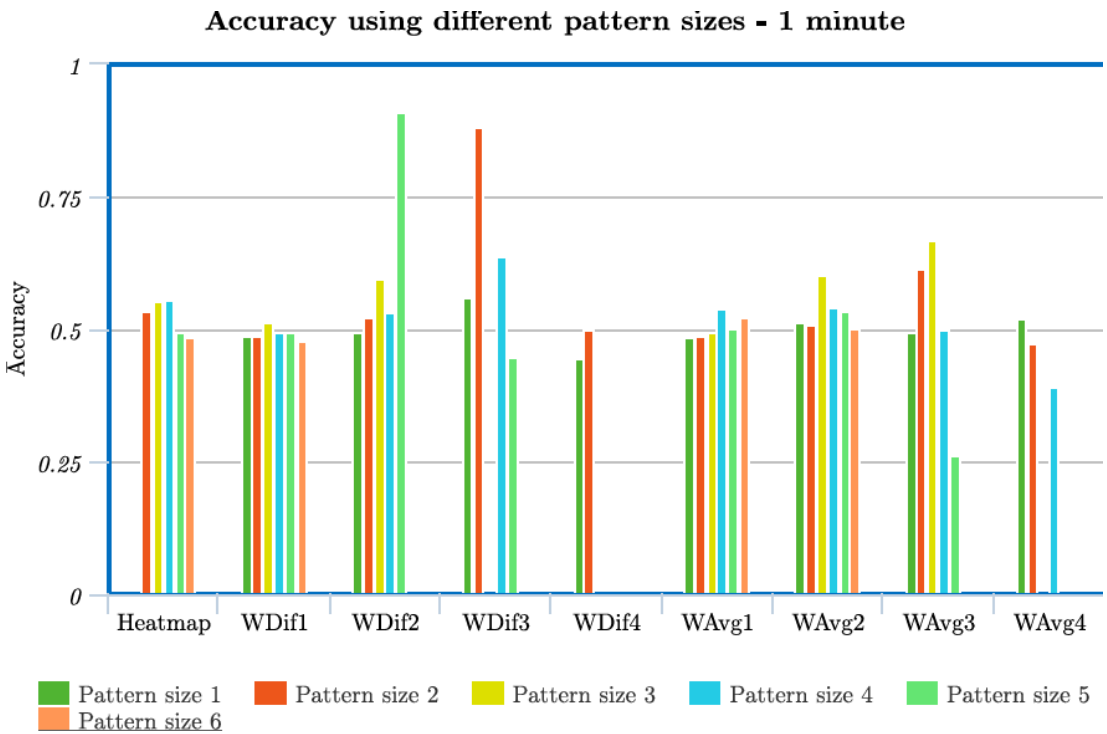
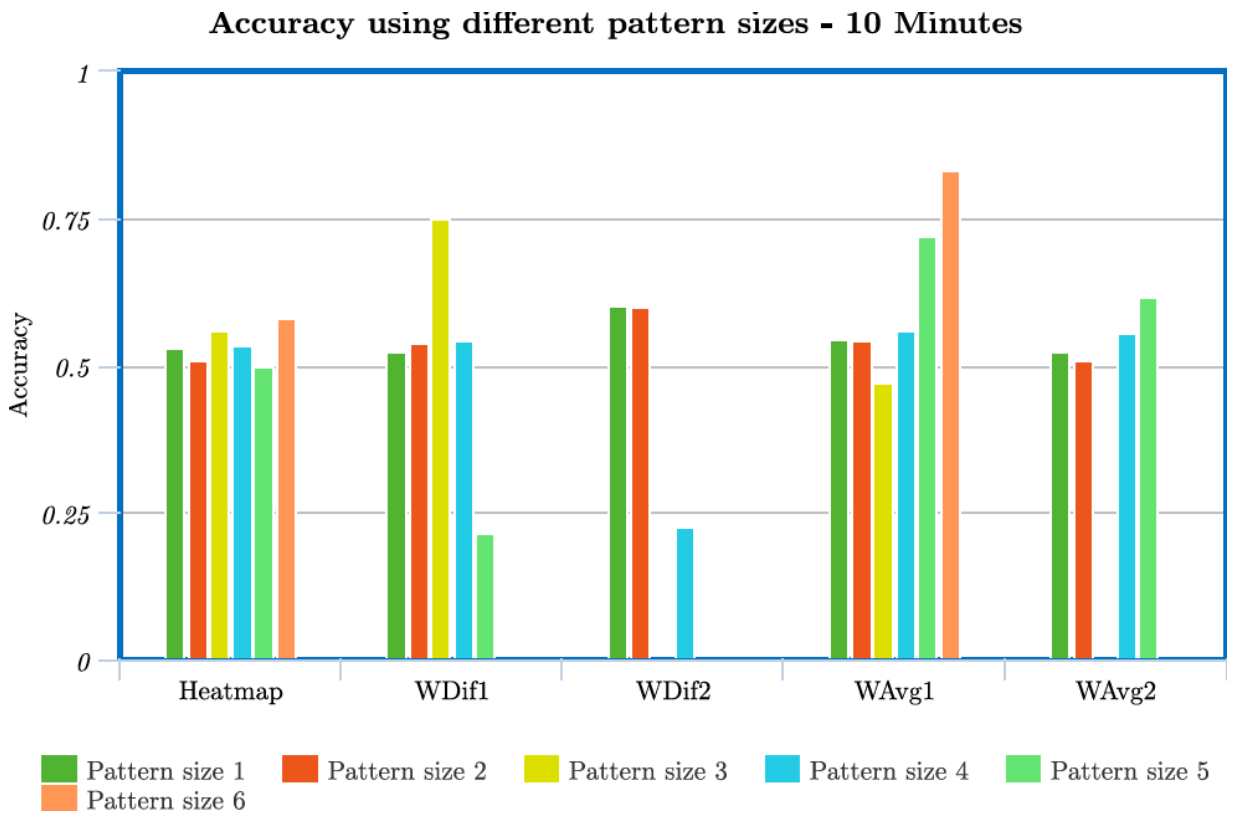
Heatmap based approach vs. Wavelets based approach



Heatmap based approach vs. Wavelets based approach



Behavior within and outside a Global Trend

- The Heatmap and the Wavelet approach were applied over the whole dataset and the performance difference between datasets suggests the existence of seasonal patterns [30].
- To test this hypothesis, two subsets with global opposite trends were identified using moving average and the performance of 400 different pattern sizes was evaluated using only the hash function.
- In this scenario, 35 pattern sizes achieved accuracy higher than 0.6 in the first subset, when tested in the opposite trend, only 4 kept their accuracy.

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Behavior within and outside a Global Trend

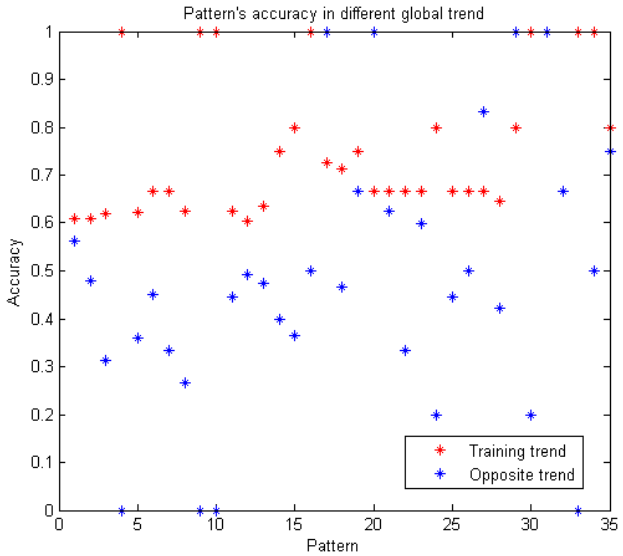

Figure: Patterns accuracy within and outside a global trend.

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Adaptive Method

1. Make an initial training stage in which a general market trend is identified.
2. Every time that a new sample arrives for classification, recalculate the probabilities associated to each trend for the patterns found in the sample.
3. When the count for a new pattern apparitions reaches an specific amount and its probability of being associated with a determined trend surpasses a threshold, add that pattern to the informative frequent patterns' dictionary.
4. When the count of misclassifications for a pattern from the informative frequent patterns' dictionary reaches an specific number or when its probability of being associated with a determined trend falls to a determined threshold, remove that pattern from the informative frequent patterns' dictionary.

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Adaptive Method

The previous procedure was tested for 300 different patterns' sizes, producing 29 configurations where patterns highly associated with a trend were found and whose accuracy was above 0.6. From those 29 configurations, 10 produce 5 or more predictions on the dataset. Three different convergence behaviors were found as it could be observed in figure 12.

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Adaptive Method

There is a need of identifying when a labeled pattern starts to lose the ability to predict the trend. For this reason we presented an online method for informative frequent patterns identification.

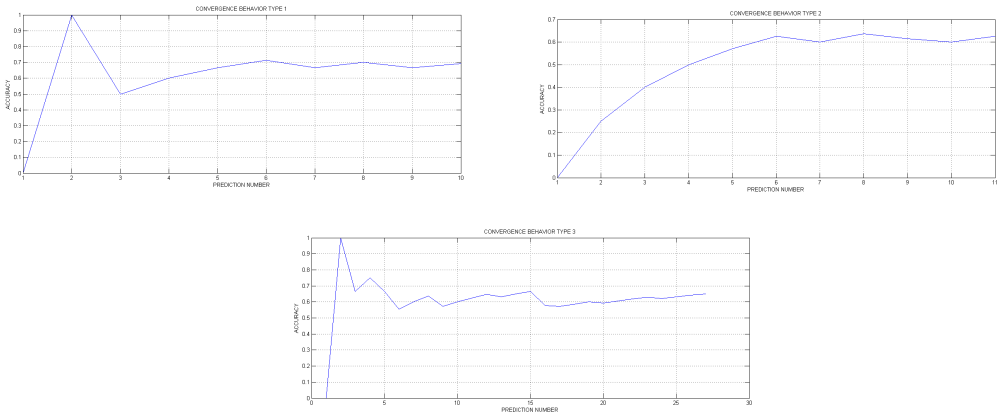

Figure: Different convergence behaviors found for the adaptive method.

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Cluster approach

- Introduces the idea of similarity among patterns.
- Reduces the patterns' search universe to 13 clusters.
- This study is based on the trading data of the manual market of Colombian Forex Market from May 2nd until October 10 during the year 2014. For being more informative, the order book section closer to the spread was chosen for the exploration[45].

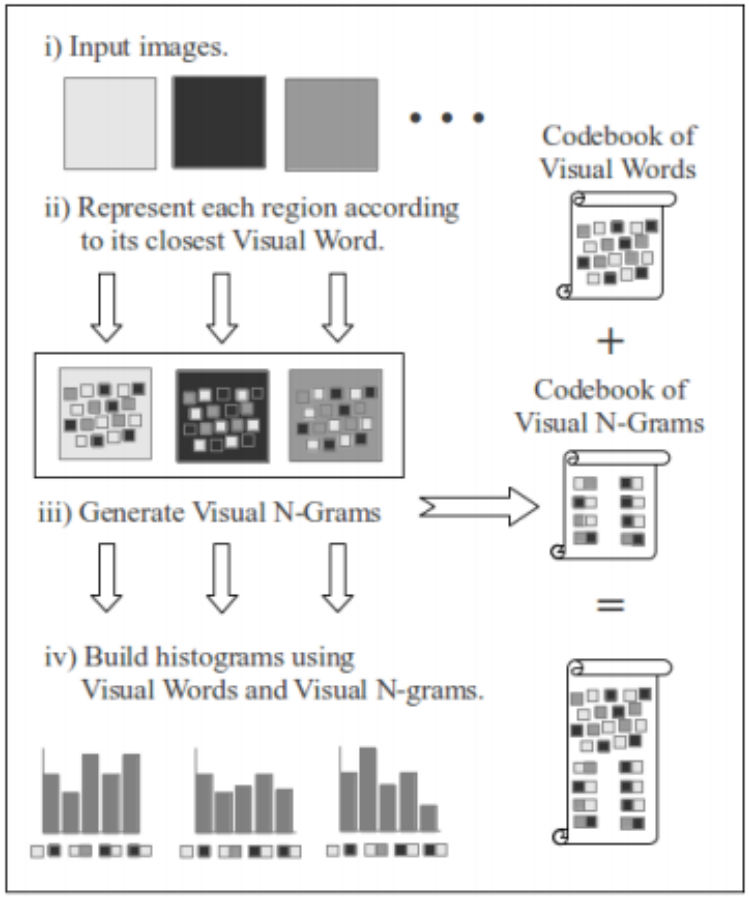

Figure: Bagofvisualngrams general scheme provided by Lopez Monroy et al. [13]

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Cluster approach

- Time-price-volume matrix was chopped and adjusted for working in regions near to the spread.
- The matrix was traversed using tiles of 30x30.
- Every pattern was assigned to a cluster using k-means.
- In a new matrix, the size of each cluster was registered in order to keep track of the frequency at which patterns were assigned to every cluster.
- Finally, each cluster was labeled with the observed trend when the probability of being associated to it was higher than 0.55.

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Cluster approach

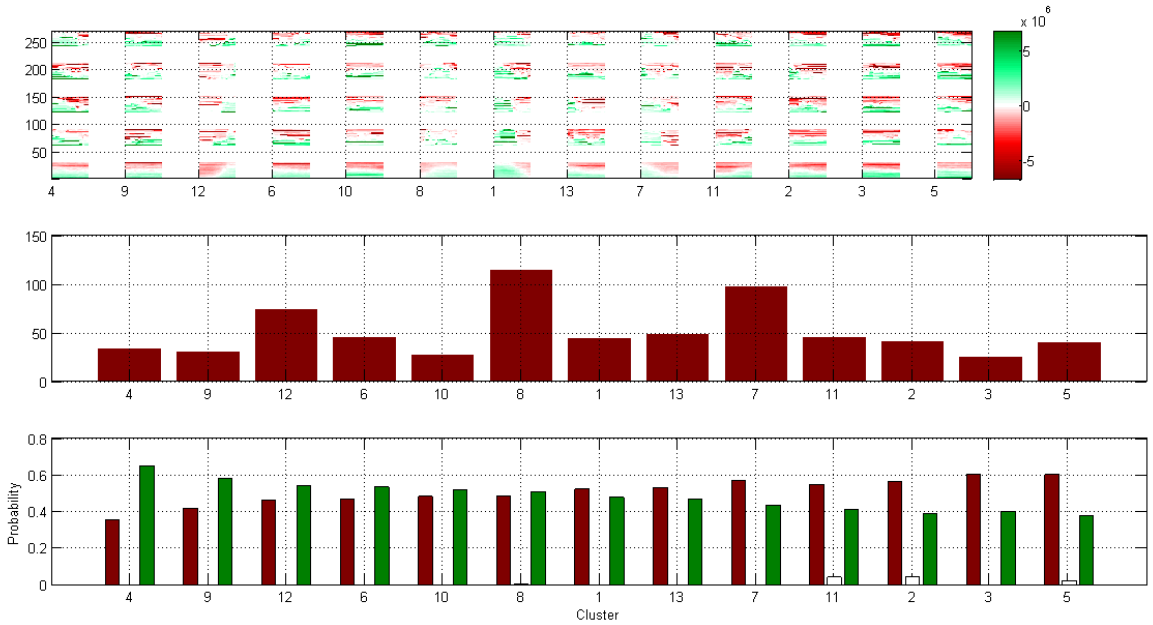

Figure: Clusters and their performance.

Variable Time Horizon and Sliding Window

- This method used five different window arrangements:Vertical arrangement, Horizontal arrangement, Haar Wavelet Transform arrangement, sliding window arrangement and adjacent window arrangement.
- This method used six different time horizons: 2, 4, 6, 10, 16 and 30 minutes.
- There are two important factors to be measured: first, the potential profit generated for each method and second, the risk level associated to each method. The mean of the returns allows to win insights about each methods potential profit. With the purpose of providing a reliability measure, the returns variance was normalized.

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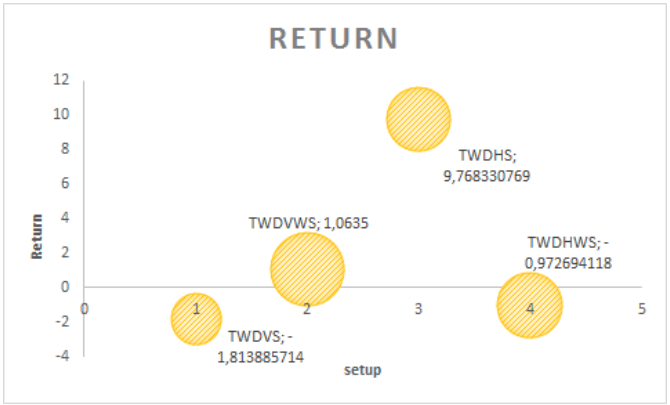
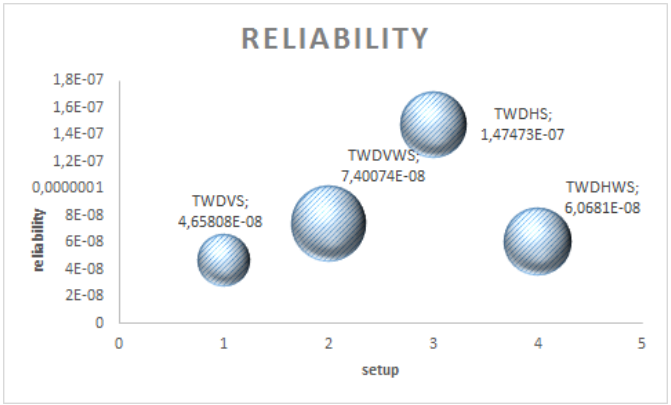
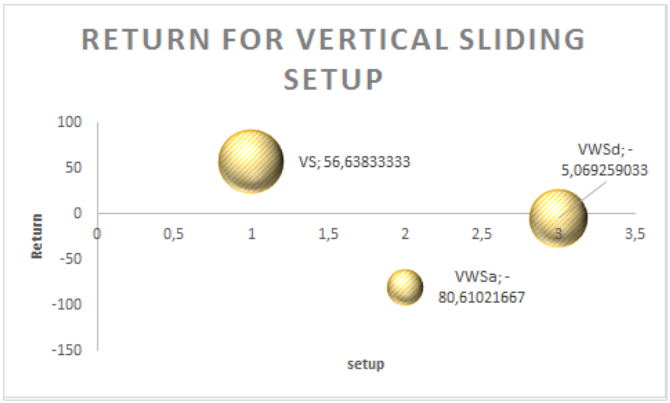


(a) Returns' means over the whole dataset.

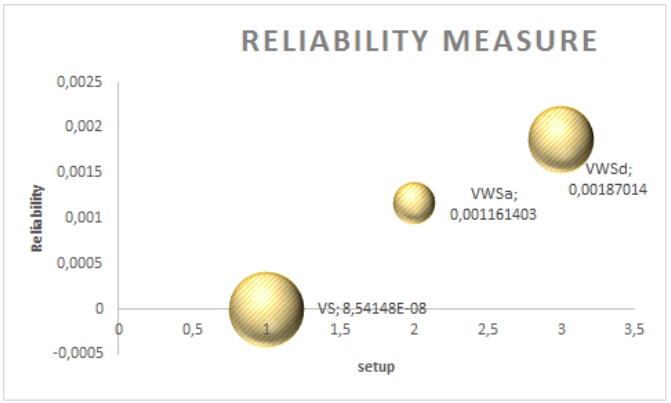


(b) Reliabilities means over the whole dataset.

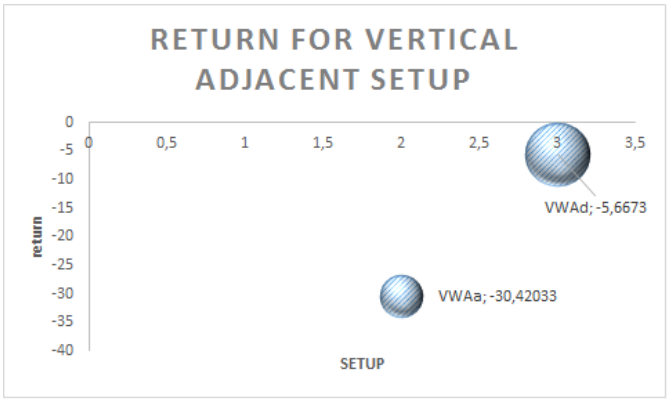
Figure: Returns and Reliabilities Means over the whole dataset using vertical and horizontal window arrangement



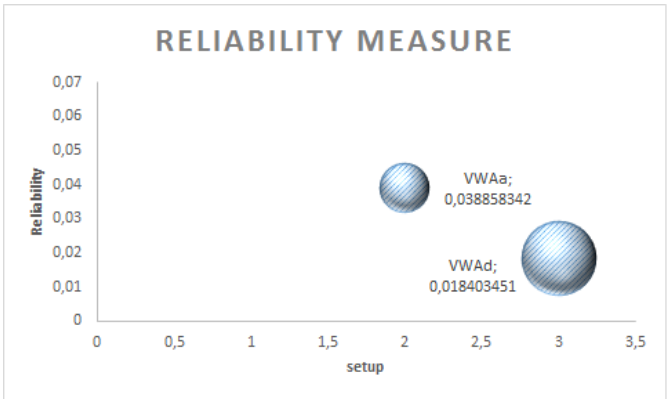
(a) Returns' means over a subset using Vertical Sliding Window arrangement.



(b) Reliability means over a subset using Vertical Sliding Window arrangement.

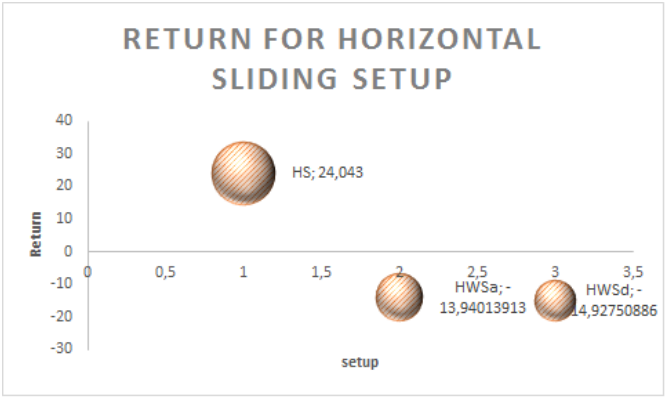


(c) Returns' means over a subset using using Vertical Adjacent Window arrangement.

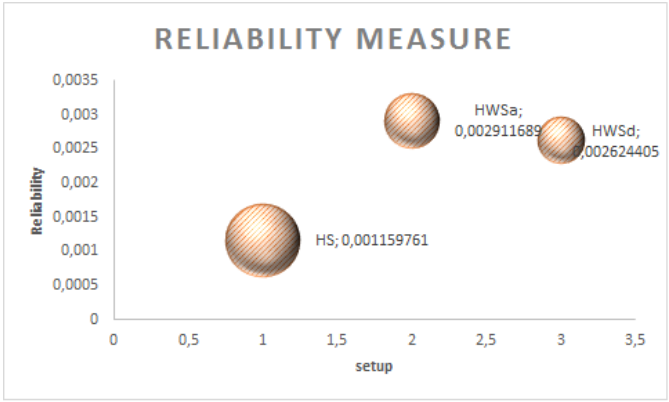


(d) Reliability means over a subset using Vertical Adjacent Window arrangement.

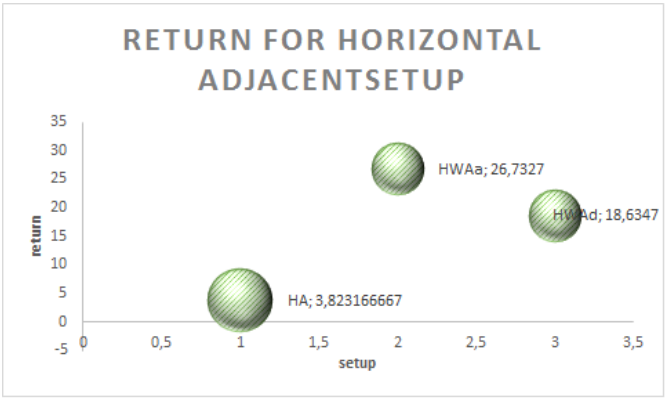
Figure: Returns and Reliabilities means over the same subset



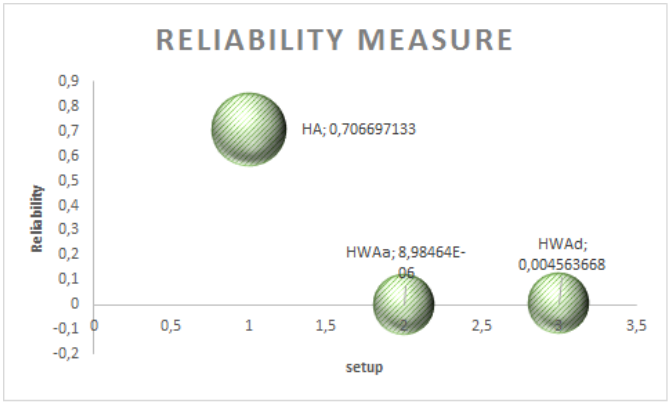
(e) Returns' means over a subset using Horizontal Sliding Window arrangement.



(f) Reliability means over a subset using Horizontal Sliding Window arrangement.



(g) Returns' means over a subset using Horizontal Adjacent Window arrangement.



(h) Reliability means over a subset using Horizontal Adjacent Window arrangement.

Figure: Returns and Reliabilities means over the same subset displaying a clear trend using different Window arrangements.

Conclusions

- A systematic literature review about the Order Book was presented, there is no evidence of previous work made based on the LOB for the Colombian Forex Market until the writting date of the second chapter.
- A methodology which allows representing properly the Colombian Forex Market Order Book information dynamics is presented. The visualization tools presented in this work, can provide the user with a global understanding of a selected time interval in the Colombian Forex Market.

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Conclusions

- Wavelet Heatmap visualization presents in a summarized and efficient way the order book information.
- A trading strategies detection system for the Colombian Forex Market using Order Book information was designed by means of a frequent patterns exploration approximation.

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Conclusions

- Given the seasonality of the found patterns, the presented strategy was reformulated as an adaptive strategy which detects when a pattern is losing predictability in order to start a new training stage for detecting new informative patterns.
- The performace of the proposed system in supporting the financial decision making process in the Colombian Forex Market was evaluated.

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Main Contributions

The following is the summary of the main contributions of this work:

Forex Market Order Book Visualization

A Forex Market Order Book Visualization is presented. This visualization provides the trader with a framework which allows the interpretation of large sections of the limit order book at a glance. It shows relationships between price, volume and time directly. This work was published as a contributed talk named ((Order Book Microstructure Visualization: The case of Colombian High-Frequency Foreign Market. XIII Latin American Congress of Probability and Mathematical Statistics CLAPEM. September, 2014.))

Efficient Trend Predicting LOB Patterns Dictionary Building

Algorithms for Frequent Patterns Exploration are presented. These algorithms have reduced the amount of time required for mining a dataset up to two orders of magnitude depending on the pattern size, thanks to the use of a pattern summary function. The use of the Haar Transform, in some time windows, can reduce the initial dataset without loss of accuracy for the classifier, so it reduces the amount of non valuable information.

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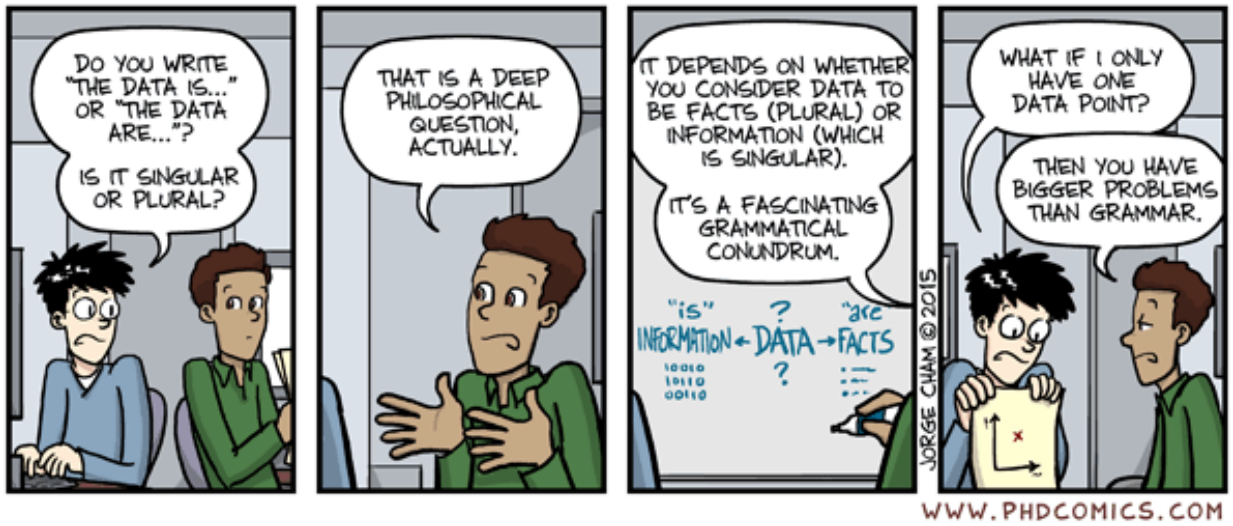
Cluster Based Patterns Identification using Bag of Words

Algorithms for association between frequent patterns and a specific trend are depicted. These algorithms allow calculating the probability of each pattern of being associated with a bearish trend, a bullish trend or with no trend, labeling each pattern accordingly. The use of these algorithms allowed to detect patterns seasonality in the Colombian Forex Market Order Book. This work was presented under the title ((Market Trend Visual Bag of Words Informative Patterns in Limit Order Books)) in the 6th Annual Stevens Conference on High Frequency Finance and Analytics (HF2015) that was held on October 29th-31st, 2015 at Stevens Institute of Technology, Hoboken, NJ, USA. It was published under the same title in the International Conference on Computer Science Proceedings. San Diego, California, U.S.A. (ICCS2016). **Effective Trend Predicting LOB Patterns Dictionary**

Further work on this topic was submitted to the 39th edition of the German Conference on Artificial Intelligence that will be held on September 26th-30th, 2016 in Klagenfurt, Austria. The title of this contribution is ((Liquidity Patterns Identification with Variable Time Horizon Using Bag of Words)). It is currently under peer

Future Work

The fact that the proposed strategies provide useful results with a relatively small dataset from one single currency, throws as a natural consequence the need of testing them in broader datasets and new assets, even for portfolio selection.



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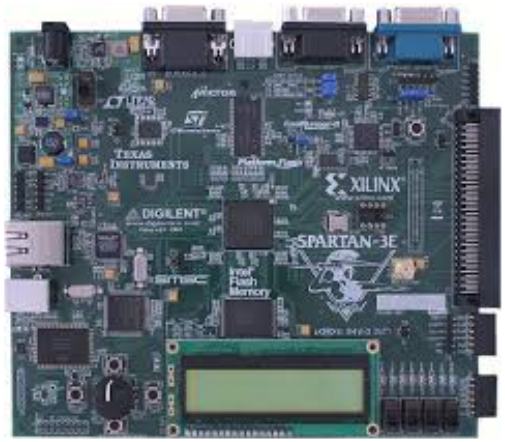
On the other hand, an important feature of the Wavelet based approach is that is highly parallelizable, allowing easy implementation in distributed systems such as GPUs. In order to reduce latency, it would be useful to implement the presented algorithms directly on hardware, for instance in a FPGA.



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