Deep Learning for Event-Driven Stock Prediction

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Abstract

We propose a deep learning method for event-driven stock market prediction. First, events are extracted from news text, and represented as dense vectors, trained using a novel neural tensor network. Second, a deep convolutional neural network is used to model both short-term and long-term influences of events on stock price movements. Experimental results show that our model can achieve nearly 6% improvements on S&P 500 index prediction and individual stock prediction, respectively, compared to state-of-the-art baseline methods. In addition, market simulation results show that our system is more capable of making profits than previously reported systems trained on S&P 500 stock historical data.

1 Introduction

It has been shown that the financial market is "informationally efficient" [Fama, 1965] — stock prices reflect all known information, and the price movement is in response to news or events. As web information grows, recent work has applied Natural Language Processing (NLP) techniques to explore financial news for predicting market volatility.

Pioneering work mainly uses simple features from news documents, such as bags-of-words, noun phrases, and named entities [Kogan *et al.*, 2009; Schumaker and Chen, 2009]. Although useful, these features do not capture structured relations, which limits their potentials. For example, representing the event "Microsoft sues Barnes & Noble." using term-level features {"Microsoft", "sues", "Barnes", "Noble"} alone, it can be difficult to accurately predict the price movements of *Microsoft Inc.* and *Barnes & Noble Inc.*, respectively, as the unstructured terms cannot differentiate the accuser ("Microsoft") and defendant ("Barnes & Noble").

Recent advances in computing power and NLP technology enables more accurate models of events with structures. Using open information extraction (Open IE) to obtain structured events representations, we find that the actor and object

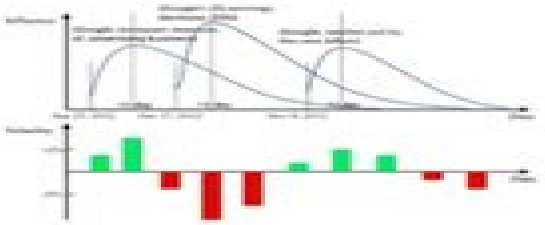

Figure 1: Example news influence of *Google Inc.*

of events can be better captured [Ding *et al.*, 2014]. For example, a structured representation of the event above can be (Actor = *Microsoft*, Action = *sues*, Object = *Barnes & Noble*). They report improvements on stock market prediction using their structured representation instead of words as features.

One disadvantage of structured representations of events is that they lead to increased sparsity, which potentially limits the predictive power. We propose to address this issue by representing structured events using *event embeddings*, which are dense vectors. Embeddings are trained such that similar events, such as (Actor = *Nvidia fourth quarter results*, Action = *miss*, Object = *views*) and (Actor = *Delta profit*, Action = *didn't reach*, Object = *estimates*), have similar vectors, even if they do not share common words. In theory, embeddings are appropriate for achieving good results with a density estimator (e.g. convolutional neural network), which can misbehave in high dimensions [Bengio *et al.*, 2005]. We train event embeddings using a novel neural tensor network (NTN), which can learn the semantic compositionality over event arguments by combining them multiplicatively instead of only implicitly, as with standard neural networks.

For the predictive model, we propose to use deep learning [Bengio, 2009] to capture the influence of news events over a history that is longer than a day. Research shows diminishing effects of reported events on stock market volatility. For example, Xie et al. [2013], Tetlock et al. [2008] and Ding et al. [2014] show that the performance of daily prediction is better than weekly and monthly prediction. As shown in Figure 1, the influences of three actual events for Google

*This work was done while the first author was visiting Singapore University of Technology and Design

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Zugang zu Daten nach europäischem Kartellrecht Stefan A. Schmidt,2020-08-05 Durch den Einsatz neuer Technologien im Rahmen der Digitalisierung fallen immer mehr Daten an die sich bei wenigen Unternehmen konzentrieren Datenmonopole entstehen was nachhaltige Auswirkungen auf das Wettbewerbsgeschehen haben kann Einem von den Daten abhangigen Unternehmen kann ohne Datenzugang ggf die Teilnahme am Wettbewerb vorenthalten bleiben Wie kann das europaische Kartellrecht auf solche Datenakkumulationen reagieren Folgt aus dem Missbrauchsverbot des Art 102 AEUV ein Recht auf Datenzugang fur Wettbewerber ahnlich wie bei immateriellen Schutzrechten eine Zwangslizenz Stefan A Schmidt analysiert bei welchen Marktgegebenheiten negativen Konzentrationstendenzen mit einem Datenzugang begegnet werden kann und wann ein solcher Zugang aufgrund der wettbewerblichen Situation oder aufgrund anderer negativer Auswirkungen z B datenschutzrechtlicher Natur versagt werden sollte Dazu gibt der Autor einen ersten Ausblick auf die Datenzugangsregeln der 10 GWB Novelle *Mining Data for Financial Applications* Valerio Bitetta,Ilaria Bordino,Andrea Ferretti,Francesco Gullo,Giovanni Ponti,Lorenzo Severini,2021-01-14 This book constitutes revised selected papers from the 5th Workshop on Mining Data for Financial Applications MIDAS 2020 held in conjunction with ECML PKDD 2020 in Ghent Belgium in September 2020 The 8 full and 3 short papers presented in this volume were carefully reviewed and selected from 15 submissions They deal with challenges potentialities and applications of leveraging data mining tasks regarding problems in the financial domain The workshop was held virtually due to the COVID 19 pandemic Information Extraction from the GDELT Database to Analyse EU Sovereign Bond Markets and Exploring the Predictive Power of News and Neural Machine Learning Models for Economic Forecasting are available open access under a Creative Commons Attribution 4 0 International License via link springer com *Deep Learning Theory and Applications* Donatello Conte,Ana Fred,Oleg Gusikhin,Carlo Sansone,2023-07-30 This book consitiutes the refereed proceedings of the 4th International Conference on Deep Learning Theory and Applications DeLTA 2023 held in Rome Italy from 13 to 14 July 2023 The 9 full papers and 22 short papers presented were thoroughly reviewed and selected from the 42 qualified submissions The scope of the conference includes such topics as models and algorithms machine learning big data analytics computer vision applications and natural language understanding **Handbook Of Financial Econometrics, Mathematics, Statistics, And Machine Learning (In 4 Volumes)** Cheng Few Lee,John C Lee,2020-07-30 This four volume handbook covers important concepts and tools used in the fields of financial econometrics mathematics statistics and machine learning Econometric methods have been applied in asset pricing corporate finance international finance options and futures risk management and in stress testing for financial institutions This handbook discusses a variety of econometric methods including single equation multiple regression simultaneous equation regression and panel data analysis among others It also covers statistical distributions such as the binomial and log normal distributions in light of their applications to portfolio theory and asset management in addition to

their use in research regarding options and futures contracts In both theory and methodology we need to rely upon mathematics which includes linear algebra geometry differential equations Stochastic differential equation Ito calculus optimization constrained optimization and others These forms of mathematics have been used to derive capital market line security market line capital asset pricing model option pricing model portfolio analysis and others In recent times an increased importance has been given to computer technology in financial research Different computer languages and programming techniques are important tools for empirical research in finance Hence simulation machine learning big data and financial payments are explored in this handbook Led by Distinguished Professor Cheng Few Lee from Rutgers University this multi volume work integrates theoretical methodological and practical issues based on his years of academic and industry experience **Deep Learning Concepts in Operations Research** Biswadip Basu Mallik,Gunjan Mukherjee,Rahul Kar,Aryan Chaudhary,2024-08-30 The model based approach for carrying out classification and identification of tasks has led to the pervading progress of the machine learning paradigm in diversified fields of technology Deep Learning Concepts in Operations Research looks at the concepts that are the foundation of this model based approach Apart from the classification process the machine learning ML model has become effective enough to predict future trends of any sort of phenomena Such fields as object classification speech recognition and face detection have sought extensive application of artificial intelligence AI and ML as well Among a variety of topics the book examines An overview of applications and computing devices Deep learning impacts in the field of AI Deep learning as state of the art approach to AI Exploring deep learning architecture for cutting edge AI solutions Operations research is the branch of mathematics for performing many operational tasks in other allied domains and the book explains how the implementation of automated strategies in optimization and parameter selection can be carried out by AI and ML Operations research has many beneficial aspects for decision making Discussing how a proper decision depends on several factors the book examines how AI and ML can be used to model equations and define constraints to solve problems and discover proper and valid solutions more easily It also looks at how automation plays a significant role in minimizing human labor and thereby minimizes overall time and cost *International Conference on Innovative Computing and Communications* Deepak Gupta,Ashish Khanna,Siddhartha Bhattacharyya,Aboul Ella Hassanien,Sameer Anand,Ajay Jaiswal,2022-09-22 This book includes high quality research papers presented at the Fifth International Conference on Innovative Computing and Communication ICICC 2022 which is held at the Shaheed Sukhdev College of Business Studies University of Delhi Delhi India on February 19 20 2022 Introducing the innovative works of scientists professors research scholars students and industrial experts in the field of computing and communication the book promotes the transformation of fundamental research into institutional and industrialized research and the conversion of applied exploration into real time applications **Emerging Trends in Data Driven Computing and Communications** Rajeev Mathur,C. P. Gupta,Vaibhav Katewa,Dharm Singh Jat,Neha Yadav,2021-09-27 This book

includes best selected high quality research papers presented at International Conference on Data Driven Computing and IoT DDCIoT 2021 organized jointly by Geetanjali Institute of Technical Studies GITS Udaipur and Rajasthan Technical University Kota India during March 20 21 2021 This book presents influential ideas and systems in the field of data driven computing information technology and intelligent systems **Neural Information Processing** Derong Liu,Shengli Xie,Yuanqing Li,Dongbin Zhao,El-Sayed M. El-Alfy,2017-11-07 The six volume set LNCS 10634 LNCS 10635 LNCS 10636 LNCS 10637 LNCS 10638 and LNCS 10639 constituts the proceedings of the 24rd International Conference on Neural Information Processing ICONIP 2017 held in Guangzhou China in November 2017 The 563 full papers presented were carefully reviewed and selected from 856 submissions The 6 volumes are organized in topical sections on Machine Learning Reinforcement Learning Big Data Analysis Deep Learning Brain Computer Interface Computational Finance Computer Vision Neurodynamics Sensory Perception and Decision Making Computational Intelligence Neural Data Analysis Biomedical Engineering Emotion and Bayesian Networks Data Mining Time Series Analysis Social Networks Bioinformatics Information Security and Social Cognition Robotics and Control Pattern Recognition Neuromorphic Hardware and Speech Processing

Data Science and Applications Satyasai Jagannath Nanda,Rajendra Prasad Yadav,Amir H. Gandomi,Mukesh Saraswat,2025-06-06 This book gathers outstanding papers presented at the 5th International Conference on Data Science and Applications ICDSA 2024 organized by Soft Computing Research Society SCRS and Malaviya National Institute of Technology Jaipur India from July 17 to 19 2024 The book is divided into four volumes and it covers theoretical and empirical developments in various areas of big data analytics big data technologies decision tree learning wireless communication wireless sensor networking bioinformatics and systems artificial neural networks deep learning genetic algorithms data mining fuzzy logic optimization algorithms image processing computational intelligence in civil engineering and creative computing **Intelligent Computing Theories and Application** De-Shuang Huang,Vitoantonio Bevilacqua,Prashan Premaratne,Phalguni Gupta,2018-08-08 This two volume set LNCS 10954 and LNCS 10955 constitutes in conjunction with the volume LNAI 10956 the refereed proceedings of the 14th International Conference on Intelligent Computing ICIC 2018 held in Wuhan China in August 2018 The 275 full papers and 72 short papers of the three proceedings volumes were carefully reviewed and selected from 632 submissions The papers are organized in topical sections such as Neural Networks Pattern Recognition Image Processing Intelligent Computing in Robotics Intelligent Control and Automation Intelligent Data Analysis and Prediction Fuzzy Theory and Algorithms Supervised Learning Unsupervised Learning Kernel Methods and Supporting Vector Machines Knowledge Discovery and Data Mining Natural Language Processing and Computational Linguistics Gene Expression Array Analysis Systems Biology Computational Genomics Computational Proteomics Gene Regulation Modeling and Analysis Protein Protein Interaction Prediction Next Gen Sequencing and Metagenomics Structure Prediction and Folding Evolutionary Optimization for Scheduling High Throughput Biomedical Data Integration and Mining

Machine Learning Algorithms and Applications Heuristic Optimization Algorithms for Real World Applications Evolutionary Multi Objective Optimization and Its Applications Swarm Evolutionary Algorithms for Scheduling and Combinatorial Optimization Swarm Intelligence and Applications in Combinatorial Optimization Advances in Metaheuristic Optimization Algorithm Advances in Image Processing and Pattern Recognition Techniques AI in Biomedicine Bioinformatics Biometrics Recognition Information Security Virtual Reality and Human Computer Interaction Healthcare Informatics Theory and Methods Intelligent Computing in Computer Vision Intelligent Agent and Web Applications Reinforcement Learning Machine Learning Modeling Simulation and Optimization of Biological Systems Biomedical Data Modeling and Mining Cheminformatics Intelligent Computing in Computational Biology Protein Structure and Function Prediction Biomarker Discovery Hybrid Computational Intelligence Theory and Application in Bioinformatics Computational Biology and Systems Biology IoT and Smart Data Intelligent Systems and Applications for Bioengineering Evolutionary Optimization Foundations and Its Applications to Intelligent Data Analytics Protein and Gene Bioinformatics Analysis Algorithms and Applications

Deep Learning Models explored with help of Python Programming Editor IJSMI,2020-11-04 This is the second book in the Deep Learning models series by the author Deep learning models are widely used in different fields due to its capability to handle large and complex datasets and produce the desired results with more accuracy at a greater speed In Deep learning models features are selected automatically through the iterative process wherein the model learns the features by going deep into the dataset and selects the features to be modeled In the traditional models the features of the dataset needs to be specified in advance The Deep Learning algorithms are derived from Artificial Neural Network concepts and it is a part of broader Machine Learning Models The book starts with the Introduction part which is adopted from Author s Deep Learning Models and its application An overview with the help of R software book and move on to the Python s important data processing packages such Numpy and Pandas Book then explores the Deep Learning models with the help of packages such as Pytorch Tensor Flow and Keras and their applications in image processing stock market prediction recommender systems and natural language processing Editor International Journal of Statistics and Medical Informatics www ijsmi com book php ISBN 9798558877953 E Books https www amazon com dp B08MQTM1ZP Paperbacks https www amazon com dp B08MSQ3R8R **FinTech as a Disruptive Technology for Financial Institutions** Rafay, Abdul,2019-01-18 Financial institutions are tasked with keeping businesses of all sizes financially sounds while also providing accessible banking options to everyday individuals Fintech or financial technology is an emerging disruptive technology in financial transaction that will change banking behavior for stakeholders and enable better traceability of funds against specific assets FinTech as a Disruptive Technology for Financial Institutions is an essential reference source that discusses applications of FinTech in financial institutions in small medium and large businesses and through cultural and religious filters Featuring research on topics such as machine learning market development crypto currency financial security blockchain and financial technology

this book is ideally designed for bankers business managers economists computer scientists academicians researchers financial professionals and students Theory and Applications of Time Series Analysis Olga Valenzuela,Fernando Rojas,Luis Javier Herrera,Héctor Pomares,Ignacio Rojas,2023-11-09 This book presents the latest developments in the theory and applications of time series analysis and forecasting Comprising a selection of refereed papers it is divided into several parts that address modern theoretical aspects of time series analysis forecasting and prediction with applications to various disciplines including econometrics and energy research The broad range of topics discussed including matters of particular relevance for sustainable development will give readers a modern perspective on the subject The included contributions were originally presented at the 8th International Conference on Time Series and Forecasting ITISE 2022 held in Gran Canaria Spain June 27 30 2022 The ITISE conference series provides a forum for scientists engineers educators and students to discuss the latest advances and implementations in the foundations theory models and applications of time series analysis and forecasting It focuses on interdisciplinary research encompassing computer science mathematics statistics and econometrics **AI Marketing and Ethical Considerations in Consumer Engagement** J Nair, Arjun,Manohar, Sridhar,Mittal, Amit,Patwa, Nitin,2025-05-07 As artificial intelligence AI transforms the landscape of marketing it brings both unprecedented opportunities and complex ethical challenges AI driven tools enable businesses to personalize consumer engagement at higher levels offering tailored experiences that increase customer satisfaction and drive sales However these advancements also raise ethical concerns regarding privacy data usage and the potential for manipulation Marketers must navigate this balance between leveraging AI for business growth and ensuring they respect consumer rights transparency and trust This intersection of innovation and ethics requires further exploration of how AI should be applied in consumer engagement strategies AI Marketing and Ethical Considerations in Consumer Engagement examines the use of AI in business marketing practices It explores ethical issues in consumer science that might influence the successful integration of AI in organizational processes This book covers topics such as ethics and law data privacy and sustainability and is a useful resource for business owners computer engineers marketing professionals academicians researchers and data scientists Advances in Computational Intelligence Systems George Panoutsos,Mahdi Mahfouf,Lyudmila S Mihaylova,2024-05-18 The scope of this book is to present the papers included at the 21st UK Workshop on Computational Intelligence UKCI 2022 hosted by The University of Sheffield between 7 and 9 September 2022 Sheffield UK This marks the first fully in person UKCI conference following the pandemic a testament to the success and resilience of the UKCI community as well as to the importance of computational intelligence CI research The papers in this book are divided into five sections fuzzy logic systems machine learning hybrid methods and network systems deep learning and neural networks and optimization and search Information Retrieval Zhicheng Dou,Qiguang Miao,Wei Lu,Jiaxin Mao,Guang Jia,2020-08-10 This book constitutes the refereed proceedings of the 26th China Conference on Information Retrieval CCIR 2020 held in Xi an China in August

2020 The 12 full papers presented were carefully reviewed and selected from 102 submissions The papers are organized in topical sections search and recommendation NLP for IR and IR in finance Due to the COVID 19 pandemic the conference was held online supplemented with local on site events **Deep Learning Models and its application: An overview with the help of R software: Second in series (Machine Learning)** Editor IJSMI,2019-02-09 Deep Learning Models and its application An overview with the help of R softwarePrefaceDeep learning models are widely used in different fields due to its capability to handle large and complex datasets and produce the desired results with more accuracy at a greater speed In Deep learning models features are selected automatically through the iterative process wherein the model learns the features by going deep into the dataset and selects the features to be modeled In the traditional models the features of the dataset needs to be specified in advance The Deep Learning algorithms are derived from Artificial Neural Network concepts and it is a part of broader Machine Learning Models This book intends to provide an overview of Deep Learning models its application in the areas of image recognition classification sentiment analysis natural language processing stock market prediction using R statistical software package an open source software package The book also includes an introduction to python software package which is also open source software for the benefit of the users This books is a second book in series after the author s first book Machine Learning An Overview with the Help of R Software https www amazon com dp B07KQSN447EditorInternational Journal of Statistics and Medical Informaticswww ijsmi com book php Advances In Pattern Recognition And Artificial Intelligence Marleah Blom,Nicola Nobile,Ching Yee Suen,2021-11-16 This book includes reviewed papers by international scholars from the 2020 International Conference on Pattern Recognition and Artificial Intelligence held online The papers have been expanded to provide more details specifically for the book It is geared to promote ongoing interest and understanding about pattern recognition and artificial intelligence Like the previous book in the series this book covers a range of topics and illustrates potential areas where pattern recognition and artificial intelligence can be applied It highlights for example how pattern recognition and artificial intelligence can be used to classify predict detect and help promote further discoveries related to credit scores criminal news national elections license plates gender personality characteristics health and more Chapters include works centred on medical and financial applications as well as topics related to handwriting analysis and text processing internet security image analysis database creation neural networks and deep learning While the book is geared to promote interest from the general public it may also be of interest to graduate students and researchers in the field Proceedings of the Future Technologies Conference (FTC) 2018 Kohei Arai,Rahul Bhatia,Supriya Kapoor,2018-10-17 The book presenting the proceedings of the 2018 Future Technologies Conference FTC 2018 is a remarkable collection of chapters covering a wide range of topics including but not limited to computing electronics artificial intelligence robotics security and communications and their real world applications The conference attracted a total of 503 submissions from pioneering researchers scientists industrial engineers and students

from all over the world After a double blind peer review process 173 submissions including 6 poster papers have been selected to be included in these proceedings FTC 2018 successfully brought together technology geniuses in one venue to not only present breakthrough research in future technologies but to also promote practicality and applications and an intra and inter field exchange of ideas In the future computing technologies will play a very important role in the convergence of computing communication and all other computational sciences and applications And as a result it will also influence the future of science engineering industry business law politics culture and medicine Providing state of the art intelligent methods and techniques for solving real world problems as well as a vision of the future research this book is a valuable resource for all those interested in this area *Intelligent Data Engineering and Automated Learning – IDEAL 2019* Hujun Yin,David Camacho,Peter Tino,Antonio J. Tallón-Ballesteros,Ronaldo Menezes,Richard Allmendinger,2019-11-07 This two volume set of LNCS 11871 and 11872 constitutes the thoroughly refereed conference proceedings of the 20th International Conference on Intelligent Data Engineering and Automated Learning IDEAL 2019 held in Manchester UK in November 2019 The 94 full papers presented were carefully reviewed and selected from 149 submissions These papers provided a timely sample of the latest advances in data engineering and machine learning from methodologies frameworks and algorithms to applications The core themes of IDEAL 2019 include big data challenges machine learning data mining information retrieval and management bio neuro informatics bio inspired models including neural networks evolutionary computation and swarm intelligence agents and hybrid intelligent systems real world applications of intelligent techniques and AI

The book delves into Deep Learning For Event Driven Stock Prediction. Deep Learning For Event Driven Stock Prediction is an essential topic that needs to be grasped by everyone, ranging from students and scholars to the general public. The book will furnish comprehensive and in-depth insights into Deep Learning For Event Driven Stock Prediction, encompassing both the fundamentals and more intricate discussions.

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    - Chapter 4: Deep Learning For Event Driven Stock Prediction in Specific Contexts
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6. In chapter 5, the author will draw a conclusion about Deep Learning For Event Driven Stock Prediction. This chapter will summarize the key points that have been discussed throughout the book.

The book is crafted in an easy-to-understand language and is complemented by engaging illustrations. It is highly recommended for anyone seeking to gain a comprehensive understanding of Deep Learning For Event Driven Stock Prediction.

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