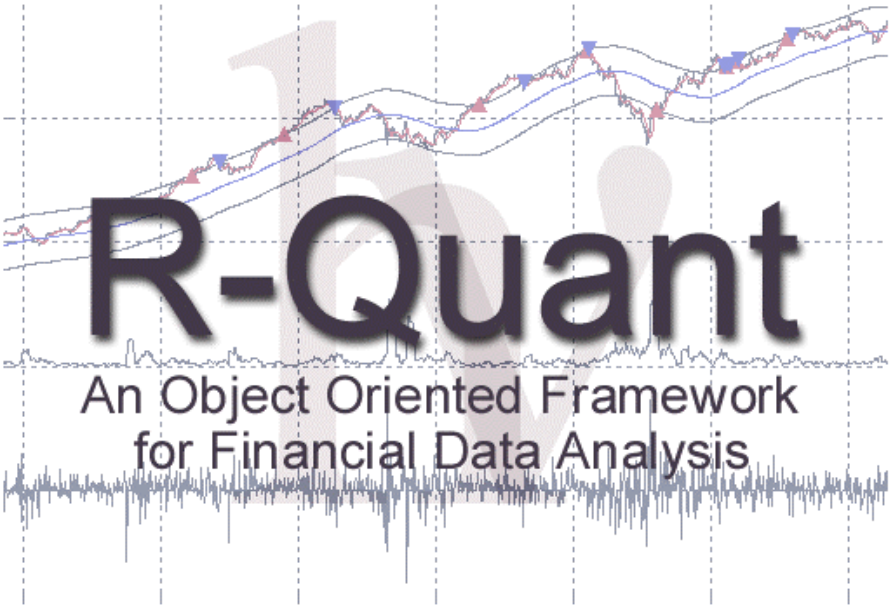

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Abstract

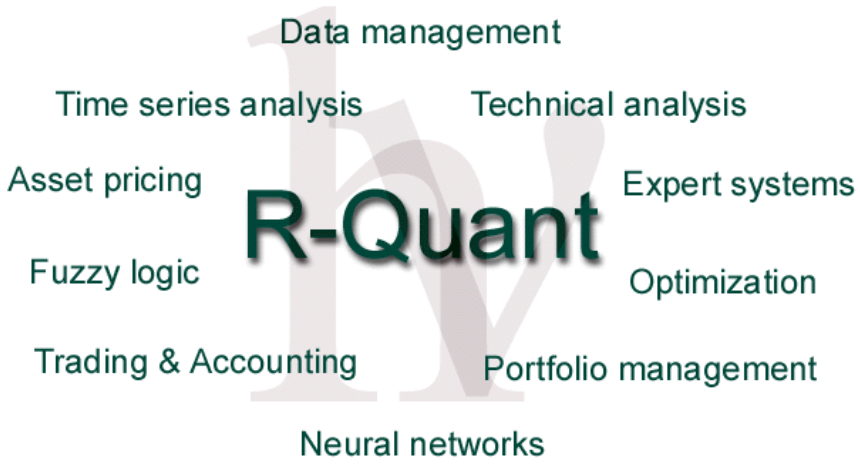
Rapidly growing financial markets bring a wide range of specific problems to a new generation of practical investors responsible for the management of billions dollars on behalf of banks, mutual funds and other financial institutions or private money holders. Quantitative methods becomes deadly important for the selection and further management of an appropriate investment portfolio in situations where the final choice has to be made out of hundreds of assets and other financial instruments presented on the national or international financial markets. On-line data taking, database management, intensive computer modeling, networking and data visualization are distinctive features of the modern quantitative research in finance. R-Quant is a software toolbox, which provides a researcher or quantitative investor with an advanced object oriented data analysis framework. R-Quant is a stand-alone extension of the ROOT and it is especially designed to work with financial objects. A number of projects starting from a simple portfolio evaluation or technical analysis of financial indicators up to a full-scale automatic trading system utilizing neural networks, genetic technologies and fuzzy logic can be handled within this framework.

Introduction

Reflecting an accelerated progress in quantitative research and computer technologies, investment banking and financial markets shift from a competition between human skills and personalities to a competition between mathematical models and computer programs. Quantitative analysis and automatic security trading is a perfect example of cooperation between science and financial industry, where scientific innovations and results of advanced research transform immediately into returns of investments.

Moreover, nowadays it becomes easy for an individual investor to get top quality financial information from a number of Internet based providers and brokerage companies. It implies that an individual with quantitative academic backgrounds can perform on-line trading based on advanced technologies recently used only by large corporative investors.

R-Quant is an object-oriented framework for financial data analysis, which is meant to provide individual or corporative investors and researchers with a set of quantitative tools shown in the figure below.



Because of the ROOT advanced facilities for data storage, networking, visualization and GUI, it becomes possible to concentrate purely on the development of quantitative financial objects and tools.

Data management

Modern financial data management reflects all features of a full-scale data acquisition and storage system. An ordinary NYSE (New York Stock Exchange) TAQ (Trade and Quote) monthly database fills several CDROM disks, therefore it becomes possible to talk about manipulation and analysis of tens or even hundreds gigabytes of off-line data. Moreover a large amount of new information is coming in real time with tick intervals ranging from seconds (FOREX trade and quotes) to hours and days (closing stock prices).

R-Quant uses ROOT trees and files to store historical data for off- or on-line processing. R-Quant also provides a user with a central data manager, which takes care of all manipulations with data base files and trees. Financial data flow may come from different sources: from an external (text) file, from a remote SQL database or from an Internet based on-line data provider such as Telerate or Bloomberg. Therefore R-Quant data manager holds a list of data sources and triggers them according to their scheduling policies. The scheduling can be set individually for every data source object, e.g. data from a text file need to be added only once (on-load) but a scheduler can be set to trigger a new update every second (FOREX) or every hour (delayed stock quotes). If new data are added to the R-Quant database, the data manager will notify all related active objects (time series, indicators, signals, displays) about data change. In this way the on-line data processing and monitoring is organized in R-Quant. The data manager is developed to work in a separate thread to make use of multiprocessing and prevent the system from blocking during intensive data manipulations.

Additionally, since the ROOT I/O model supports object serialization, any R-Quant object can be stored in a ROOT file.

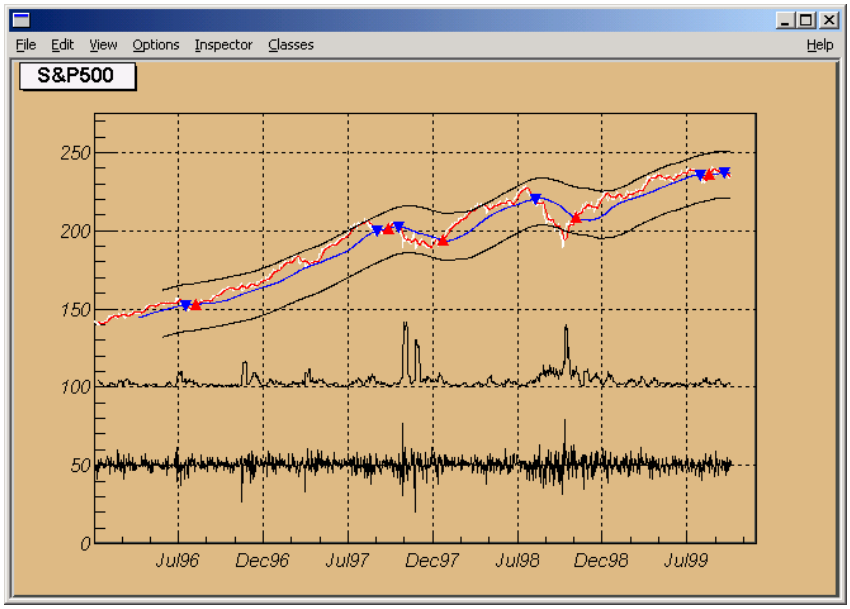
Time series analysis

In general all financial data may be divided into two large groups: time series and cross-sectional data. Historical price (return) series are widely used to determine “volatility” and “expectations” of financial instruments in the portfolio management or asset pricing in order to forecast their future behavior. On the other hand cross-sectional “snap-shots” reflect different states of the whole market and are used to study market clustering, instabilities, crashes, etc.

R-Quant has a developed module for the time series management and analysis. Apart from a variety of statistical methods it also has advanced visualization tools inherited from ROOT. All objects of time series derived classes (indicators, signals) can be set as standardized inputs to R-Quant analyzing facilities (technical analysis, portfolio optimization, Monte-Carlo simulations, neural networks, etc.).

Technical analysis

Apart from a number of embedded technical indicators (SMA, WMA, EMA, PCU, BB, MACD, PTP, DM, ADX, Momentum, ROC, CCI, RSI, PKS, PKF, ALF, KRI, OSC, UOS, PCR, etc.), it is possible to create user-defined indicators and signals using C++ as a scripting language. It is also easy to make an indicator based on another indicator, for example Momentum based on SMA (simple moving average). A trade signal class represents a series of buy, sell and hold signals generated from technical indicators and rules of technical analysis (a simple example: buy or sell signal appears at a cross-point of two, long and short, moving average indicators). Because of the ROOT advanced graphical facility, the technical analysis module of R-Quant can easily compete with existing commercial packages.



Base and derivative instruments

An inheritance tree representing base financial instruments is divided into two branches: risk-free assets (bank accounts, obligations) and risky assets (stocks, bonds, funds). A bank account is considered as a risk-free asset in the portfolio analysis. A base asset class is derived from a ROOT class representing a named object. Once an object of an asset-derived class is created, it is automatically registered by R-Quant and can be accessed by its name in a stand-alone application or via CINT (ROOT C++ interpreter) session. Derivative financial instruments (options, futures, swaps) form another branch and have references to their underlying assets.

Asset pricing

R-Quant has a number of embedded asset pricing methods:

- Black-Scholes
- Finite difference
- Binomial
- Trinomial
- Monte-Carlo

Portfolio management

R-Quant allows a user to create, optimize, dynamically rebalance and trace portfolios containing unlimited number of financial instruments. R-Quant performs portfolio management based on the MPT (Modern Portfolio Theory) and CAPM (Capital Asset Pricing Model). Apart from ROOT MINUIT minimization package, the simulated annealing with Metropolis algorithm is utilized in R-Quant to optimize a portfolio of financial instruments. Dynamical properties of this algorithm can also be applied in quantitative financial modeling. Genetic optimization is planned to be included in R-Quant.

Trade simulations

R-Quant has a “what if?” facility to simulate continuous trading according to a chosen strategy or time series of trading signals. Transaction and other (such as mutual fund fees) costs can be taken into account. This facility is used to evaluate and optimize specific parameters of trading strategies.

Neural networks and genetic algorithms

Neural networks are widely used in finance for pattern recognition and forecasting. As multivariate nonlinear analytical tools, neural networks have the capability to learn underlying market dynamics from noisy and complex time series data. Latest research in genetic algorithms shows promising results in solving different minimization and optimization problems. Particularly they are used to build optimal neural network topologies, select good indicators, create new indicators from existing ones, etc.

Fuzzy logic and expert systems

Apart from Boolean computer logic, in finance humans use rather fuzzy definitions, such as “high” or “low”, which might have different meaning in different situations. A number of R-Quant classes describe fuzzy logic constants, variables and production rules. A fuzzy expert system operates with a collection of fuzzy membership functions and production rules of “*if* x is low *and* y is high *then* z is medium” type. R-Quant implements the forward chaining technique to draw a conclusion based on a set of given facts and a knowledge base. Classes representing fuzzy variables and rules can be combined with R-Quant neural network classes to build neuro-fuzzy expert applications.

Conclusion

In this article R-Quant, an object-oriented framework for financial data analysis, was briefly presented to the HEP computing community.

R-Quant is an "open software" project in its initialization stage and you are welcome to join R-Quant development team if you are interested in quantitative finance, optimization, neural networking, fuzzy logic, genetic algorithms, expert systems and would like to share your experience with the rest of the community.

You are also welcome to visit R-Quant site at *http://garbo.lucas.lu.se/~kosu_fokin/rquant.htm* or contact me at *fokin@tsl.uu.se*