1 Introduction

The rapid growth of the Internet in recent years makes available to every investor an unprecedented wealth of information and data used in the stock portfolio decision-making process. However, easy access to information does not translate into knowledge and does not automatically result in a higher yield. In this thesis, we present NELION, a stock prediction and portfolio management tool that takes advantage of the Internet. NELION is designed to help small investors improve their return on investment and achieve consistently higher yields.

Since the introduction of the first stock market, many attempts have been made to predict the prices of commodities. The result of a simple calculation by Farmer and Lo impressively underlines the motivation for these predictions: A single US dollar invested in US Treasury bills in January 1926 and not touched since then, would have grown to 14 dollars by December 1996. A single US dollar invested in the S&P 500 for the same period would have grown to 1,370 dollars. In the same period, an investor with perfect foresight and who would have placed his cumulative fortune in the financial vehicle with the highest yield at the beginning of every month would have grown his one dollar investment to a staggering 2,296,183,456 dollars [Farmer, Lo 1998]. With returns like those calculated

above, it is easy to see why market prediction almost coincides with the creation of the actual market.

As early as the late 1800's, Charles Dow focused on simple models to predict share prices [Bishop 1960]. One of the components of what was later called the Dow Theory tracked the Industrial Average and the Railroad Average. The theory stated that when the price of both averages remains within a band of 5% for several weeks, "a line has been drawn." If, thereafter, both averages break out of this band in the same direction, the Dow Theory states that the price movement has the momentum to continue with its trend.

Since then both the legal framework and technology progressed. On May 1, 1975, the Security and Exchange Commission of the U.S. ruled that security exchanges could not fix brokerage commission rates, forcing them into a competitive market situation. The result has been a rich landscape of different service providers, including many discount brokers. Unlike traditional stockbrokers, these companies do not offer any investment advice but will manage the stock portfolio of private investors at very competitive prices.

The recent advances of computer technology and the availability of diverse and comprehensive investment information on-line have dramatically affected the domain of the inidividual investor. For the first time, it is feasible for small investors to manage their own investment portfolio, though not necessarily wise. Barber and Odean show that Frank Zappa's

statement that “Information is not knowledge” applies here as well [Barber, Odean 1999] [Zappa 1979]. They show that access to the breadth of information that is available today tends to give investors a false sense of confidence prompting them to trade excessively. Additionally, the authors show that investors tend to hold onto their losing investments disproportionately, while selling winners.

This psychological trap seems to be the Achilles heel for most private investors. Because most investors do not have a clear understanding of their adversity to risk given a medium term benefit, investors are likely to take counterproductive decisions. Inevitably, these decisions have a negative affect on the long-term profitability of the portfolio. Kahneman and Tversky documented this phenomenon as early as 1979 [Kahneman, Tversky 1979]. They asked two groups of subjects the following two questions:

1. In addition to whatever you own, you have been given US$ 1,000. You are now asked to choose between A) A sure gain of US$ 500 and B) A 50% chance to gain US$ 1,000 and a 50% chance to gain nothing.

2. In addition to whatever you own, you have been given US$ 2,000. You are now asked to choose between A) A sure loss of US$ 500 and B) A 50% chance to lose US$ 1,000 and a 50% chance to lose nothing.

Statistically, the two questions evaluate to the same result so that neither choice affects the expected net gain. However, in

the first group 84% chose A), while 69% of the second group chose B). The result indicates that generally, persons tend to be risk averse when faced with a potential gain, but are willing to take more of a risk when faced with a loss.

As Joachim Goldman, the head of the behavioral Finance department of the Deutsche Bank explained in 1999, this tendency leads investors to sell stocks too quickly, simply because they have appreciated from their purchase value [Reitz 2000]. This directly contradicts the old saying that “no one has gotten poorer by realizing gains”, a popular saying within the investment community. However, the development of a portfolio depends on future movements, not on gains or losses in the past. Unless there are clear reasons for the sale of a commodity that has appreciated, one is better off holding the stock than incurring transaction costs by selling it.

Similarly, investors tend to keep stocks in order to avoid realizing a paper loss. Selling a commodity at a depreciated level seals the loss and that seems to be a mental hurdle for the human psychology. However, Koija Rudzio agrees with the behavioral finance research and states that holding an overvalued stock is liable to result in further losses [Rudzio 1999].

In this thesis, I present a system, NELION, that harnesses the massive amounts of stock data available on the Internet and provides an objective prediction and stock selection strategy. The system automatically downloads select information to a local database and uses mathematical models to predict a

stock prediction using auto-regressive, Markov, k-nearest neighbors and artificial neural network algorithms one day, one week and one month into the future.

In order to optimize the mathematical predictors, a background thread uses a genetic algorithm to search the input parameter space for improved models. Since this task can be distributed to any number of task agents running on different computers in the network, NELION is a very powerful prediction tool that constantly adjusts to the changing dynamics of the market.

At the same time, NELION maintains parameters set by the investor in a profile that takes into account the desired return in conjunction with adversity to risk. Based on these investor profiles and the predictions for each stock, the system suggests specific purchases or sales at defined intervals with a selected investment horizon, that lead to an optimal portfolio.

NELION helps the investor set parameters by use of the Test Investor function. This module simulates automatic trades during a specified interval in the past to observe how the investor would have fared. By choosing a profile that corresponds to his needs, a new investor can expect relevant suggestions in the future.

As a proof of concept, an Auto-Investor function built into the system executed transactions for two different investor profiles as an autonomous agent for one year in a simulation using real data and realistic transaction costs. The results show that without any intervention, NELION was able to out-perform the

major indexes, depending on the exact profile and the target markets.

Though one could blindly follow the investment advice as recommended by the system, NELION is designed as a trading advisor that helps the investor focus on promising opportunities and maintain a balanced portfolio. A real investor still has to verify that these suggestions conform to his geographical, industry and personal preferences and estimations.

The rest of the thesis is organized as follows:

In chapter 2, I present the theory of stock price prediction and the Efficient Market Hypothesis. Based on this, I compare numerous examples of how different authors have implemented stock price prediction models.

Chapter 3 addresses the theory of portfolio management based on the Markowitz' approach [Markowitz 1952]. After defining the return of a portfolio and comparing it to the inherent risk associated with investments, I introduce the theory of optimal portfolios and how this theory can be applied.

Based on these two pillars, I describe the theoretical foundation of NELION, in chapter 4. It describes the mathematical models used in the system and how each algorithm is designed.

Chapter 5 covers the implementation details of the system from an information technical perspective, including the interfaces to the Internet for external communication.

The use of NELION is described in Chapter 6, starting with the identification of adequate investor profiles with different risk and return requirements. In this chapter, I also present the promising results from a simulation using the Auto-Investor function, working with real data, executing transactions autonomously for one year.

Finally, in Chapter 7 I conclude on the strengths and weaknesses of NELION and suggest further directions of research.