Pattern Recognition Topics for Student Study

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Document created in summer 2017; you are invited to look for more recent publications

Students in CISC859 choose a pattern recognition topic to study and present to the class (oral presentation and brief written report). Below I provide suggestions for possible topics. You are welcome to choose from this list, or select any other topic that is related to pattern recognition. Tell me by the fifth week of term what topic you selected. I will alert students who have chosen similar topics, so that you can coordinate your presentations so that they complement one another without too much duplication.

Journals and IAPR resources

Articles in the following journals are generally substantive and of very high quality. You can scan through recent issues of these journals to find a topic that interests you.

- *IEEE Transactions on Pattern Analysis and Machine Intelligence* (IEEE T-PAMI)
- *International Journal of Pattern Recognition and Artificial Intelligence* (IJPRAI)
- *Computing Surveys* Look for surveys related to pattern recognition; many listed below.

The IAPR education committee http://homepages.inf.ed.ac.uk/rbf/IAPR/researchers/index.php provides resources for three areas of core technology (symbolic PR; statistical PR; machine learning) and two broad families of application areas (1D signal analysis; 2D image analysis). For each area, they provide links to tutorials and surveys; explanations; online demos; datasets; books; code.

Suggested topics

For many of the topics I cite one or more related papers. These papers are intended as a starting point. You are encouraged to look for other papers and websites, demos, tutorials that relate to your topic.

Some of the papers cover many different subtopics. You cannot cover lots of subtopics in a short presentation, so organize your presentation as a brief general overview followed by details about a few selected subtopics.

1. Towards the Unification of Structural and Statistical Pattern Recognition

Horst Bunke and Kaspar Riesen (2012) *Pattern Recognition Letters*.
http://www.sciencedirect.com/science/article/pii/S0167865511001309

Abstract: The field of pattern recognition is usually subdivided into the statistical and the structural approach. Structural pattern recognition allows one to use powerful and flexible representation formalisms but offers only a limited repertoire of algorithmic tools needed to solve classification and clustering problems. By contrast, the statistical approach is mathematically well founded and offers many tools, but provides a representation formalism that is limited in its power and flexibility. Hence, both subfields are complementary to each other. During the last three decades several efforts have been made towards bridging the gap between structural and statistical pattern recognition in order to profit from the benefits of each approach and eliminate the drawbacks. The present paper reviews some of these attempts made towards the unification of structural and statistical pattern recognition and analyzes the progress that has been achieved.

Perhaps relate to techniques summarized here: IJPRAI 2012 Pattern Recognition Techniques: A Review http://www.ijcst.org/Volume3/Issue8/p4_3_8.pdf

2. Template matching

2012 An Overview of Template Matching Techniques in Image Processing
http://maxwellsci.com/print/rjaset/v4-5469-5473.pdf

2013 An Overview on Template Matching Methodologies and its Applications
http://www.ijrcct.org/index.php/ojs/article/view/377

2016 Template Matching advances and applications in image analysis
http://asrjetsjournal.org/index.php/American_Scientific_Journal/article/view/2378

2005 A Survey of elastic matching techniques for handwritten character recognition
http://dl.acm.org/citation.cfm?id=1184702

2009 book Template matching techniques in computer vision: theory and practice
http://ca.wiley.com/WileyCDA/WileyTitle/productCd-0470517069.html

3. Feature selection; dataset shift

Feature Selection Based on Structured Sparsity: A Comprehensive Study (2017) IEEE Trans. Neural Networks and Learning Systems http://ieeexplore.ieee.org/document/7458185

Abstract: Feature selection (FS) is an important component of many pattern recognition tasks. In these tasks, one is often confronted with very high-dimensional data. FS algorithms are designed to identify the relevant feature subset from the original features, which can facilitate subsequent analysis, such as clustering and classification. Structured sparsity-inducing feature selection (SSFS) methods have been widely studied in the last few years, and a number of algorithms have been proposed. However, there is no comprehensive study concerning the connections between different SSFS methods, and how they have evolved. In this paper, we attempt to provide a survey on various SSFS methods, including their motivations and mathematical representations. We then explore the relationship among different formulations and propose a taxonomy to elucidate their evolution. We group the existing SSFS methods into two categories, i.e., vector-based feature selection (feature selection based on lasso) and matrix-based feature selection (feature selection based on l_{n}-norm). Furthermore, FS has been combined with other machine learning algorithms for specific applications, such as multitask learning, multilabel learning, multiview learning, classification, and clustering. This paper not only compares the differences and commonalities of these methods based on regression and regularization strategies, but also provides useful guidelines to practitioners working in related fields to guide them how to do feature selection.

2014 Science and Information conference. A survey of feature selection and feature extraction techniques in machine learning http://ieeexplore.ieee.org/document/6918213/

Abstract: Dimensionality reduction as a preprocessing step to machine learning is effective in removing irrelevant and redundant data, increasing learning accuracy, and improving result comprehensibility. However, the recent increase of dimensionality of data poses a severe challenge to many existing feature selection and feature extraction methods with respect to efficiency and effectiveness. In the field of machine learning and pattern recognition, dimensionality reduction is important area, where many approaches have been proposed. In this paper, some widely used feature selection and feature extraction techniques have analyzed with the purpose of how effectively these techniques can be used to achieve high performance of learning algorithms that ultimately improves predictive accuracy of classifier. An endeavor to analyze dimensionality reduction techniques briefly with the purpose to investigate strengths and weaknesses of some widely used dimensionality reduction methods is presented.

2012 "A survey on feature extraction for pattern recognition"
http://or.nsfc.gov.cn/bitstream/00001903-5/91929/1/1000004257124.pdf Ding, Zhi, Jia, Su (2012) A survey on feature extraction for pattern recognition. Artificial Intelligence Review 37(3):169-180

2012 "A unifying view on dataset shift in classification" *Pattern Recognition*
http://dl.acm.org/citation.cfm?id=2031236

Abstract: The field of dataset shift has received a growing amount of interest in the last few years. The fact that most real-world applications have to cope with some form of shift makes its study highly relevant. The literature on the topic is mostly scattered, and different authors use different names to refer to the same concepts, or use the same name for different concepts. With this work, we attempt to present a unifying framework through the review and comparison of some of the most important works in the literature.

4. Gaussian mixture models

Briefly mention in course reader section 4.1.1. Mixture models are needed to create a good fit to mulltimodal data.

5. Decision trees

L. Rokach, O. Maimon, "Top-down Induction of Decision Tree Classifiers - A Survey," *IEEE Trans. Systems, Man, and Cybernetics*, Vol. 35, No. 4, pp. 476-487, Nov. 2005.

2013 *Computing Surveys*. A survey of cost-sensitive decision tree induction algorithms

CART decision tree design discussed extensively in DHS Sec 8.3.

Section 14.4.3 Decision Trees www.visionbib.com/bibliography/pattern639.html
Full table of contents for the Annotated Computer Vision Bibliography at
www.visionbib.com/bibliography/contents.html

6. Clustering

An extensive comparative study of cluster validity indices (2013) *Pattern Recognition*.
http://www.sciencedirect.com/science/article/pii/S003132031200338X

Abstract: The validation of the results obtained by clustering algorithms is a fundamental part of the clustering process. The most used approaches for cluster validation are based on internal cluster validity indices. Although many indices have been proposed, there is no recent extensive comparative study of their performance. In this paper we show the results of an experimental work that compares 30 cluster validity indices in many different environments with different characteristics. These results can serve as a guideline for selecting the most suitable index for each possible application and provide a deep insight into the performance differences between the currently available indices.

2015 *Computing Surveys*. A survey of multiobjective evolutionary clustering.

2013 *Computing Surveys*. Data stream clustering: a survey.

I briefly mention *conceptual clustering* in section 4.7.2 of the course reader, but am not sure how much recent work there has been. This 2014 conference paper claims “important and active research area”
https://link.springer.com/chapter/10.1007/978-3-642-55038-6_1

Abstract: Traditional clustering methods are unable to describe the generated clusters. Conceptual clustering is an important and active research area that aims to efficiently cluster and explain the data. Previous conceptual clustering approaches provide descriptions that do not use a human comprehensible knowledge. This paper presents an algorithm which uses Wikipedia concepts to process a clustering method. The generated clusters overlap each other and serve as a basis for an information retrieval system. The method has been implemented in order to improve the performance of the system. It reduces the computation cost.

7. Classifier combination

Random decision forests. First created by Tin Kam Ho in 1995. Students can try this out in Weka or elsewhere.

Many publications on classifier combination, such as 2017 *Computing Surveys*, A Survey on Ensemble Learning for Data Stream Classification.

8. Graph-based pattern matching

Gallagher (2006) Matching Structure and Semantics: A Survey on Graph-based Pattern Matching http://www.briangallagher.net/pubs/gallagher-aaaifall-2006.pdf

Abstract: The task of matching patterns in graph-structured data has applications in such diverse areas as computer vision, biology, electronics, computer aided design, social networks, and intelligence analysis. Consequently, work on graph-based pattern matching spans a wide range of research communities. Due to variations in graph characteristics and application requirements, graph matching is not a single problem, but a set of related problems. This paper presents a survey of existing work on graph matching, describing variations among problems, general and specific solution approaches, evaluation techniques, and directions for further research. An emphasis is given to techniques that apply to general graphs with semantic characteristics.

See website of IAPR Technical Committee #15 on Graph-based Representations in Pattern Recognition. https://iapr-tc15.greyc.fr/index.php

9. Grammars and Grammatical Inference

2013 *Computing Surveys*. Using grammars for pattern recognition in images: a systematic review

Maybe relate to software engineering (as surveyed by our colleagues in School of Computing):

Andrew Stevenson and James R. Cordy (2014) A survey of grammatical inference in software engineering. *Science of Computer Programming* 96:444-459.

10. Stochastic grammars and fuzzy grammars

http://www.sciencedirect.com/science/article/pii/S0076539209604641

Publisher summary: This chapter discusses the stochastic languages and stochastic syntax analysis. Languages have been used for pattern description and algorithms of syntactic analysis have been used as recognition procedures. In some practical applications, a certain amount of uncertainty exists in the process under study. Languages used to describe the noisy and distorted patterns under consideration are often ambiguous in the sense that one string can be generated by more than one grammar that specifies the patterns generated from a particular pattern class. In decision-theoretic pattern recognition terminology, this is the case of overlapping pattern classes and patterns belonging to different classes may have the same descriptions or measurement values. Two natural ways of extending the concept of formal languages to stochastic languages are to randomize the productions of grammars and the state transitions of the recognition devices, respectively. It is found that, as the productions of a stochastic grammar are exactly the same as those of the nonrandomized grammar except for the assignment of the probability distribution, the set of languages generated by a stochastic grammar is the same as that generated by the nonrandomized version.

https://link.springer.com/chapter/10.1007/978-3-319-26154-6_9 (2015) conference paper

Abstract: One of the main problems in the syntactic pattern recognition area concerns analysis of distorted/fuzzy string patterns. Classical methods developed to solve the problem are based on the error-correcting approach or the stochastic one. These methods are useful but have several limitations. Therefore, there is still the need to construct effective models of syntactic recognition of distorted/fuzzy patterns. The new approach to the problem is presented in the paper. It is based on the fuzzy primitives and the new class of fuzzy automata. The advantages of the approach are presented in the paper, as well as its comparison to classical approaches.

11. OCR for various languages; whole book recognition

Many papers have been published on Chinese character recognition, Arabic character recognition, recognition of handwritten text (printed or cursive), word recognition etc.

2013 *Computing Surveys*. Offline Arabic handwritten text recognition: a survey.

Whole book recognition. Xiu, Baird (2012) PAMI. http://dl.acm.org/citation.cfm?id=2412898

Abstract: Whole-book recognition is a document image analysis strategy that operates on the complete set of a book's page images using automatic adaptation to improve accuracy. We describe an algorithm which expects to be initialized with approximate iconic and linguistic models—derived from (generally errorful) OCR results and (generally imperfect) dictionaries—and then, guided entirely by evidence internal to the test set, corrects the models which, in turn, yields higher recognition accuracy. The iconic model describes image formation and determines the behavior of a character-image classifier, and the linguistic model describes word-occurrence probabilities. Our algorithm detects "disagreements" between these two models by measuring cross entropy between 1) the posterior probability distribution

of character classes (the recognition results resulting from image classification alone) and 2) the posterior probability distribution of word classes (the recognition results from image classification combined with linguistic constraints). We show how disagreements can identify candidates for model corrections at both the character and word levels. Some model corrections will reduce the error rate over the whole book, and these can be identified by comparing model disagreements, summed across the whole book, before and after the correction is applied. Experiments on passages up to 180 pages long show that when a candidate model adaptation reduces whole-book disagreement, it is also likely to correct recognition errors. Also, the longer the passage operated on by the algorithm, the more reliable this adaptation policy becomes, and the lower the error rate achieved. The best results occur when both the iconic and linguistic models mutually correct one another. We have observed recognition error rates driven down by nearly an order of magnitude fully automatically without supervision (or indeed without any user intervention or interaction). Improvement is nearly monotonic, and asymptotic accuracy is stable, even over long runs. If implemented naively, the algorithm runs in time quadratic in the length of the book, but random subsampling and caching techniques speed it up by two orders of magnitude with negligible loss of accuracy. Whole-book recognition has potential applications in digital libraries as a safe unsupervised anytime algorithm.

12. Pattern recognition for indexing and retrieval of images and video

2002 PR Antani, Kasturi, Jain A survey on the use of pattern recognition methods for abstraction, indexing and retrieval of images and video.
https://pdfs.semanticscholar.org/950d/56ca43b56e78da79f4ed07d5448ed80475b6.pdf

2014 *Computing Surveys*. Spaces, trees and colors: the algorithmic landscape of document retrieval on sequences.

2008 *Computing Surveys*. Image retrieval: ideas, influences, and trends of the new age. http://dl.acm.org/citation.cfm?id=1348246

13. Biometrics and face recognition

2017 *Computing Surveys*. Presentation attack detection methods for face recognition.

2016 *Computing Surveys*. Biometric recognition in automated border control.

2016 *Computing Surveys*. A survey of wearable biometric recognition systems.

2016 *Computing Surveys*. Knuckle print biometrics and fusion schemes -- overview, challenges and solutions.

2016 *Computing Surveys*. Audio surveillance: A systematic review.

2015 *Computing Surveys*. The impact of bio-inspired approaches toward the advancement of face recognition.

2015 *Computing Surveys*. A survey on antispoofing schemes for fingerprint recognition systems.

2014 *Computing Surveys*. A tutorial on human activity recognition using body-worn inertial sensors.

2013 *Computing Surveys*. A survey on ear biometrics.

2012 *Computing Surveys*. A review of recent advances in 3D ear- and expression-invariant face biometrics.

2012 *Computing Surveys*. A comparative study of palmprint recognition algorithms.

14. Other pattern recognition topics in *Computing Surveys*

2017 *Computing Surveys*. Automated vehicle detection and classification.

2017 *Computing Surveys*. Spatio-temporal analysis of team sports.

2017 *Computing Surveys*. Current state of text sentiment analysis from opinion to emotion mining
2016 *Computing Surveys*. A survey and comparative study of tweet sentiment analysis via semi-supervised learning

2017 *Computing Surveys*. Imitation Learning.

2016 *Computing Surveys*. On precision bound of distributed fault-tolerant sensor fusion algorithms.

2016 *Computing Surveys*. Understanding the limitations of particle swarm algorithm for dynamic optimization tasks.

2016 *Computing Surveys*. Data-driven human mobility modeling: A Survey and Engineering Guidance for Mobile Networking

2015 *Computing Surveys*. Performance anomaly detection and bottleneck identification
2009 *Computing Surveys*. Anomaly detection: A survey Chandola, Banerjee, Kuma

2014 *Computing Surveys*. A survey of digital map processing techniques.

2014 *Computing Surveys*. Discrete Bayesian network classifiers: A survey.

2014 *Computing Surveys*. A survey on ontologies for human behavior recognition.

2014 *Computing Surveys*. A survey on concept drift adaptation.

2014 *Computing Surveys*. When errors become the rule: 20 years with transformation-based learning.
This is a machine learning method for sequential classification from 1993; used in computational linguistics and natural language processing.

2013 *Computing Surveys*. A survey of intelligent assistants for data analysis.
Serban, Vanschoren, Kietz, Bernstein (2013) A survey of intelligent assistants for data analysis. ACM Computing Surveys 45(3)

2013 *Computing Surveys*. Sequential pattern mining -- approaches and algorithms.