

Portfolio Theory of Information Retrieval

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ABSTRACT

This paper studies document ranking under uncertainty. It is tackled in a general situation where the relevance predictions of individual documents have uncertainty, and are dependent between each other. Inspired by the Modern Portfolio Theory, an economic theory dealing with investment in financial markets, we argue that ranking under uncertainty is not just about picking individual relevant documents, but about choosing the right combination of relevant documents. This motivates us to quantify a ranked list of documents on the basis of its expected overall relevance (mean) and its variance; the latter serves as a measure of risk, which was rarely studied for document ranking in the past. Through the analysis of the mean and variance, we show that an optimal rank order is the one that balancing the overall relevance (mean) of the ranked list against its risk level (variance). Based on this principle, we then derive an efficient document ranking algorithm. It generalizes the well-known probability ranking principle (PRP) by considering both the uncertainty of relevance predictions and correlations between retrieved documents. Moreover, the benefit of diversification is mathematically quantified; we show that diversifying documents is an effective way to reduce the risk of document ranking. Experimental results in text retrieval confirm the theoretical insights with improved retrieval performance.

Categories and Subject Descriptors

H.3.3 [Information Search and Retrieval]: Retrieval models, Search process, and Selection process

General Terms

Algorithms, Experimentation, Measurement, Performance

Keywords

Modern portfolio theory, Mean-variance analysis, Probability ranking principle, Ranking under uncertainty

1 Introduction

Information retrieval (IR) concerns how to retrieve documents for a user information need. The process of retrieving documents may be divided into two stages. In the first stage, the relevance between the given user information need and each of the documents in a collection is calculated. Probabilistic retrieval models that have been proposed and tested over decades are primarily focusing on this task, aiming at

producing a “best guess” at a document’s relevance. Examples include the RSJ model [15] (a further development of that model led to the BNE25 term weighting function [16]), and the language modelling approaches [23]. The second stage focuses on how to present (normally rank) documents to the user. The probability ranking principle (PRP) [6] forms the basis in this stage, stating that the system should rank documents in order of decreasing probability of relevance; it has been shown that, following the principle, the overall effectiveness of an IR system, such as expected Precision, is maximized [12].

If we make an analogy with the field of finance, our ranking task resembles the investment problem in financial markets; for example, suppose that an investor needs to select a set (portfolio) of n stocks that will provide the best distribution of future return, given his or her investment budget – an analogy with IR is that we invest ranking positions in documents. The PRP of IR might suggest that, for optimal selection, one should first rank stocks in order of decreasing future returns and then choose the top- n most “profitable” stocks to construct the portfolio. Such a principle that essentially maximizes the expected future return was, however, rejected by an economist Harry Markowitz in his Nobel Prize winning work, the Modern Portfolio Theory (MPT) of finance, in 1952 [11]. As one of the most influential economic theories dealing with finance and investment, the MPT was motivated on the basis of the following two observations [11]. 1) The future return of a stock is unknown and cannot be calculated with absolute certainty. Investors have different preferences of the risk associated with uncertainty. Therefore, it is highly desirable to have a method of quantifying this uncertainty or risk, and reflect them and incorporate users’ risk preferences when selecting stocks. 2) Since in practice the future returns of stocks are correlated, assuming independence between the returns and selecting them independently to construct a portfolio is not preferable.

Realizing the two fundamental issues, the MPT emphasizes that risk (uncertainty) is an inherent part of future return, and quantifies it by using the variance (or the standard deviation) of the return. The theory suggests that, for a risk-averse decision, an investor should both maximize the return as a desirable thing and minimize the variance of the return as an undesirable thing. Under such a formulation, the MPT mathematically shows that diversification, known as “not putting all of your eggs in one basket”, is an effective way to reduce the risk of the portfolio.

Going back to our IR problem, we have two similar critical issues: 1) during retrieval, the relevance of documents is unknown and cannot be estimated with absolute certainty from IR models. There are many sources of uncertainty such as ambiguity in the query, specific user preferences,

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David Baud



Portfolio Theory Of Information Retrieval:

Advances in Information Retrieval Theory Giambattista Amati, Fabio Crestani, 2011-09-01 This book constitutes the refereed proceedings of the Third International Conference on the Theory of Information Retrieval ICTIR 2011 held in Bertinoro Italy in September 2011 The 25 revised full papers and 13 short papers presented together with the abstracts of two invited talks were carefully reviewed and selected from 65 submissions The papers cover topics ranging from query expansion co occurrence analysis user and interactive modelling system performance prediction and comparison and probabilistic approaches for ranking and modelling IR to topics related to interdisciplinary approaches or applications They are organized into the following topical sections predicting query performance latent semantic analysis and word co occurrence analysis query expansion and re ranking comparison of information retrieval systems and approximate search probability ranking principle and alternatives interdisciplinary approaches user and relevance result diversification and query disambiguation and logical operators and descriptive approaches

Advances in Information Retrieval Theory
Leif Azzopardi, Gabriella Kazai, Stephen Robertson, Stefan R ger, Milad Shokouhi, Dawei Song, Emine Yilmaz, 2009-09-03 This book constitutes the refereed proceedings of the Second International Conference on the Theory of Information Retrieval ICTIR 2009 held in Cambridge UK in September 2009 The 18 revised full papers 14 short papers and 11 posters presented together with one invited talk were carefully reviewed and selected from 82 submissions The papers are categorized into four main themes novel IR models evaluation efficiency and new perspectives in IR Twenty one papers fall into the general theme of novel IR models ranging from various retrieval models query and term selection models Web IR models developments in novelty and diversity to the modeling of user aspects There are four papers on new evaluation methodologies e g modeling score distributions evaluation over sessions and an axiomatic framework for XML retrieval evaluation Three papers focus on the issue of efficiency and offer solutions to improve the tractability of PageRank data cleansing practices for training classifiers and approximate search for distributed IR Finally four papers look into new perspectives of IR and shed light on some new emerging areas of interest such as the application and adoption of quantum theory in IR

Postmodern Portfolio Theory James Ming Chen, 2016-07-26 This survey of portfolio theory from its modern origins through more sophisticated postmodern incarnations evaluates portfolio risk according to the first four moments of any statistical distribution mean variance skewness and excess kurtosis In pursuit of financial models that more accurately describe abnormal markets and investor psychology this book bifurcates beta on either side of mean returns It then evaluates this traditional risk measure according to its relative volatility and correlation components After specifying a four moment capital asset pricing model this book devotes special attention to measures of market risk in global banking regulation Despite the deficiencies of modern portfolio theory contemporary finance continues to rest on mean variance optimization and the two moment capital asset pricing model The term postmodern portfolio theory captures many of the advances in financial learning since the original

articulation of modern portfolio theory A comprehensive approach to financial risk management must address all aspects of portfolio theory from the beautiful symmetries of modern portfolio theory to the disturbing behavioral insights and the vastly expanded mathematical arsenal of the postmodern critique Mastery of postmodern portfolio theory's quantitative tools and behavioral insights holds the key to the efficient frontier of risk management [ACRN Proceedings in Finance and Risk Series '13](#) Dr. Othmar M. Lehner, Dr. Richard Harrison, 2014-03-06 Proceedings of the 14th FRAP Finance Risk and Accounting Perspectives conference taking place in Cambridge UK **Portfolio Theory: the Selection of Asset Combinations** William J. Baumol, 1970 **Accountancy**, 1984 [Journal of Management Information Systems](#), 2007 **Documentation Abstracts**, 1999 *Library Catalog of the Metropolitan Museum of Art, New York. Supplement* Metropolitan Museum of Art (New York, N.Y.). Library, 1962 **The Directory of Graduate Studies**, 1999 **Transactions of the American Society of Civil Engineers** American Society of Civil Engineers, 1978 Vols 29-30 contain papers of the International Engineering Congress Chicago 1893 v 54 pts A-F papers of the International Engineering Congress St Louis 1904 **Journal of the Construction Division** American Society of Civil Engineers. Construction Division, 1978 *ERIC Educational Documents Index, 1966-69: Major descriptors*, 1970 **Business Periodicals Index**, 1977 **Municipal Reference Library Notes** Municipal Reference and Research Center (New York, N.Y.), 1965 **Municipal Reference Library Notes** New York Public Library. Municipal Reference Library, 1964 **Current Index to Journals in Education**, 2001 *Peterson's Annual Guides to Graduate Study* Peterson's Guides, Inc, 1983 **Library Catalog of the Metropolitan Museum of Art** Metropolitan Museum of Art (New York, N.Y.). Library, 1968 **Theory and Practice** Linda Shirato, Elizabeth R. Bucciarelli, 1998

This book delves into Portfolio Theory Of Information Retrieval. Portfolio Theory Of Information Retrieval is a crucial topic that must be grasped by everyone, from students and scholars to the general public. This book will furnish comprehensive and in-depth insights into Portfolio Theory Of Information Retrieval, encompassing both the fundamentals and more intricate discussions.

1. The book is structured into several chapters, namely:

- Chapter 1: Introduction to Portfolio Theory Of Information Retrieval
- Chapter 2: Essential Elements of Portfolio Theory Of Information Retrieval
- Chapter 3: Portfolio Theory Of Information Retrieval in Everyday Life
- Chapter 4: Portfolio Theory Of Information Retrieval in Specific Contexts
- Chapter 5: Conclusion

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4. In chapter 3, the author will examine the practical applications of Portfolio Theory Of Information Retrieval in daily life. The third chapter will showcase real-world examples of how Portfolio Theory Of Information Retrieval can be effectively utilized in everyday scenarios.

5. In chapter 4, the author will scrutinize the relevance of Portfolio Theory Of Information Retrieval in specific contexts. The fourth chapter will explore how Portfolio Theory Of Information Retrieval is applied in specialized fields, such as education, business, and technology.

6. In chapter 5, this book will draw a conclusion about Portfolio Theory Of Information Retrieval. The final chapter will summarize the key points that have been discussed throughout the book.

This 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 Portfolio Theory Of Information Retrieval.

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Portfolio Theory Of Information Retrieval Introduction

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