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

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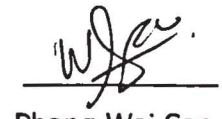

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ABSTRACT

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

Pengurusan kekayaan persendirian memerlukan satu pelan sebelum membuat pelaburan demi memastikan pemulangan yang menguntungkan untuk para pelabur. Proses untuk membina portfolio pelaburan yang baik adalah kompleks kerana ianya melibatkan pelbagai parameter yang perlu dipertimbangkan seperti rekod prestasi syarikat, unjuran pendapatan syarikat, penilaian risiko, keadaan politik dan jenis perniagaan. Dalam karya ini, satu kerangka multi-agen diperkenalkan untuk mengatasi masalah tersebut. Karya ini memberi tumpuan kepada reka bentuk dan implementasi multi-agen bagi pengurusan kekayaan khususnya pada pelaburan saham. Objektif induk kajian ini adalah untuk membina "Intelligent Wealth Planner" yang merupakan satu sistem perancang pelaburan pintar yang melibatkan pelbagai agent yang berkerjasama untuk merancang, meramal, menghimpun, dan menjana satu portfolio pelaburan yang menguntungkan bagi para pelabur. Bursa Saham Kuala Lumpur (KLSE) telah dipilih sebagai pasaran saham dalam kajian ini. Empat bentuk agen diperkenalkan termasuk agent pelombong (WMA), agent ramalan (WFA), agent strategi (SA), dan agent perancang (WPA). WMA mempunyai satu algoritma untuk melombong dan mengekstrak maklumat separa struktur dan kemudianya menyimpan maklumat tersebut secara struktur di dalam ontologi. Ontologi yang dicipta tidak terhad kepada penyimpanan data dalam format yang berstruktur tetapi ia menjadi satu sumber data untuk menjalankan analisis fundamental saham. WFA mempunyai satu model ramalan harga saham melalui kajian terhadap prestasi pelbagai classifiers (mengguna kaedah yang siap sedia/ kombinasi kaedah/ kaedah baru). Rangkaian Neural Buatan (ANN) dipilih dalam karya ini kerana keupayaanya untuk menyelesaikan masalah seperti ramalan harga saham. Rangkaian Neural Feed Forward (FFNN) dan Rangkaian Neural Reccurent (RNN) telah dikaji. Rangkaian Neural Ensemble (ENN) diperkenalkan seterusnya. ENN merupakan model rangkaian neural yang menggabungkan output dari FFNN dan RNN dan menjadikan ia sebagai input kepada model ENN untuk mencapai pretasi yang lebih baik dari segi ketepatan ramalan. SA bertujuan untuk menjana isyarat jual-beli berdasarkan harga peramalan saham. WPA memain peranan untuk menjana portfolio pelaburan berdasarkan isyarat jual-beli saham dan analisis fundamental saham. Pelbagai eksperimen dijalankan untuk mengkaji prestasi "Intelligent Wealth Planner" dalam persekitaran yang berbeza dengan menggunakan pelbagai strategi dagangan saham. Keputusan yang dicapai dalam eksperimen menunjukkan bahawa "Intelligent Wealth Planner" mampu menjana portfolio pelaburan yang menguntungkan.

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LIST OF ABBREVIATIONS

AL	-	Agent Lookup
ANN	-	Artificial Neural Network
AORD	-	Australian all Ordinary Indexes
ARIMA	-	Autoregressive Integrated Moving Average
BSE	-	Bombay Stock Exchange
BDI	-	Belief-Desire-Intention
BP	-	Back propagation
BPNN	-	Back propagation Neural Network
CP	-	Closing Price
DCMI	-	Dublin Core Metadata Initiative
ECG	-	Electrocardiogram
EMA	-	Exponential Moving Average
EMH	-	Efficient Market Hypothesis
ENN	-	Ensemble Neural Network
EPS	-	Earnings per Share
ERNN	-	Elman Recurrent Neural Network
FFNN	-	Feed Forward Neural Network
FIPA-ACL	-	Foundation for Intelligent Physical Agents- Agent Communication Language
FOAF	-	Friend of a Friend
GD	-	Gradient Descent
GI	-	General Index
GRNNs	-	Multiple Generalized Regression Neural Networks
GUI	-	Graphical User Interface
IVR	-	Interactive Voice Response
IWP	-	Intelligent Wealth Planner
JADE	-	Java Agent Development Framework
JADEX	-	JADE eXtension
JRNN	-	Jordan Recurrent Neural Network
KB	-	knowledge base
KLSE	-	Kuala Lumpur Stock Exchange

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

%	-	Percentage
%K	-	Stochastics
%D	-	Moving Average of Stochastics

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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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