

# Portfolio Theory of Information Retrieval

Jun Wang and Jianhan Zhu  
Department of Computer Science, University College London  
Malet Place, London WC1E 6BT, UK  
jun\_wang@acm.org, jianhan.zhu@ucl.ac.uk

## 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 HSIJ model [15] (a further development of that model led to the HME25 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 [13].

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 returns, 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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*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

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## **Table of Contents Portfolio Theory Of Information Retrieval**

1. Understanding the eBook Portfolio Theory Of Information Retrieval
  - The Rise of Digital Reading Portfolio Theory Of Information Retrieval
  - Advantages of eBooks Over Traditional Books
2. Identifying Portfolio Theory Of Information Retrieval
  - Exploring Different Genres
  - Considering Fiction vs. Non-Fiction
  - Determining Your Reading Goals
3. Choosing the Right eBook Platform
  - Popular eBook Platforms
  - Features to Look for in an Portfolio Theory Of Information Retrieval
  - User-Friendly Interface
4. Exploring eBook Recommendations from Portfolio Theory Of Information Retrieval
  - Personalized Recommendations
  - Portfolio Theory Of Information Retrieval User Reviews and Ratings
  - Portfolio Theory Of Information Retrieval and Bestseller Lists
5. Accessing Portfolio Theory Of Information Retrieval Free and Paid eBooks
  - Portfolio Theory Of Information Retrieval Public Domain eBooks
  - Portfolio Theory Of Information Retrieval eBook Subscription Services
  - Portfolio Theory Of Information Retrieval Budget-Friendly Options

6. Navigating Portfolio Theory Of Information Retrieval eBook Formats
  - ePub, PDF, MOBI, and More
  - Portfolio Theory Of Information Retrieval Compatibility with Devices
  - Portfolio Theory Of Information Retrieval Enhanced eBook Features
7. Enhancing Your Reading Experience
  - Adjustable Fonts and Text Sizes of Portfolio Theory Of Information Retrieval
  - Highlighting and Note-Taking Portfolio Theory Of Information Retrieval
  - Interactive Elements Portfolio Theory Of Information Retrieval
8. Staying Engaged with Portfolio Theory Of Information Retrieval
  - Joining Online Reading Communities
  - Participating in Virtual Book Clubs
  - Following Authors and Publishers Portfolio Theory Of Information Retrieval
9. Balancing eBooks and Physical Books Portfolio Theory Of Information Retrieval
  - Benefits of a Digital Library
  - Creating a Diverse Reading Collection Portfolio Theory Of Information Retrieval
10. Overcoming Reading Challenges
  - Dealing with Digital Eye Strain
  - Minimizing Distractions
  - Managing Screen Time
11. Cultivating a Reading Routine Portfolio Theory Of Information Retrieval
  - Setting Reading Goals Portfolio Theory Of Information Retrieval
  - Carving Out Dedicated Reading Time
12. Sourcing Reliable Information of Portfolio Theory Of Information Retrieval
  - Fact-Checking eBook Content of Portfolio Theory Of Information Retrieval
  - Distinguishing Credible Sources
13. Promoting Lifelong Learning
  - Utilizing eBooks for Skill Development
  - Exploring Educational eBooks
14. Embracing eBook Trends
  - Integration of Multimedia Elements

- Interactive and Gamified eBooks

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web workplace skills plan wsp grant application guidelines the mandatory grant comprises the workplace skills plan wsp application combined with the annual training report atr this application is fixed as a percentage of levies paid by an employer an employer who makes an application on time and in the proper manner will

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web sep 28 2020 one of the very first yearly calendar items for hr is of course the submission of workplace skills plans wsp and annual training reports atr this is otherwise known as the mandatory grant

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web mar 6 2023 submitting a wsp makes your organisation eligible to apply for discretionary grants from your affiliated seta these grants can provide valuable funding to help you implement your skills plans effectively including learnerships internships or skills training programmes as indicated on submission of the wsp and atr

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