MULTI-AGENT AND ARTIFICIAL NEURAL NETWORKS PREDICTION FRAMEWORK DEVELOPMENT FOR STOCK INVESTMENT STRATEGY

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DECLARATION

I hereby declare that this dissertation is a presentation of my work and has been generated by me as the result of my own original research. The work has not been submitted to any universities for a higher degree. Wherever contributions of others are involved, they have been acknowledged.

14 March 2016

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PK20108242
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Phang Wai San
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14 March 2016
ABSTRACT

In personal wealth management, it is necessary to have a plan before making investment in order to ensure a profitable return for the investors. The process of generating an investment portfolio with good investment options is complex as it needs to consider a lot of parameters such as the track record of the companies, the company's revenue projection, the risk assessment, the political conditions and the nature of business. In this case, a multi-agent framework can be applied to solve the problem. This thesis focuses on the development of a multi-agent framework for wealth management particularly on stock market investment. The core objective is to develop an Intelligent Investment Planner which utilizes multiple agents that work together to plan, predict, assemble and generate a profitable investment portfolio for its investor. Kuala Lumpur Stock Exchange (KLSE) was selected as the targeted stock market. Four types of agents were developed, including the Web Mining Agent (WMA), the Wealth Forecasting Agent (WFA), the Strategy Agent (SA), and the Wealth Planning Agent (WPA). WMA comprises of an algorithm for web mining which enables it to mine and extract semi-structured information and create new structured information using ontology. The ontology developed is not limited to just a knowledge base to store data in structured format but it plays an important role as an inference sources in the decision making of the buying and selling of stock by performing fundamental analysis. WFA consists of a forecasting model to predict the stock price. This work involves the investigation of the performance of different classifiers (established/combinations/new prediction methods) that are used in stock market prediction. Artificial Neural Network (ANN) was chosen as the target candidates for the forecasting model in this work because of its ability to solve complex problems such as the stock price prediction. Feed Forward Neural Network (FFNN), Elman Recurrent Neural Network (ERNN), Jordan Recurrent Neural Network (JRNN) and Ensemble Neural Network (ENN) were tested in the experiments. Based on the results, ENN outperformed the other ANNs and so it was used in the stock market prediction. SA is responsible to generate the buy-sell signal based on the predicted stock prices. WPA generates the investment portfolio based on the buy-sell signal and the fundamental analysis of stock. It selects potential stocks based on investor's preferences and passes these potential stock candidates to WFA for stock price prediction. In turn, WPA decides on a suitable trading strategy that gives the most profitable investment returns and presents the investment portfolio to the investor. Several experiments were conducted to investigate the performance of the Intelligent Investment Planner in different environments using two trading strategies and the results obtained showed that the proposed planner was able to generate a profitable investment portfolio.
ABSTRAK

MENGIMPLEMENTASI KERANGKA MULTI-AGEN UNTUK PENGURUSAN KEKAYAAN PERSENDIRIAN

# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>CERTIFICATION</td>
</tr>
<tr>
<td>DECLARATION</td>
</tr>
<tr>
<td>ACKNOWLEDGEMENT</td>
</tr>
<tr>
<td>ABSTRACT</td>
</tr>
<tr>
<td>ABSTRAK</td>
</tr>
<tr>
<td>TABLE OF CONTENTS</td>
</tr>
<tr>
<td>LIST OF TABLES</td>
</tr>
<tr>
<td>LIST OF FIGURES</td>
</tr>
<tr>
<td>LIST OF ABBREVIATIONS</td>
</tr>
<tr>
<td>LIST OF SYMBOLS</td>
</tr>
<tr>
<td>LIST OF PUBLICATIONS</td>
</tr>
<tr>
<td>CHAPTER 1: INTRODUCTION</td>
</tr>
<tr>
<td>1.1 Introduction</td>
</tr>
<tr>
<td>1.2 Introduction to Wealth Management</td>
</tr>
<tr>
<td>1.3 Problem Definition</td>
</tr>
<tr>
<td>1.4 Research Questions</td>
</tr>
<tr>
<td>1.5 Research Domain</td>
</tr>
<tr>
<td>1.6 Advantages of multi agent platform for Wealth Management</td>
</tr>
<tr>
<td>1.7 Motivation</td>
</tr>
<tr>
<td>1.8 Research Objectives</td>
</tr>
<tr>
<td>1.9 Research Contributions</td>
</tr>
<tr>
<td>1.10 Organization of the Thesis</td>
</tr>
</tbody>
</table>
CHAPTER 2: LITERATURE REVIEWS

2.1 Introduction

2.2 Agent Technology

2.2.1 How it works?

2.2.2 Multi-agent System (MAS)

2.2.3 The Multi-agent System in Financial Domain

2.2.4 The Multi-agent Framework

2.3 Information Extraction for Ontology Modeling

2.4 Stock Market Prediction

2.5 Artificial Neural Network (ANN)

2.5.1 Introduction to Artificial Neural Network (ANN)

2.5.2 Training Neural Network

2.5.3 Benefits of Artificial Neural Network (ANN)

2.5.4 Types of Artificial Neural Network (ANN)

2.5.5 Application of Artificial Neural Network (ANN)

2.6 Ensemble Machine Learning

2.7 Stock Trading Strategy

2.8 Discussion

2.9 Summary

CHAPTER 3: METHODOLOGY

3.1 Introduction

3.2 Research Methodology

3.3 The Multi-agent Framework

3.4 The System Architecture

3.5 Agent Roles and Responsibilities
3.5.1 The Web Mining Agent
3.5.2 The Wealth Forecasting Agent
3.5.3 The Strategy Agent
3.5.4 The Wealth Planning Agent

3.6 Agents Interaction

3.7 Modeling the IWP Knowledge
3.7.1 Ontology Modeling
3.7.2 Ontology Harvesting
3.7.3 Web Extraction
3.7.4 Populating the Ontology

3.8 Financial Time Series Forecasting with Artificial Neural Network
3.8.1 Feed Forward Neural Network
3.8.2 Elman Recurrent Neural Network
3.8.3 Jordan Recurrent Neural Network
3.8.4 Ensemble Neural Network
3.8.5 The Tuning of Artificial Neural Network

3.9 Data Collection
3.9.1 Data Sources
3.9.2 Data Normalization

3.10 Experimental Evaluation

3.11 Summary

CHAPTER 4: USING ARTIFICIAL NEURAL NETWORK FOR STOCK PRICES PREDICTION

4.1 Introduction
4.2 Experimental Setup
4.3 Experiments on Input
# LIST OF TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Table 2.1:</td>
<td>List of activation function</td>
<td>21</td>
</tr>
<tr>
<td>Table 2.2:</td>
<td>Applications of ANN in different domains</td>
<td>34</td>
</tr>
<tr>
<td>Table 2.3:</td>
<td>ANN in stock market prediction</td>
<td>41</td>
</tr>
<tr>
<td>Table 3.1:</td>
<td>IWP Ontology’s Class Table</td>
<td>55</td>
</tr>
<tr>
<td>Table 3.2:</td>
<td>IWP Ontology’s Property Table</td>
<td>57</td>
</tr>
<tr>
<td>Table 4.1:</td>
<td>The average of 10 trainings using 5 days CP</td>
<td>78</td>
</tr>
<tr>
<td>Table 4.2:</td>
<td>The average of 10 trainings using 5 days CP + EMA₅, MO₅ and RSI₅</td>
<td>79</td>
</tr>
<tr>
<td>Table 4.3:</td>
<td>The average of 10 trainings using 10 days CP</td>
<td>80</td>
</tr>
<tr>
<td>Table 4.4:</td>
<td>The average of 10 trainings using 10 days CP, EMA₁₀, MO₁₀ and RSI₁₀</td>
<td>80</td>
</tr>
<tr>
<td>Table 4.5:</td>
<td>The average of 10 trainings using EMA₅, MO₅, RSI₅, EMA₁₀, MO₁₀ and RSI₁₀</td>
<td>81</td>
</tr>
<tr>
<td>Table 4.6:</td>
<td>Summary of testing on input sets</td>
<td>82</td>
</tr>
<tr>
<td>Table 4.7:</td>
<td>Error rate with 13-4-1</td>
<td>83</td>
</tr>
<tr>
<td>Table 4.8:</td>
<td>Error rate with 13-4-4-1</td>
<td>84</td>
</tr>
<tr>
<td>Table 4.9:</td>
<td>Error rate with 13-10-1</td>
<td>84</td>
</tr>
<tr>
<td>Table 4.10:</td>
<td>Error rate with 13-10-10-1</td>
<td>85</td>
</tr>
<tr>
<td>Table 4.11:</td>
<td>Error rate with pruning</td>
<td>85</td>
</tr>
<tr>
<td>Table 4.12:</td>
<td>Summary of training on the number of hidden neurons</td>
<td>86</td>
</tr>
<tr>
<td>Table 4.13:</td>
<td>Summary of training on the learning rate</td>
<td>87</td>
</tr>
<tr>
<td>Table 4.14:</td>
<td>Summary of training on the momentum rate</td>
<td>89</td>
</tr>
<tr>
<td>Table 4.15:</td>
<td>Feed Forward Artificial Neural Network (FFNN)</td>
<td>92</td>
</tr>
<tr>
<td>Table 4.16:</td>
<td>Elman Recurrent Artificial Neural Network (ERNN)</td>
<td>93</td>
</tr>
</tbody>
</table>
Table 4.17: Jordan Recurrent Artificial Neural Network (JRNN) 95
Table 4.18: Ensemble Artificial Neural Network (ENN) 97
Table 4.19: Summary of ANNs result 98
Table 5.1: Buy-Sell Signal generated by the Strategy Agent 107
Table 5.2: The Filter Strategy 111
### LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Figure 2.1</td>
<td>Agent interacts with environment through sensors and actuators</td>
<td>10</td>
</tr>
<tr>
<td>Figure 2.2</td>
<td>Autonomous Agent</td>
<td>11</td>
</tr>
<tr>
<td>Figure 2.3</td>
<td>Vocabularies collection in Linked Open Vocabularies (LOV, 2016)</td>
<td>16</td>
</tr>
<tr>
<td>Figure 2.4</td>
<td>Open Linked data diagram in March, 2009 (Bizer, Heath and Lee, 2009)</td>
<td>16</td>
</tr>
<tr>
<td>Figure 2.5</td>
<td>Open Linked data diagram in August, 2014</td>
<td>17</td>
</tr>
<tr>
<td>Figure 2.6</td>
<td>Supervised training algorithm</td>
<td>23</td>
</tr>
<tr>
<td>Figure 2.7</td>
<td>Unsupervised training algorithm</td>
<td>24</td>
</tr>
<tr>
<td>Figure 2.8</td>
<td>Feedforward Neural Network topology</td>
<td>28</td>
</tr>
<tr>
<td>Figure 2.9</td>
<td>Full Recurrent Neural Network Topology</td>
<td>29</td>
</tr>
<tr>
<td>Figure 2.10</td>
<td>Jordan Recurrent Neural Network</td>
<td>29</td>
</tr>
<tr>
<td>Figure 2.11</td>
<td>Elman Recurrent Neural Network</td>
<td>30</td>
</tr>
<tr>
<td>Figure 3.1</td>
<td>Flowchart of Research Methodology</td>
<td>44</td>
</tr>
<tr>
<td>Figure 3.2</td>
<td>The Intelligent Wealth Planner Multi-Agent Framework.</td>
<td>46</td>
</tr>
<tr>
<td>Figure 3.3</td>
<td>The System Architecture.</td>
<td>47</td>
</tr>
<tr>
<td>Figure 3.4</td>
<td>Flowchart of Modeling the IWP Knowledge.</td>
<td>53</td>
</tr>
<tr>
<td>Figure 3.5</td>
<td>High Level Overview of the IWP Knowledge Base Architecture.</td>
<td>54</td>
</tr>
<tr>
<td>Figure 3.6</td>
<td>IWP Ontology's Class Diagram.</td>
<td>55</td>
</tr>
<tr>
<td>Figure 3.7</td>
<td>IWP Ontology's Property Hierarchy</td>
<td>56</td>
</tr>
<tr>
<td>Figure 3.8</td>
<td>IWP Ontology's Architecture</td>
<td>59</td>
</tr>
</tbody>
</table>
Figure 3.9: Snapshot of the targeted Web page to harvest.

Figure 3.10: Tag Tree Indicating the structure of a HTML page.

Figure 3.11: The Extraction Template.

Figure 3.12: IWP Ontology's Architecture (A-box).

Figure 3.13: IWP Ontology's Architecture (A-box) 1.

Figure 3.14: The FFNN Model.

Figure 3.15: The ERNN Model.

Figure 3.16: The JRNN Model.

Figure 3.17: The ENN Model.

Figure 3.18: Flowchart of Tuning the ANN Baseline Model.

Figure 3.19: Screenshot of the Historical Price for BAT.

Figure 4.1: Incremental Pruning Algorithm

Figure 4.2: The ENN Model.

Figure 4.3: Training of the five input sets.

Figure 4.4: Training of the hidden neurons structure.

Figure 4.5: Training error rate at learning rate 0.01.

Figure 4.6: Training error rate at momentum rate 0.53.

Figure 4.7: The highest prediction result using ENN obtained by Company 24 with testing error rate of 0.00069.

Figure 4.8: The lowest prediction result using ENN obtained by Company 32 with testing error rate of 0.01986.

Figure 5.1: The Trading Flow

Figure 5.2: The screenshot of Front End Visualizer
Figure 5.3: The Simple Trading Strategy
Figure 5.4: Earning rate trading in 1 company
Figure 5.5: Earning rate trading in 5 companies
Figure 5.6: Earning rate trading in 10 companies
Figure 5.7: Earning rate trading in 15 companies
Figure 5.8: Earning rate trading in 20 companies
Figure 5.9: Earning rate trading in 25 companies
Figure 5.10: The Screenshot of the Outcome of Intelligent Wealth Planner Visualizer
**LIST OF ABBREVIATIONS**

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>AL</td>
<td>Agent Lookup</td>
</tr>
<tr>
<td>ANN</td>
<td>Artificial Neural Network</td>
</tr>
<tr>
<td>AORD</td>
<td>Australian all Ordinary Indexes</td>
</tr>
<tr>
<td>ARIMA</td>
<td>Autoregressive Integrated Moving Average</td>
</tr>
<tr>
<td>BSE</td>
<td>Bombay Stock Exchange</td>
</tr>
<tr>
<td>BDI</td>
<td>Belief-Desire-Intention</td>
</tr>
<tr>
<td>BP</td>
<td>Back propagation</td>
</tr>
<tr>
<td>BPNN</td>
<td>Back propagation Neural Network</td>
</tr>
<tr>
<td>CP</td>
<td>Closing Price</td>
</tr>
<tr>
<td>DCMI</td>
<td>Dublin Core Metadata Initiative</td>
</tr>
<tr>
<td>ECG</td>
<td>Electrocardiogram</td>
</tr>
<tr>
<td>EMA</td>
<td>Exponential Moving Average</td>
</tr>
<tr>
<td>EMH</td>
<td>Efficient Market Hypothesis</td>
</tr>
<tr>
<td>ENN</td>
<td>Ensemble Neural Network</td>
</tr>
<tr>
<td>EPS</td>
<td>Earnings per Share</td>
</tr>
<tr>
<td>ERNN</td>
<td>Elman Recurrent Neural Network</td>
</tr>
<tr>
<td>FFNN</td>
<td>Feed Forward Neural Network</td>
</tr>
<tr>
<td>FIPA-ACL</td>
<td>Foundation for Intelligent Physical Agents- Agent Communication Language</td>
</tr>
<tr>
<td>FOAF</td>
<td>Friend of a Friend</td>
</tr>
<tr>
<td>GD</td>
<td>Gradient Descent</td>
</tr>
<tr>
<td>GI</td>
<td>General Index</td>
</tr>
<tr>
<td>GRNNs</td>
<td>Multiple Generalized Regression Neural Networks</td>
</tr>
<tr>
<td>GUI</td>
<td>Graphical User Interface</td>
</tr>
<tr>
<td>IVR</td>
<td>Interactive Voice Response</td>
</tr>
<tr>
<td>IWP</td>
<td>Intelligent Wealth Planner</td>
</tr>
<tr>
<td>JADE</td>
<td>Java Agent Development Framework</td>
</tr>
<tr>
<td>JADEX</td>
<td>JADE eXtension</td>
</tr>
<tr>
<td>JRNN</td>
<td>Jordan Recurrent Neural Network</td>
</tr>
<tr>
<td>KB</td>
<td>knowledge base</td>
</tr>
<tr>
<td>KLSE</td>
<td>Kuala Lumpur Stock Exchange</td>
</tr>
</tbody>
</table>
KQML - Knowledge Query and Manipulating Language
LVQ - Learning Vector Quantization
MAS - Multi Agent System
MA - Moving Average
Max - Maximum
MFCC - Mel Frequency Cepstral Coefficient
Min - Minimum
MLP - Multilayer Perceptron
MLR - Multiple Linear Regression
MO - Momentum
MSE - Mean Square Error
NAV - Net Asset Value
NN - Neural Network
OWL - Web Ontology Language
PE - Price Earning
PSO - Particle Swarm Optimization
PSOEN - PSO based Selective Neural Network Ensemble
RDF - Resource Description Framework
RDFS - RDF Schema
RMSE - Root Mean Square Error
RNN - Recurrent Artificial Neural Network
RSI - Relative Strength Indicator
RSM - Random Subspace Method
SAF - Semantic Agent Framework
SD - Standard Deviation
SES - Singapore Stock Exchange
SKOS - Simple Knowledge Organization System
SOA - Service Oriented Architecture
SOAP - Simple Object Access Protocol
SOM - Self Organizing Map
STP - Semantic Technology Platform
TAS - Trading Alert System
URI - Uniform Resources Identifiers
WAD - Whiplash-association disorders
WSJ - Wall Street Journal
XML - Extensible Markup Language
LIST OF SYMBOLS

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>%</td>
<td>Percentage</td>
</tr>
<tr>
<td>%K</td>
<td>Stochastics</td>
</tr>
<tr>
<td>%D</td>
<td>Moving Average of Stochastics</td>
</tr>
</tbody>
</table>
LIST OF PUBLICATIONS

Conference Papers


Journal
CHAPTER 1

INTRODUCTION

1.1 Introduction
This research work focuses on the development of a multi-agent framework in a wealth management setting. The aim of this work is to develop an intelligent wealth planner which is able to plan, predict, assemble and generate a profitable investment plan to its investors. The work covers a few research areas including semantic technology, agent technology, stock market prediction and information retrieval. Stock market prediction is a process that tries to guess the stock price in the future. Predicting stock price is not easy but if the stock price can be accurately predicted, it may reduce the investment risk and possibly yield significant profit. Hence, researchers have come up with various methods to predict the stock price movements such as artificial neural network, time series and so on. In this work, experiments will be conducted to test the prediction accuracy of four prediction methods. The best prediction method will be used as the prediction model that will be used by the Wealth Forecasting Agent. Information retrieval is the process of obtaining information that is relevant to the system. In this research, a Web Mining Agent is developed to retrieve information relevant to a particular company. This agent will mine the web to collect relevant information relating to the company’s profile. The retrieved information is then transformed from a semi-structured data into a structured representation via the use of ontology. A successful stock trading strategies is important to consistently make successful stock trades. There are a lot of stock trading strategies available and it may vary from investor to investor. A stock trading strategy helps investors decide what stocks to buy and sell at a particular time. In this research, the strategy agent will choose the suitable trading strategy based on the forecasted stock prices and the Wealth Planning Agent decides on the investment options and generates a financial plan for its investors. A suitable stock trading strategy will be used by this agent so that it can suggest the
most profitable investment plan to its investors. The details of this research are elaborated in this chapter.

1.2 Introduction to Wealth Management
In general, wealth management refers to professional services that provide investment advice, wealth planning and financial plan management to the investors. This service is customizable according to the investor needs. The purpose of wealth management is to manage long-term wealth while making profit. As managing wealth is an ongoing process, the plan is adjusted along the way to cope with the changes. A good wealth management services fulfill the investors’ financial needs and help them to make profit from the investment. A tailored wealth management solution is crucial to help an investors reach their goals.

This research explores the possibility of developing a wealth management system using a multi-agent framework. The purpose of this research is to build a wealth management system that is able to plan, predict, assemble and recommend investment plan for its investors based on certain parameters. In this framework, multiple agents with a variety tasks work together to achieve a certain goal.

1.3 Problem Definition
Currently, there is a trend in Malaysia where investors are starting to rely on the financial services to manage their wealth. It is necessary to have a plan that covers a variety of investment options in order to ensure a profitable return for the investors. From the current trend, it shows that wealth management has a high research value. The task to generate an investment plan with good investment options is complex and dynamic. Thus, an approach that is able to provide simplified yet efficient solution to handle wealth management is required.

This research utilizes multi agent approach in wealth management. The agent concept provides a simplified solution to the problem by using a distributed problem solving strategy. The wealth management system is built on top of a multi-agent platform where multiple agents work together to achieve a pre-determined goal. Each agent performs a specific task such as mining data (Web Mining Agent),
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