

# Towards an Indexing Method to Speed-Up Music Retrieval

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## ABSTRACT

Computations in most music retrieval systems strongly depend on the size of data compared. We propose to enhance performances of a music retrieval system, namely a harmonic similarity evaluation method, by first indexing relevant parts of music pieces. The indexing algorithm represents each audio piece exclusively by its major repetition, using harmonic descriptions and string matching techniques. Evaluations are performed in the context of a state-of-the-art retrieval method, namely cover songs identification, and results highlight the success of our indexing system in keeping similar results while yielding a substantial gain in computation time.

## Categories and Subject Descriptors

H.3.1 [Information Storage and Retrieval]: Content Analysis and Indexing—*Indexing methods*

## General Terms

Algorithms, Performance, Experimentation

## 1. INTRODUCTION

With the growing presence of large collections of musical content, methods for facilitating efficient browsing become more and more useful. The research field of Music Information Retrieval (MIR) aims at analysing and comparing music pieces on musical criteria, such as harmony, timbre, rhythm etc. Most MIR comparison systems are based on a common scheme to estimate similarity on audio material. One or several audio features are chosen and computed on signals segmented in small parts, or frames, thus providing feature sequences representing pieces. For instance, harmonic information is often used since it provides a good insight of the architecture of music pieces. Then, adapted algorithms, such as dynamic time warping or alignment techniques, are used to yield similarity scores between sequences. However, algorithms involved in such retrieval systems highly depend on the length of representative sequences. Harmonic sequences, for instance, are usually relatively long and induce a high computational cost to be compared. Hence, many works over the last decades focused on the detection of the most salient parts in musical sequences in order to speed-up music retrieval and analysis (see for instance [8]).

In this study, we propose to reduce the size of musical sequences by selecting relevant parts in order to index data involved in retrieval tasks. Our indexing method uses harmonic representations analysed by string matching techniques to isolate specific parts. Then, our indexing process is evaluated in the context of harmonic similarity from a data reduction step preliminary to cover song identification.

## 2. INDEXING PROCESS

Audio pieces are represented by sequences using *Harmonic Pitch Class Profiles* (HPCP) [1], frequently used to describe harmonic information. The aim of the indexing step is to extract a specific part in each audio piece, namely the *major repetition*, that can roughly be described as the longest repeated part perceived in a piece. In western popular music, for instance, this repetition classically consists in the concatenation of a verse and a chorus. The motivation of such a selection is to reduce the audio representation to a summarized, less redundant version, that remains relevant to characterize properly the music piece. To isolate relevant parts, each harmonic sequence is analysed using string matching techniques by considering each HPCP feature as a symbol. We consider the polynomial algorithm proposed by Karman et al. [2], that mainly relies on a local alignment algorithm [5] to detect approximate repetitions. In order to evaluate the alignment score of approximate repetitions, the latter technique requires scores for substituting each feature by another one and gap penalties. These scores are determined according to the *Optimal Transposition Index* (OTI) method [4], which ensures a higher robustness to musical variations. The Pearson correlation coefficient is used as a similarity measure for OTI evaluations. For a detailed description of the indexing process, please refer to [3].

## 3. HARMONIC SIMILARITY

The above process is evaluated as an indexing step for music retrieval, more specifically on harmonic content. One way to evaluate harmonic similarity retrieval systems is to identify cover songs, i.e., every new recording, performance, or rendition of a previously recorded musical piece. In cover songs datasets, music pieces are divided into several classes, each one containing all the different covers of a track. Harmonic baselines of cover songs of a same piece are likely to remain very similar, even in presence of strong musical variations. For our experiments, we focus on a robust cover song identification method, proposed by Serra et al. [4], and we compare its performances with and without the major repetition indexing step.

# Research And Development In Information Retrieval

**W. Bruce Croft, C.J. van Rijsbergen**



## **Research And Development In Information Retrieval:**

ACM SIGIR Conference on Research and Development in Information Retrieval ,2004      Advances in Information Retrieval Center for Intelligent Information Retrieval,2000-04-30 The NSF Center for Intelligent Information Retrieval CIIR was formed in the Computer Science Department of the University of Massachusetts Amherst in 1992 Through its efforts in basic research applied research and technology transfer the CIIR has become known internationally as one of the leading research groups in the area of information retrieval The CIIR focuses on research that results in more effective and efficient access and discovery in large heterogeneous distributed text and multimedia databases The scope of the work that is done in the CIIR is broad and goes significantly beyond traditional areas of information retrieval such as retrieval models cross lingual search and automatic query expansion The research includes both low level systems issues such as the design of protocols and architectures for distributed search as well as more human centered topics such as user interface design visualization and data mining with text and multimedia retrieval *Advances in Information Retrieval Recent Research from the Center for Intelligent Information Retrieval* is a collection of papers that covers a wide variety of topics in the general area of information retrieval Together they represent a snapshot of the state of the art in information retrieval at the turn of the century and at the end of a decade that has seen the advent of the World Wide Web The papers provide overviews and in depth analysis of theory and experimental results This book can be used as source material for graduate courses in information retrieval and as a reference for researchers and practitioners in industry      **SIGIR '19**,2019      **Information Retrieval Technology** Gary Geunbae Lee,Dawei Song,Chin-Yew Lin,Akiko Aizawa,Kazuko Kuriyama,Masaharu Yoshioka,Tetsuya Sakai,2009-09-29 This book constitutes the refereed proceedings of the 5th Asia Information Retrieval Symposium AIRS 2009 held in Sapporo Japan in October 2009 The 18 revised full papers and 20 revised poster papers presented were carefully reviewed and selected from 82 submissions All current aspects of information retrieval in theory and practice are addressed working with text audio image video and multimedia data      **Proceedings of the 43rd International ACM SIGIR Conference on Research and Development in Information Retrieval** Jimmy Huang,2020      *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      *SIGIR '94* W. Bruce Croft, C.J. van Rijsbergen, 2012-12-06 Information retrieval IR is becoming an increasingly important area as scientific business and government organisations take up the notion of information superhighways and make available their full text databases for searching Containing a selection of 35 papers taken from the 17th Annual SIGIR Conference held in Dublin Ireland in July 1994 the book addresses basic research and provides an evaluation of information retrieval techniques in applications Topics covered include text categorisation indexing user modelling IR theory and logic natural language processing statistical and probabilistic models of information retrieval systems routing passage retrieval and implementation issues      *A Behavioral Economics Approach to Interactive Information Retrieval* Jiqun Liu, 2023-02-17 This book brings together the insights from three different areas Information Seeking and Retrieval Cognitive Psychology and Behavioral Economics and shows how this new interdisciplinary approach can advance our knowledge about users interacting with diverse search systems especially their seemingly irrational decisions and anomalies that could not be predicted by most normative models The first part Foundation of this book introduces the general notions and fundamentals of this new approach as well as the main concepts terminology and theories The second part Beyond Rational Agents describes the systematic biases and cognitive limits confirmed by behavioral experiments of varying types and explains in detail how they contradict the assumptions and predictions of formal models in information retrieval IR The third part Toward A Behavioral Economics Approach first synthesizes the findings from existing preliminary research on bounded rationality and behavioral economics modeling in information seeking retrieval and recommender system communities Then it discusses the implications open questions and methodological challenges of applying the behavioral economics framework to different sub areas of IR research and practices such as modeling users and search sessions developing unbiased learning to rank and adaptive recommendations algorithms implementing bias aware intelligent task support as well as extending the conceptualization and evaluation on IR fairness accountability transparency and ethics FATE with the knowledge regarding both human biases and algorithmic biases This book introduces a behavioral economics framework to IR scientists seeking a new perspective on both fundamental and new emerging problems of IR as well as the development and evaluation of bias aware intelligent information systems It is especially intended for researchers working on IR and human information interaction who want to learn about the potential offered by behavioral economics in their own research areas      *Advances in Information Retrieval Theory* Leif Azzopardi, Gabriella Kazai, Stephen Robertson, Stefan Rüger, Milad Shokouhi, Dawei Song, Emine Yilmaz, 2009-08-31 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

*Information Retrieval Evaluation in a Changing World* Nicola Ferro,Carol Peters,2019-08-13 This volume celebrates the twentieth anniversary of CLEF the Cross Language Evaluation Forum for the first ten years and the Conference and Labs of the Evaluation Forum since and traces its evolution over these first two decades CLEF s main mission is to promote research innovation and development of information retrieval IR systems by anticipating trends in information management in order to stimulate advances in the field of IR system experimentation and evaluation The book is divided into six parts Parts I and II provide background and context with the first part explaining what is meant by experimental evaluation and the underlying theory and describing how this has been interpreted in CLEF and in other internationally recognized evaluation initiatives Part II presents research architectures and infrastructures that have been developed to manage experimental data and to provide evaluation services in CLEF and elsewhere Parts III IV and V represent the core of the book presenting some of the most significant evaluation activities in CLEF ranging from the early multilingual text processing exercises to the later more sophisticated experiments on multimodal collections in diverse genres and media In all cases the focus is not only on describing what has been achieved but above all on what has been learnt The final part examines the impact CLEF has had on the research world and discusses current and future challenges both academic and industrial including the relevance of IR benchmarking in industrial settings Mainly intended for researchers in academia and industry it also offers useful insights and tips for practitioners in industry working on the evaluation and performance issues of IR tools and graduate students specializing in information retrieval

Charting a New Course: Natural Language Processing and Information Retrieval. John I. Tait,2005-08-01 Karen Sp rck Jones is one of the major figures of 20th century and early 21st Century computing and information processing Her ideas have had an important influence on the development of Internet Search Engines Her contribution has been recognized by awards from the natural language processing information retrieval and artificial intelligence communities including being asked to present the prestigious Grace Hopper lecture She continues to be an active and influential researcher Her contribution to the scientific evaluation of the effectiveness of such computer systems has been quite outstanding This book celebrates the life and work of Karen Sp rck Jones in her seventieth year It consists of fifteen new and original chapters written by leading international

authorities reviewing the state of the art and her influence in the areas in which Karen Spärck Jones has been active. Although she has a publication record which goes back over forty years, it is clear even the very early work reviewed in the book can be read with profit by those working on recent developments in information processing like bioinformatics and the semantic web.

**A Feature-Centric View of Information Retrieval** Donald Metzler, 2011-09-18. Commercial Web search engines such as Google, Yahoo and Bing are used every day by millions of people across the globe. With their ever growing refinement and usage, it has become increasingly difficult for academic researchers to keep up with the collection sizes and other critical research issues related to Web search, which has created a divide between the information retrieval research being done within academia and industry. Such large collections pose a new set of challenges for information retrieval researchers. In this work, Metzler describes highly effective information retrieval models for both smaller classical data sets and larger Web collections. In a shift away from heuristic hand-tuned ranking functions and complex probabilistic models, he presents feature-based retrieval models. The Markov random field model he details goes beyond the traditional yet ill-suited bag of words assumption in two ways. First, the model can easily exploit various types of dependencies that exist between query terms, eliminating the term independence assumption that often accompanies bag of words models. Second, arbitrary textual or non-textual features can be used within the model. As he shows, combining term dependencies and arbitrary features results in a very robust, powerful retrieval model. In addition, he describes several extensions such as an automatic feature selection algorithm and a query expansion framework. The resulting model and extensions provide a flexible framework for highly effective retrieval across a wide range of tasks and data sets. *A Feature-Centric View of Information Retrieval* provides graduate students as well as academic and industrial researchers in the fields of information retrieval and Web search with a modern perspective on information retrieval modeling and Web searches.

**Information Retrieval Technology** Hwee Tou Ng, Mun-Kew Leong, Min-Yen Kan, Donghong Ji, 2006-10-18. This book constitutes the refereed proceedings of the Third Asia Information Retrieval Symposium, AIRS 2006. The book presents 34 revised full papers and 24 revised poster papers. All current issues in information retrieval are addressed: applications, systems, technologies, and theoretical aspects of information retrieval in text, audio, image, video, and multi-media data. The papers are organized in topical sections on text retrieval, search and extraction, text classification and indexing, and more.

**Evaluation of Multilingual and Multi-modal Information Retrieval** Cross-Language Evaluation Forum. Workshop, Carol Peters, 2007-09-06. This book constitutes the thoroughly refereed postproceedings of the 7th Workshop of the Cross Language Evaluation Forum, CLEF 2006, held in Alicante, Spain, September 2006. The revised papers presented together with an introduction were carefully reviewed and selected for inclusion in the book. The papers are organized in topical sections on Multilingual Textual Document Retrieval, Domain Specific Information Retrieval, CLEF QA, CLEF Image, CLEF CLSR, WebCLEF, and GeoCLEF.

**Learning to Rank for Information Retrieval** Tie-Yan Liu, 2011-04-29. Due to the fast growth of the Web and the difficulties in finding desired

information efficient and effective information retrieval systems have become more important than ever and the search engine has become an essential tool for many people. The ranker, a central component in every search engine, is responsible for the matching between processed queries and indexed documents. Because of its central role, great attention has been paid to the research and development of ranking technologies. In addition, ranking is also pivotal for many other information retrieval applications such as collaborative filtering, definition ranking, question answering, multimedia retrieval, text summarization, and online advertisement. Leveraging machine learning technologies in the ranking process has led to innovative and more effective ranking models and eventually to a completely new research area called learning to rank. Liu first gives a comprehensive review of the major approaches to learning to rank. For each approach, he presents the basic framework with example algorithms and discusses its advantages and disadvantages. He continues with some recent advances in learning to rank that cannot be simply categorized into the three major approaches; these include relational ranking, query dependent ranking, transfer ranking, and semisupervised ranking. His presentation is completed by several examples that apply these technologies to solve real information retrieval problems and by theoretical discussions on guarantees for ranking performance. This book is written for researchers and graduate students in both information retrieval and machine learning. They will find here the only comprehensive description of the state of the art in a field that has driven the recent advances in search engine development.

*Advances in Information Retrieval* Claudia Hauff, Craig Macdonald, Dietmar Jannach, Gabriella Kazai, Franco Maria Nardini, Fabio Pinelli, Fabrizio Silvestri, Nicola Tonellotto, 2025-04-02. The five volume set LNCS 15572, 15573, 15574, 15575, and 15576 constitutes the refereed conference proceedings of the 47th European Conference on Information Retrieval (ECIR 2025) held in Lucca, Italy, during April 6–10, 2025. The 52 full papers, 11 findings, 42 short papers, and 76 papers of other types presented in these proceedings were carefully reviewed and selected from 530 submissions. The accepted papers cover the state of the art in information retrieval and recommender systems, user aspects, system and foundational aspects, artificial intelligence, and machine learning applications, evaluation, new social and technical challenges, and other topics of direct or indirect relevance to search and recommendation.

*Advances in Information Retrieval* Nazli Goharian, Nicola Tonellotto, Yulan He, Aldo Lipani, Graham McDonald, Craig Macdonald, Iadh Ounis, 2024-03-22. The six volume set LNCS 14608, 14609, 14610, 14611, 14612, and 14613 constitutes the refereed proceedings of the 46th European Conference on IR Research (ECIR 2024) held in Glasgow, UK, during March 24–28, 2024. The 57 full papers, 18 finding papers, 36 short papers, 26 IR4Good papers, 18 demonstration papers, 9 reproducibility papers, 8 doctoral consortium papers, and 15 invited CLEF papers were carefully reviewed and selected from 578 submissions. The accepted papers cover the state of the art in information retrieval, focusing on user aspects, system and foundational aspects, machine learning applications, evaluation, new social and technical challenges, and other topics of direct or indirect relevance to search.

**Proceedings of the 44th International ACM SIGIR Conference on Research and**

**Development in Information Retrieval** Fernando Diaz,2021

**Readings in Information Retrieval** Karen Sparck

Jones,Peter Willett,1997 This compilation of original papers on information retrieval presents an overview covering both general theory and specific methods of the development and current status of information retrieval systems Each chapter contains several papers carefully chosen to represent substantive research work that has been carried out in that area each is preceded by an introductory overview and followed by supported references for further reading

*Information Retrieval* Ayse Goker,John Davies,2009-12-15 This book is an essential reference to cutting edge issues and future directions in information retrieval Information retrieval IR can be defined as the process of representing managing searching retrieving and presenting information Good IR involves understanding information needs and interests developing an effective search technique system presentation distribution and delivery The increased use of the Web and wider availability of information in this environment led to the development of Web search engines This change has brought fresh challenges to a wider variety of users needs tasks and types of information Today search engines are seen in enterprises on laptops in individual websites in library catalogues and elsewhere Information Retrieval Searching in the 21st Century focuses on core concepts and current trends in the field This book focuses on Information Retrieval Models User centred Evaluation of Information Retrieval Systems Multimedia Resource Discovery Image Users Needs and Searching Behaviour Web Information Retrieval Mobile Search Context and Information Retrieval Text Categorisation and Genre in Information Retrieval Semantic Search The Role of Natural Language Processing in Information Retrieval Search for Meaning and Structure Cross language Information Retrieval Performance Issues in Parallel Computing for Information Retrieval This book is an invaluable reference for graduate students on IR courses or courses in related disciplines e g computer science information science human computer interaction and knowledge management academic and industrial researchers and industrial personnel tracking information search technology developments to understand the business implications Intermediate advanced level undergraduate students on IR or related courses will also find this text insightful Chapters are supplemented with exercises to stimulate further thinking



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