Description of CurrClust – The Currency Clusterer Application

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# Background

The volume of currency markets has a daily value nearly five trillion US dollars. The currency exchange rates reflect the economic balance between countries. Trend in exchange rates of a currency is used to evaluate the economic status of a country and widely used as indicators for investment strategies. However, currencies are priced against each other, and neither of them can be regarded as a standard; all the currencies are constantly exposed to fluctuating economic situations. On the foreign exchange market, not only a pair of currencies are traded but the whole market. To get more precise data, we should look at the whole landscape. A possible solution for this problem is to consider all the major currencies and plot the changes in the exchange rates in a multidimensional space. Instead of focusing on individual currency pairs, we can find those which are bound more strongly and set up a tree of relationships.

An approach to determine the similarity between currencies is calculating the correlation between them. Keksina et al. measured the Pearson correlation coefficient between several pair of currencies. The coefficients were applied for average-linkage cluster analysis and a minimum spanning tree was created [1-2]. This analysis reveals if the value of different currencies are affected by similar economic circumstances and if their exchange rates change similarly.

From clustered currencies, indicators can be extracted about foreign exchange market either to describe trends or to catch impulses [3]. Unbiased indicators are useful tools for those who seek investment in any currencies or for foreign currency traders. Using such tools allows the investor to rely on more exact data than intuitions and helps to plan more successful investment strategies.

# Description of the application

CurrClust, the web application presented here determines the distance between currencies and performs an average-linkage cluster analysis [4]. The data are obtained from the database of the European Central Bank (ECB) consisting historical exchange rates for 33 currencies [5]. To access data within the application, the API from fixer.io [6] was used from where exchange rates can be obtained in json format. The application was written in R using the Shiny package and RStudio.

Instead of using correlations, the change of exchange rates between two time points are used for distance calculation. Therefore, this approach requires less resources and allows short computation time. For a currency pair *A*, *B*, we have the exchange rates at two examined time points *Rab0* = *a0*/*b0*, *Rab1* = *a1*/*b1*. The change of this exchange rates between the time points can be represented as *V*ab = *loge*(*Rab1*) – *loge*(*Rab0*), which can be interpreted as a vector that describes the change of the value of the currency *A* over the change of *B*. This vector is usually determined for other approaches aiming currency relationship analysis [7]. For a given currency, *A*, we can get its value change vector, *VA* in a multidimensional space from the element vectors *V*aa, *V*ab, *V*ac, … (the first term is a zero-length vector). In other words, the changes in exchange rates are regarded as vectors in a space of all currencies. In the currency space, neither vectors can be identical since each currency have zero-length vector in its own dimension. The angles can be determined between a pair of vectors corresponding to any currencies, eg. *VA*, *VB* which can serve as a distance metric. We can calculate the cosine similarity, *cos*(*VA*, *VB*) = *VA* ∙ *V*B / (||*VA*||2 \* ||*VB*||2), where *VA* ∙ *VB* is the dot product, ||*VA*||2 and ||*VB*||2 are the Euclidean norms (length) of the vectors. This similarity value can be reformulated to distance as follows: *dist*(*VA*, *VB*) = *cos-1*(*VA*, *VB*) / π.

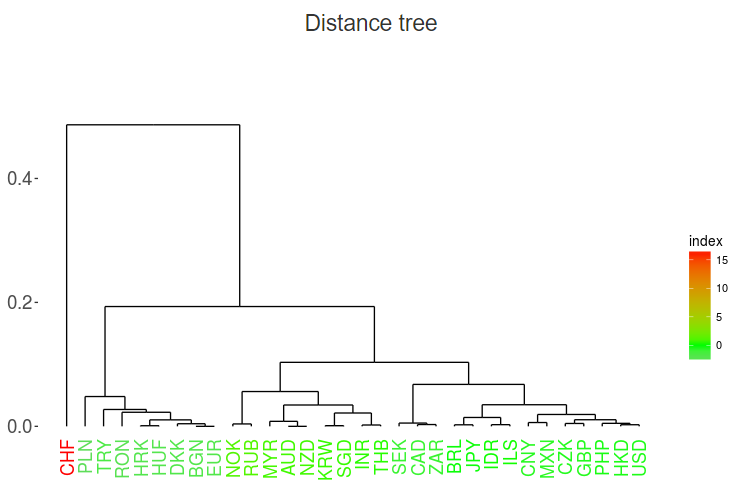
The application calculates two other indicators from the changes of the exchange rates. The Index is resulted as follows: For a given currency, *A*, a hypothetic value change is: *a* = *a1*/*a0*, where *a0* is the value of *A* at the starting date and *a1* is the value of A at the end date. However, we do not know the exact value of *a*, *a1* or *a0*, but we know its exchange rate with another currency, *B*: *a1*/*b1* at starting date and *a0*/*b0* at the end date. Since *b* = *b1*/*b0*, we get *a*/*b* as *a1*/*b1* / *a0*/*b0*. We assume, that the net value changes of all currencies (*A*, *B*, *C*, …) is zero since the changes are balanced; the currencies are strengthened or weakened to one another. Therefore, the averaged value changes *a*, *b*, *c*, … should be 1. For the given currency, *A*, we multiply up the ratios with the given *N* currencies: *a*/*a*, *a*/*b*, *a*/*c* at the logarithmic scale (ln(a) – ln(a), ln(a) – ln(b), ln(a) – ln(c) … to get: (*N \* ln(a) – (ln(a)* + *ln(b)* + *ln(c)*, …)/*a*. Since *a* \* *b* \* *c* \* … should multiply up to the geometric mean, 1, we will get (*N* \* *ln(a)* – 0). We can obtain the value of *a* from this formula. This is a rate by which the value of the currency *A* is changed. This is a base independent value, but still depends on the set of currencies we included in the analysis. CurrClust shows the Index as the percent change of the given currency, therefore negative or positive values indicate weakening or strengthening respectively. CurrClust also calculates a rank based on this index; lower rank indicates that the given currency is stronger than the rest.

The application performs an average-linkage hierarchical clustering on the distance matrix obtained from cosine distances. The user can subsequently pick up a currency to view the most similar currencies.

# Example of use

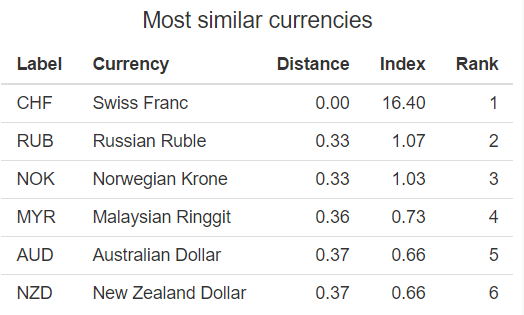
On January 15, 2015, The Swiss National Bank decided to end its cap on Swiss Franc. This event was called as “Frankenschock” since it caused turbulence on foreign exchange market [7]. CurrClust was run on the time interval: the day before the “Frankenschock”, January 14, 2015 and a couple of days later, January 16, 2105. As seen on the clustogram below, the Swiss Franc sharply separated from the rest of the clusters with the highest Index (Figure 1).

**Figure 1.** *Clustogram of the change in currency exchange rates before and after the “Frankenschock” (January 15, 2015)*



If we look at the most similar currencies to the Swiss Franc in this period, we can see that neither of them has the distance value less than 0.4. After such an event, you might want to find a suitable investment in some currencies: if you want to avoid the negative interest rates of the Swiss Franc, you may choose a currency which is the most similar. As seen on the list of most similar currencies, your choice might be the Russian Ruble or the Norwegian Krone (Figure 2). Though the “Frankenschock” had a strong effect on the foreign currency market, it had the least impact on the Norwegian currency.

**Figure 2.** *Most similar currencies to Swiss Franc during the event “Frankenschock” – output of CurrClust*



# Further developmental goals

* Other data sources can be used to obtain exchange rates. However, these data sources may not be freely accessible.
* Instead of the two endpoint vectors of a time interval, correlation coefficients can be used to determine distances. However, the analysis of a whole-time series would require more data processing including smoothing via moving average or phase synchronization. This approach would require more computational resource on the server side, therefore server development would be required.
* Indices of currency value changes will be given for a time series. The user will be able to set the starting and ending time window to plot the data. Furthermore, moving average can be calculated from the indices.

# References

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