PREDICTOR AGENT FOR ONLINE AUCTION CLOSING PRICE

LIM PHAIK KUAN

THESIS SUBMITTED IN PARTIAL FULFILLMENT FOR THE DEGREE OF MASTER OF SCIENCE

SCHOOL OF ENGINEERING & INFORMATION TECHNOLOGY
UNIVERSITI MALAYSIA SABAH

2009

UNIVERSITI MALAYSIA SABAH

BORANG PENGESAHAN STATUS TESIS

JUDUL : PREDICTOR AGANT FOR ONLINE AUCTION CLOSING PRICE

IJAZAH : IJAZAH SARJANA SAINS (SAINS KOMPUTER)

SESI PENGAJIAN : 2006-2009

MATRIX NUMBER : PK2006-8043

Saya, Lim Phaik Kuan mengaku bahawa membenarkan tesis sarjana ini disimpan di perpustakaan Universiti Malaysia Sabah dengan syarat-syarat kegunaan seperti berikut:

1. **Tesis adalah hak milik Universiti Malaysia Sabah.**
2. **Perpustakaan Universiti Malaysia Sabah dibenarkan membuat salinan untuk tujuan mengajar sahaja.**
3. **Perpustakaan dibenarkan membuat salinan tesis ini sebagai bahan pertukaran antara institusi pengajian tinggi.**
4. **TIDAK THERHAD.**

DISAHKAN OLEH

PENULIS: LIM PHAIK KUAN

TANDATANGAN PUSTAKAWAN

ALAMAT:
CENTER OF EXCELLENCE IN SEMANTIC AGENTS,
SCHOOL OF ENGINEERING AND INFORMATION TECHNOLOGY,
UNIVERSITI MALAYSIA SABAH,
LOCKED BAG 2073, 88999,
SABAH.

PENYELIA: A.P. DR. PATRICIA ANTHONY

PENYELIA BERSAMA: A.P. DR. HO CHONG MUN

TARIKH: 2009

CERTIFICATION

NAME	**: LIM PHAIK KUAN**
MATRIX NUMBER	**: PK2006-8043**
TITLE	**: PREDICTOR AGENT FOR ONLINE AUCTION**
DEGREE	**: MASTER OF SCIENCE (COMPUTER SCIENCE)**
VIVA DATE	**: 12 May 2009**

DECLARED BY

1. **SUPERVISOR** **Signature**
   A.P. DR. PATRICIA ANTHONY

2. **CO-SUPERVISOR** **Signature**
   A.P. DR. HO CHONG MUN

3. **DEAN** **Signature**
   A.P. DR. ROSALAM SARBARTLY

DECLARATION

I hereby declare that the material in this thesis in my own except for quotations, excerpts, equations, summaries and references, which have been duly acknowledged.

28 July 2009

Lim Phaik Kuan
PK2006-8043

ACKNOWLEDGMENTS

Firstly, I would like to thank God for his great and awesome power. His grace is always plentiful in my life.

I would like to express my sincere gratitude to Vice-Chancellor of Universiti Malaysia Sabah, Col. Prof. Datuk Dr. Kamaruzaman Hj. Ampon for his permission to carry out this research in Universiti Malaysia Sabah.

I would like to express my thanks to the Dean of School of Engineering and Information Technology, Dr. Rosalam Sarbatly for providing support during my research work.

I would like to take this opportunity to thank my supervisor Associate Professor Dr. Patricia Anthony for her constant encouragement and useful suggestions.

I would like to acknowledge the help and guidance that I received from my co-supervisor, Associate Professor Dr. Ho Chong Mun.

I would like to show my appreciation to the Ministry of Science, Technology and Innovation (MOSTI), Malaysia for supporting this Master's program.

Lastly, I would like to thank everyone who helped me from the beginning until the final phase of my thesis work.

ABSTRACT

Online auction has given consumers a "virtual" flea market with all the new and used merchandises from around the world. Due to the increasing demand of online auction, consumers are faced with the problem of monitoring multiple auction houses, picking which auction to participate in, and making the right bid. If bidders are able to predict the closing price for each auction, then they are able to make a better decision on the time, place and the amount they can bid for an item. However, predict closing price for an auction is not easy since it is dependent on many factors such as the behaviour and the number of the bidders. This thesis investigates one of the methods used in predicting the closing price of an auction called the Grey System Theory. This method has been known to accurately speculate values in areas where the information is insufficient. Three other predictor methods are compared with Grey System Theory which are Time Series, Artificial Neural Network and Simple Exponential Function. These four prediction methods are then applied into different agent. The Grey System Agent is compared with other prediction agents namely the Time Series Agent, the Artificial Neural Network Agent and the Simple Exponential Function Agent. The effectiveness of these agents is evaluated using a simulated auction environment as well as real data obtained from eBay. In conclusion, Grey System Agent is able to predict well in simulated marketplace and eBay. Besides that, moving observation increased the performance of the prediction.

ABSTRAK

Lelong dalam talian telah memberi pengguna-pengguna satu pasar lambak "maya" dengan semua dagangan yang baru dan terpakai dari seluruh dunia. Disebabkan oleh penokokan permintaan lelong dalam talian, pengguna-pengguna bersemuka dengan masalah memantau rumah-rumah lelong, pemilihan lelong untuk disertai, dan memastikan bahawa mereka mendapat item tersebut sesuai dengan permintaan mereka. Jika pembida-pembida mampu untuk meramalkan harga penutup untuk tiap-tiap lelong, maka mereka mempunyai kelebihan daripada pembida-pembida yang lain. Bagaimanapun, meramal satu harga penutup untuk satu jualan lelong adalah bukan mudah memandangkan ianya adalah bergantung kepada banyak faktor seperti kelakuan pembida dan jumlah pembida-pembida yang menyertai lelong itu. Tesis ini menjelaskan satu kaedah ramalan harga penutup satu jualan lelong yang dipanggil "Grey System Theory". Kaedah ini telah diketahui dapat meramal dengan tepat walaupun maklumat tidak mencukupi. Tiga kaedah-kaedah peramal yang lain dibandingkan dengan "Grey System Theory" yang adalah "Time Series", "Artificial Neural Network" dan "Simple Exponential Function". Ini empat kaedah-kaedah ramalan sedang kemudian memohon kepada ejen berbeza. "Grey System Agent" dibandingkan dengan ejen-ejen ramalan lain yakni "Time Series Agent", "Artificial Neural Network Agent" dan "Simple Exponential Function Agent" secara teratur. Untuk menguji keberkesanan ini agent-agent adalah dinilaikan menggunakan satu persekitaran lelong yang tersimulasi serta data sebenar yang diperolehi dari eBay. Dalam kesimpulan, "Grey System Agent" mampu meramalkan baik dalam persekitaran lelong yang tersimulasi dan eBay. Selain itu, data bergerak member keputusan yang lebih baik daripada data tetap.

CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF SYMBOLES AND ABBREVIATION

GSA		Grey System Agent
GSAF		Grey System Agent with Fixed Observations
GSAM		Grey System Agent with Moving Observations
TSA		Time Series Agent
TSAF		Time Series Agent with Fixed Observations
TSAM		Time Series Agent with Moving Observations
ARIMA		Autoregressive Integrated Moving Average
ARMA		Autoregressive Moving Average
ANNA		Artificial Neural Network Agent
ANNAF		Artificial Neural Network Agent with Fixed Observations
ANNAM		Artificial Neural Network Agent with Moving Observations
SEFA		Simple Exponential Function Agent
SEFAF		Simple Exponential Function Agent with Fixed Observations
SEFAM		Simple Exponential Function Agent with Moving Observations
f^{i}	-	ITH ORDER ACCUMULATING GENERATION OPERATORS (AGO)
n	-	NUMBER OF OBSERVATION DATA
$\sum$	-	SUMMATION
t	-	TIME STEP
$\forall$	-	EVERY
$\hat{f}$	-	INVERSE ACCUMULATING GENERATION OPERATORS (IAGO)
e	-	EXPONENTIAL FUNCTION
y_t	-	VALUE FORECASTING AT TIME T
$\emptyset_p$	-	PARAMETER FOR AUTOREGRESSIVE MODEL AT ORDER P
θ_q	-	PARAMETER FOR MOVING AVERAGE MODEL AT ORDER Q
ε_t	-	RESIDUAL AT TIME T
Δy_t	-	THE FIRST DIFFERENCE OF THE EXCHANGE RATE
$\emptyset(B)$	-	AUTOREGRESSIVE OPERATOR

$\theta(B)$	-	MOVING AVERAGE OPERATOR
r_k	-	LAG *K* AUTOCORRELATION FUNCTION (ACF)
$\bar{y}$	-	MEAN OF y
r_{kk}	-	PARTIAL AUTOCORRELATION FUNCTIONS (PACF) WITH COEFFICIENT OF ORDER *K*
$\propto$	-	SIGNIFICANT VALUE
τ	-	NUMBERS OF PARAMETER
Q_{LB}	-	LJUNG-BOX TEST STATISTIC
n'	-	SAMPLE SIZE AFTER FIRST DIFFERENCE
h	-	NUMBER OF LAGS BEING TESTED
$\rho(j)$	-	RESIDUAL OF AUTOCORRELATION AT LAG j
ESS	-	SUM OF SQUARED ERRORS
k	-	TOTAL VARIABLE
N_{INPUT}	-	NUMBER OF ELEMENT IN INPUT VECTOR
$N_{HIDDEN\ LAYER}$	-	NUMBER OF NEURON IN HIDDEN LAYERS
$N_{OUTPUT\ LAYER}$	-	NUMBER OF ELEMENT IN OUTPUT LAYERS
N_{OUTPUT}	-	NUMBER OF ELEMENT IN INPUT VECTOR
W	-	WEIGHT VALUE
B	-	BIAS VALUE
F	-	ACTIVATION FUNCTION
X_i	-	INPUT UNIT OF ANN, $i = 1, \ldots, n$
Z_j	-	HIDDEN UNIT OF ANN, $j = 1, \ldots, p$
Y_k	-	OUTPUT UNIT OF ANN, $k = 1, \ldots, m$
δ_k	-	ERROR INFORMATION TERM
Δw_{jk}	-	WEIGHT CORRECTION TERM
C	-	CONSTANT VALUE IN GREY SYSTEM PREDICTION MODEL

LIST OF APPENDIX

CHAPTER 1

INTRODUCTION

1.1. Overview

The word "auction" is derived from the Latin "aguere", which means "to increase" or "augment" (Krishna, 2002). Auction markets provide centralized procedures for the exposure of purchase and sale orders to all market participants simultaneously (Lee, 1996). In fact, auctions are not a new topic but have been widely used for centuries (Cassady, 1968). The design and conduct of auctioning institutions have caught the attention of many people over thousands of years. One of the earliest reports of an auction was that used to allocate scarce resources in Babylon from about five hundred B.C. (Shubik, 1983). During the closing years of the Roman Empire, auctions were used to sell everyday household objects, war spoils, or even tax collection rights. In China, the personal belongings of deceased Buddhist monks were sold at auctions as early as the seventh century A.D. (Paul and Robert, 1982). Auction is defined as a market institution with an explicit set of rules determining resource allocation and price on the basis of bids from the market participants (McAfee and Mcmillan, 1987). An auction is also defined as a bidding mechanism, described by a set of auction rules that specify how the winner is determined and how much he has to pay (Wolfstetter, 2002). Against this background, an online auction can be defined as an Internet-based version of a traditional auction. Online auction is one of the most popular and effective ways of trading by bidding for products and services over the Internet (Bapna *et al.*, 2001). Nowadays, online auctions have become an increasingly popular and effective medium for transacting businesses as well, either procuring goods or services, both between individuals over the internet and between business and their suppliers. According to He *et al.*, (2003), online auctions are increasingly being used for a variety of e-commerce applications. Online auctions are establishing the "true market value" and distribution of goods, property, and real estate to those who value it most highly. Today, online auction is an accepted media where bidders can compete equally and act in their own interest. They fill the buying and selling needs of thousands of people, products and properties all over the world. Objects as diverse as spectrum rights, treasury bills, and cars are regularly auctioned off. Since many products have their origin on the auction block, no one, regardless of financial status, can escape the effects of auction buying and selling in online auction. The utilization of online auction is widely emerging and becoming a popular business entity because of the flexibility and convenience that it offers to consumers. Online auction has given consumers a "virtual" flea market with all the new and used merchandises from around the world. They also give sellers a global storefront from which to market their goods. Compared to traditional auction, the globalization of internet auction has attracted more consumers to purchase various goods anywhere and anytime by just a click on their finger tip.

Over the last few years, a big number of online auction houses have emerged and the number is increasing rapidly. Some examples of popular online auction houses include eBay[1], Amazon[2], Yahoo!Auction[3] and UBid[4]. According to the internet auction list[5], there are currently more than two thousand six hundred auction company listings around the world. The total revenue of the popular auction house e-Bay (in Figure 1.1) has increased by more than $4.4 billion from 2004 ($3,271,309) to 2007 ($7,672,329). In addition, over ten million items can be found daily for sale at online auctions. Some of the examples are the antiques, books, electronic appliances, agricultural products and so forth. Online auctions continue to attract many customers, and currently sell goods worth over thirty billion USD annually (David *et al.*, 2005). In eBay alone, for example, there are often hundreds or sometimes even thousands of concurrent auctions running worldwide selling such substitutable items.

---

[1] http://www.ebay.com/
[2] http://www.amazon.com/
[3] http://auctions.yahoo.com/
[4] http://www.ubid.com/
[5] http://www.internetauctionlist.com/

EBAY
eBay Inc. NASDAQ-GS

Learn More About XBRL

Income Statements | Balance Sheets | Statements of Cash Flow | Financial Ratios

Annual Income Statement (values in 000's)

Get Quarterly Data

Period Ending:	12/31/2007	12/31/2006	12/31/2005	12/31/2004
Total Revenue	$7,672,329	$5,969,741	$4,552,401	$3,271,309
Cost of Revenue	$1,762,972	$1,256,792	$818,104	$614,415
Gross Profit	$5,909,357	$4,712,949	$3,734,297	$2,656,894
Operating Expenses				
Research and Development	$619,727	$494,695	$328,191	$240,647
Sales, General and Admin.	$3,081,408	$2,598,220	$1,835,458	$1,291,078
Non-Recurring Items	$1,390,938	$0	$0	$0
Other Operating Items	$204,104	$197,078	$128,941	$65,927
Operating Income	$613,180	$1,422,956	$1,441,707	$1,059,242
Add'l income/expense items	$154,271	$130,021	$111,148	$77,867
Earnings Before Interest and Tax	$767,451	$1,552,977	$1,552,855	$1,137,109
Interest Expense	$16,600	$5,916	$3,478	$8,879
Earnings Before Tax	$750,851	$1,547,061	$1,549,377	$1,128,230
Income Tax	$402,600	$421,418	$467,285	$343,885
Minority Interest	$0	($4)	($49)	($6,122)
Net Income-Cont. Operations	$348,251	$1,125,639	$1,082,043	$778,223
Net Income	$348,251	$1,125,639	$1,082,043	$778,223
Net Income Applicable to Common Shareholders	$348,251	$1,125,639	$1,082,043	$778,223

Figure 1.1: Annual Revenue of eBay Auction House from 2004 until 2007[6]

1.2 Online Auction

A question may be asked, "Why are auctions used rather than other selling devices such as posting a fixed price?" According to Cassady (Cassady, 1968), one of the answers is, perhaps that some products have no standard value. For example, the price of any catch of fish depends on the demand and supply conditions at a specific moment of time, influenced possibly by prospective market developments. Besides, for manuscripts and antiques too, price must be remade for each transaction. For example, how can one discover the worth of an original copy of antiques from Tang Dynasty except by an auction method? To date, many traditional auction businesses are moving into the online auctions space joining winners in this market place as a consequence of rapid growth of advance computer technology (Akula and Menasce, 2004). The major difference between these two types is the additional degree of flexibility, multiplicity as well as convenience in the way the online auction is conducted.

[6] http://fundamentals.nasdaq.com/nasdaq_fundamentals.asp?CompanyID=7098&NumPeriods=4&Duration=2&documentType=1&coname=eBay+Inc.&logopath=http%3A%2F%2Fcontent.nasdaq.com%2Flogos%2FEBAY.GIF&market=NASDAQGS&PageName=Company+Financials&selected=EBAY&symbol=EBAY&ads=1

References

Akula, V. & Menasce, D. A. 2004. An Analysis of Bidding Activity in Online Auctions. *Proceedings of Springer-Verlag*. Berlin. 206-217.

Anthony, P. & Jennings N. R. 2003a. Agent for participating in multiple online auctions. *ACM TOIT*. **2**(3): 1-32.

Anthony, P. & Jennings, N. R. 2002. Evolving Bidding Strategies for Multiple Auctions. *Proceedings of Fifteenth European Conference on AI (ECAI)*. Lyon, France. 178-182.

Anthony, P. & Jennings, N. R. 2003b. A Heuristic Bidding Strategy for Multiple Heterogeneous Auctions. *Proceedings of Fifth Int. Conference on Electronic Commerce*. Pittsburgh, USA. 6-16.

Anthony, P. & Jennings, N. R. 2003c. Developing a Bidding Agent for Multiple Heterogeneous Auctions. *ACM Trans on Internet Technology*. **3** (3): 185-217.

Anthony, P. 2003. *Bidding Agents for Multiple Heterogeneous Online Auctions*. Ph.D Thesis. Faculty of Engineering and Applied Science, Department of Electronics and Computer Science. University of Southampton.

Anthony, P., Hall, W., Dang, V. & Jennings, N. R. 2001. Autonomous Agents for Participating In Multiple On-Line Auctions. *Proceedings of IJCAI Workshop on E-Business and the Intelligent Web*. Seattle, WA. 54-64.

Anwar, S., McMillan, R., Zheng, M., L. 2006. Bidding Behaviour In Competing Auctions: Evidence From eBay. *Proceedings of European Economic Review*. **50**: 307-322.

Bapna, R., Goes, P. & Gupta, A. 2001. Insights and Analyses of Online Auctions. *Communications of the ACM*. **44**(11): 43-50.

Bapna, R., Goes, P., & Gupta, A. 2003. Replicating Online Yahoo Auctions to Analyze Auctioneers' and Bidders Strategies. *Information Systems Research*. **14**(3): 244-268.

Bierman, H. S. 1998. *Game Theory with Economic Applications, 2nd Edition*. USA: Addison-Wesley.

Bowerman B. L. and O'Connell R. T. 1993. Forcasting and Time Series: An Applied Approach Third Edition. Wadsworth, Inc.

Box, G. E. P., Jenkins, G. M. & Reinsel, G. C. 1994. *Time Series Analysis Forecasting and Control, 3rd Edition*. New Jersey: Prentice Hall.

Bussmann, S., Jennings,N. R. & Wooldridge, M. J. 2001. On The Identification of Agents in the Design of Production Control Systems. *In Agent-Oriented Software Engineering* (eds. P. Ciancarini and M. Wooldridge). 141-162. Springer Verlag.

Caglayan, A. & Harrison, C. 1997. *Agent Source Book. A Complete Guide to Desktop, Internet, and Intranet Agents*. USA: John Wiley & Sons, Inc.

Cassady, R. J. R. 1968. *Auctions and Auctioneering*. **58**(4): 959-963.

Chen, L. R., Lin, C. H., Hsu, R. C., Ku, B. G. & Liu, C. S. 2003. A study of Li-ion Battery Charge Forecasting Using Grey Theory. *Proceedings of IEICE/IEEE INTELEC'03*. 744-749.

Chiang, J. S., Wu, P. L., Chiang, S. D., Chang, T. L., Chang, S. T. & Wen, K. L. 1998. *Introduction to Grey System Theory*. Taiwan: Gao-Li Publication.

Chiou, H. K., Tzeng, G. H., Cheng, C. K. & Liu, G. S. 2004. Grey Prediction Model for Forecasting the Planning Material of Equipment Spare Parts in Navy of Taiwan. *Proceedings of the World Automation Congress IEEE, 2004*. **17:** 315- 320.

Cho, M. Y., Hwang, J. C. & Chen, C. S. 1995. Customer Short Term Load Forecasting by Using ARIMA Transfer Function Model. *Proceedings of IEEE*. 317-322.

Chu, Y., F. & Liu, S., F. 2007. Predicting Chinese Logistics Scale in 10 Years with Model GM(1,1). *Proceedings of 2007 IEEE International Conference on Grey Systems and Intelligent Services*. Nanjing, China. 370-374.

Clementsa,M., P., Fransesb, P., H. & Swanson, N., R. 2004. Forecasting Economic And Financial Time-Series With Non-Linear Models. *International Journal of Forecasting*. **20**: 169– 183.

Contreras, J., Espínola, R., Nogales, F. J. & Conejo, A. J. 2003. ARIMA Models to Predict Next-Day Electricity Prices. *Proceedings of IEEE Transactions On Power System*. **18**(3): 1014-1020.

David, E. Rogers, A., Schiff, J., Kraus, S. & Jennings, N. R. 2005. Optimal design of English auctions with discrete bid level. *Proceedings of Sixth ACM Conference on Electronic Commerce (EC'05)*. Vancouver, Canada. 98-107.

Delurgio, S. A. 1998. *Forecasting: Principles and Applications.* New York: McGraw-Hill.

Deng J. 1988. Introduction to Grey System Theory. *The Journal of Grey System.* **1** (1989):1-24.

Dimakos, X., K., & Aas, K. 2004. Integrated Risk Modeling. *The Journal of Statistical* modeling. **4**: 265-277.

Doug, Mahone, W., Lu, R. & Wu, S. 1994. Construction of an Artificial Neural Network for Simple Exponential Smoothing in Forecasting. *ACM.*

Dutta,G., Jha, P., Laha, A., K. & Mohan, N. 2006. Artificial Neural Network Models for Forecasting Stock Price Index in the Bombay Stock Exchange. *Journal of Emerging Market Finance.* **5**(3): 243-295.

Edigera, V. S. & Aka, S. 2007. ARIMA Forecasting Of Primary Energy Demand by Fuel in Turkey. *Proceedings of Energy Policy* **35** (2007). 1701–1708.

Fausett, L. 1994. *Fundamentals of Neural Networks (Architectures, Algorithms & Applications).* Florida Lastitute of Technology.

Friedman, D. & Rust, J. 1993. *The Double Auction Market: Institutions, Theories and Evidence.* USA: Perseus.

Gerding, E. H., Dash, R. K., Yuen, D. C. K. & Jennings, N. R. 2006. Optimal bidding strategies for simultaneous Vickrey auctions with perfect substitutes. *Proceedings of Eightth Int Workshop on Game Theoretic and Decision Theoretic Agents.* Hakodate, Japan. 10-17.

Gerding, E. H., Dash, R. K., Yuen, D. C. K. & Jennings, N. R. 2007. Bidding Optimally In Concurrent Second-Price Auctions of Perfectly Substitutable Goods. *Proceedings of Sixth Int. J. Conference on Autonomous Agents and Multi-agent Systems.* Hawaii, USA. 267-274.

Gregg, D. G. & Walczak. S. 2004. Auction Advisor: An Agent-Based Online Auction Decision Support System. *Decision Support Systems.* **41**: 449-471.

He, M., Jennings N. R. & Prugel-Bennett, A. 2004. An Adaptive Bidding Agent for Multiple English Auctions: A Neuro-Fuzzy Approach. *Proceedings of IEEE Conf. on Fuzzy Systems.* Budapest, Hungary. 1519-1524.

He, M., Leung, H. & Jennings, N. R. 2003. A fuzzy logic based bidding strategy for autonomous agents in continuous double auctions. *IEEE Trans on Knowledge and Data Engineering.* **15** (6): 1345-1363.

Herrera, J. L. 1999. *Time Series Prediction Using Inductive Reasoning Techniques.* PhD thesis. Spain: Universidad Politecnica De Cataluna.

Ismail, B. M. 2007. Unimodality test for global optimization of single variable functions using statistical method. *Malaysian Journal Of Mathematical Sciences.* **1**(2).

Jennings, N. R. & Wooldridge, M. J. 1998. Applications of Intelligent Agents. *In Agent Technology: Foundations, Applications, and Markets (eds. N. R. Jennings and M. Wooldridge).* pp. 3-28

Jennings. N., R. 2001 An agent-based approach for building complex software systems. *Comms. of the ACM*. **44** (4): 35-41.

Kendall, M. & Ord, J. 1999. *Time Series.* 3rd edition. Edward Arnold, Seven Oaks, Kent.

Klemperer, P. 1999. Auction Theory: A Guide to The Literature. *Journal of Economic Surveys.* **13**(3): 227-286.

Krishna, V. & Rosenthal, R. W. 1996. Simultaneous Auctions with Synergies. *Games and Economic Behaviour.* **17**: 1–31.

Krishna, V. 2002. *Auction Theory.* San Diego, USA: Academic Press.

Lee, H.G. 1996. Electronic Brokerage and Electronic Auction: The Impact of IT on Market Structures. *Proceedings of the 29th HICSS.* ***IV**: Information Systems – Organizational Systems and Technology.* Los Alamitos, CA. 397-406.

Li, X., Liu, L., Wu, L. & Zhang, Z. 2005. *Predicting the Final Price of Online Auction Items. Expert Systems with Applications.* 31(3): 542-550.

Lial M. & Miller. C. 1975. Essential calculus with applications in business, biology and behavioral sciences. Glenview, II: Scott, Foresman and Company.

Lin, Y. & Liu, S. 2004. A Historical Introduction to Grey Systems Theory. *IEEE International Conference on Systems. Man and Cybernetics.* **3**: 2403-2408.

Lin, Y. & Liu, S. 2007. National economic strength as evaluated using grey systems theory. Kybernetes: *The International Journal of Systems and Cybernetics.* 36(1): pp. 89 – 97.

Lin, Y. & Valencia, J. 2007. Grey Analysis of Colombian Migration. *Proceedings of 2007 IEEE International Conference on Grey Systems and Intelligent Services.* Nanjing, China. 7-12.

Lin, Z. C. & Lin, W. S. 2001. The application of grey theory to prediction of measurement points for circularity geometric tolerance. *The International Journal of Advanced Manufacturing Technology.* **17**: 348-360.

Liu, S. & Forrest, J. 2007. The current developing status on grey system theory. *The Journal of Grey System.* **2** (2007): 111–123.

Liu, S. & Lin, Y. 2006. *Grey Information: Theory and Practical Application with 60 Figures.* London: Springer-Verlag.

Lucking-reiley & David H. 2000. Auction on the internet: what's being auctioned and how?. *Journal of Industrial Economics.* **48**(3):227-252.

Makridakis, S. & Hibon, M. 1979. Accuracy of forecasting: an empirical investigation. *J. Roy. Stat. Soc. A.* **142**: 97-145.

Makridakis, S., Andersen, A., Carbone, R., Fildes, R., Hibon, M., Lewandowski, R., Newton, J., Parzen, E. & Winkler, R. 1984. *The Forecasting Accuracy of Major Time Series Methods.* New York: John Wiley.

McAfee, R. P. & Mcmillan, J. 1987. Auctions and bidding. *Journal of Economic Literature.* **XXV**: 699-738.

Mousel, S. A. 1996. The Exponential Function Expository Paper. Mousel – MAT Expository Paper.

Moussaoui, A., Selaimia, Y., & Abbassi, H., A. 2006. Hybrid hot strip rolling force prediction using a bayesian trained artificial neural network and analytical models. *American Journal of Applied Sciences.* **3**(6): 1885-1889.

Nishizawa, K., Hirano, M., Yamamura, S., Momose, Y., Kimura, A., Mochizuki, T., Yamamoto, Y. 1998. Prediction of Plasma Levels of Aminoglycoside Antibiotic in Patients with Severe Illness by Means of an Artificial Neural Network Simulator. *Proceedings of J Pharm Pharmaceut Sci.* **1**(3): 95-101.

Nogueira, A., Salvador, P. & Valadas, R. 2006. Predicting the Quality of Service of Wireless LANs using Neural Networks. *Proceedings of ACM MSWiM'06.* 52-60.

Nunn, I. & White, T. 2005. The Application of Antigenic Search Techniques to Time Series Forecasting. *Proceedings of the 2005 Conference on Genetic and Evolutionary Computation*. Washington DC, USA. 353-360.

Padgham, L. & Winikoff, M. 2002a. Prometheus: A methodology for developing intelligent agents. *In Third International Workshop on Agent-Oriented Software Engineering.*

Padgham, L. & Winikoff, M. 2002b. Prometheus: A pragmatic methodology for engineering intelligent agents. *Proceedings of the OOPSLA 2002 Workshop on Agent-Oriented Methodologies*. Seattle, USA. 97-108.

Padgham, L. & Winikoff, M. 2004. *Developing Intelligent Agent Systems: A Practical Guide.* England: John Wiley and Sons, Ltd.

Paul R. M. & Robert J. W. 1982. Theory of auction and competitive bidding. *Econometrica*. **50**(5): 1089-1122.

Pindyck, R. S. & Rubinfeld, D. L. 1998. *Econometric Models and Economic Forecasts*. 4th Edition. New York: McGraw-Hill.

Rocha, A. P. & Oliveira, E. 1999. Electronic Commerce: A Technological Perspective in The Future of Internet. in O Futuro da Internet, 31-41, Ed. Centro Atlántico.

Rogers, A., David, E., Payne, T. R. & Jennings, N. R. 2007. An Advanced Bidding Agent for Advertisement Selection on Public Displays. *Proceedings of Sixth Int. J. Conference on Autonomous Agents and Multi-agent Systems*. Hawaii, USA. 251-258.

Roth, A. E. & Ockenfels, A. 2002. Last-minute bidding and the rules for ending second-price auctions: evidence from ebay and amazon auctions on the internet. *Amer. Econom. Rev.* **92**(4): 1093-1103.

Sabry , M., Latif, H., A., Yousef, S. & Badra, N. 2007. A time - series forecasting of average daily traffic volume. *Australian Journal of Basic and Applied Sciences*. **1**(4): 386-394.

Sahingoz, O. K. & Erdogan, N. 2004. A Two-Leveled Mobile Agent System for E-commerce with Constraint-Based Filtering. *International Conference on Computational Science*. Berlin Heidelberg. 437-440.

Sharma, M., Aggarwal, S., Bose, P. & Deshpande, A. 2003. Meteorology-based Forecasting of Air Quality Index Using Neural Network. *Proceedings. IEEE International Conference on Industrial Informatics*. 374-378.

Shimizu, N. Ueno, O. Komata, C. 1998. Introduction of Time Series Data Analysis using Grey System Theory. *1998 Second International Conference on Knowledge-Based Intelligent Electronic System.* Australia. 67-72.

Shubik, M. 1983. *Auctions, Biddings, and Markets: An Historical Sketch.* New York, USA: New York University Press.

TAC. 2001. Welcome To The Trading Agent Competition: Competitive Benchmarking for The Trading Agent Community, http://www.sics.se/tac/page.php?id=1. Retrieved 7 May 2008.

Taylor, J., W. & Buizza, R. 2002. Neural Network Load Forecasting With Weather Ensemble Predictions. *Proceedings of IEEE Transaction on Power Systems.* **17**(3): 626-632.

Vetsikas, A. & Jennings, N. R. 2007. Outperforming the Competition in Multi-Unit Sealed Bid Auctions. *Proceedings of Sixth Int. J. Conference on Autonomous Agents and Multi-agent Systems.* New York, USA. 702-709.

Vytelingum, P., Dash, R. K., David, E. & Jennings, N. R. 2004. A Risk-Based Bidding Strategy for Continuous Double Auctions. *Proceedings of 16th European Conference on Artificial Intelligence (ECAI).* Valencia, Spain. 79-83.

Wang, W., Hao, Y., H. & Du, X. 2007. Application of Grey System GM (1, N) Model to Predicting Spring Flow. *Proceedings of 2007 IEEE International Conference on Grey Systems and Intelligent Services.* Nanjing, China. 448-452.

Weigend, A. S. and Gershenfeld, N. (Eds.). 1994. *Time Series Prediction: Forecasting the Future and Understanding the Past. Reading.* MA: Addison-Wesley.

Wolfstetter, E. 2002. Auctions: an introduction. *Journal of Economic Surveys.* **10**: 367-420.

Wooldridge, M. and Jennings, N.R. 1995. *The Knowledge Engineering Review.* **10**(2): pp. 115-152.

Wu, H. H., Liao, A. Y. H. & Wang, P. C. 2004. Using grey theory in quality function deployment to analyse dynamic customer requirement. *The International Journal of Advanced Manufacturing Technology.* **25**(11-12): 1241-1247.

Yang, M. & Li, X. R. 2003. *Predicting End-to-End Delay of the Internet Using Time Series Analysis.* LA: University of New Orleans.

Yang, X.M., Yuan, J.S., Mao, H.N. & Yuan, J.Y. 2006. A Novel Cloud Theory Based Time-series Predictive Method for Middle-term Electric Load Forecasting. *Proceedings of Computational Engineering in Systems Applications, IMACS.* **2**: 1920-1924.

Yuan, B., Jiwei, G., Guoqing, T. & Lei, Wang. 2000. Using Grey Theory to Predict the Gas-in-oil Concentrations in Oil-filled Transformer. *Proceedings of the Sixth International Conference on Properties and Applications of Dielectric Materials.* Xi'an Jiaotong University, Xi'an, China. 217-219.

Yuen, D., Byde, A. & Jennings, N. R. 2006. Heuristic Bidding Strategies For Multiple Heterogeneous Auctions. *Proceedings of 17th European Conference on AI (ECAI).* Trento, Italy. 300-304.