An Efficient URL-Pattern Based Algorithm for Accurate Web Page Classification

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Preamble

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Motivation

- The paper proposes an efficient algorithm to classify web pages based on nothing but their URLs.
- Presented at the 12th International Conference on Fuzzy Systems and Knowledge Discovery, 2015

Colophon

- Made with $\LaTeX$ version 3.1415926. Presented with Beamer
- Source available at

  `http://github.com/pawandubey/seminar`

Introduction

Web Page Classification

- Assigning web pages to one of the predefined categories
- Difficult because of the amount of data
- Useful for contexual action

State of the Art

- Reading page text, hyperlinks etc
- Natural Language Processing techniques on the page text

Problems

- Too slow and inefficient
- Complicated models

URL Based Approach

URLs are the cheapest to access

- Speed boost
- Many relevant features due to SEO

Current Methods

- Use the same content-based techniques
- No incremental learning methods

Background on URL Patterns

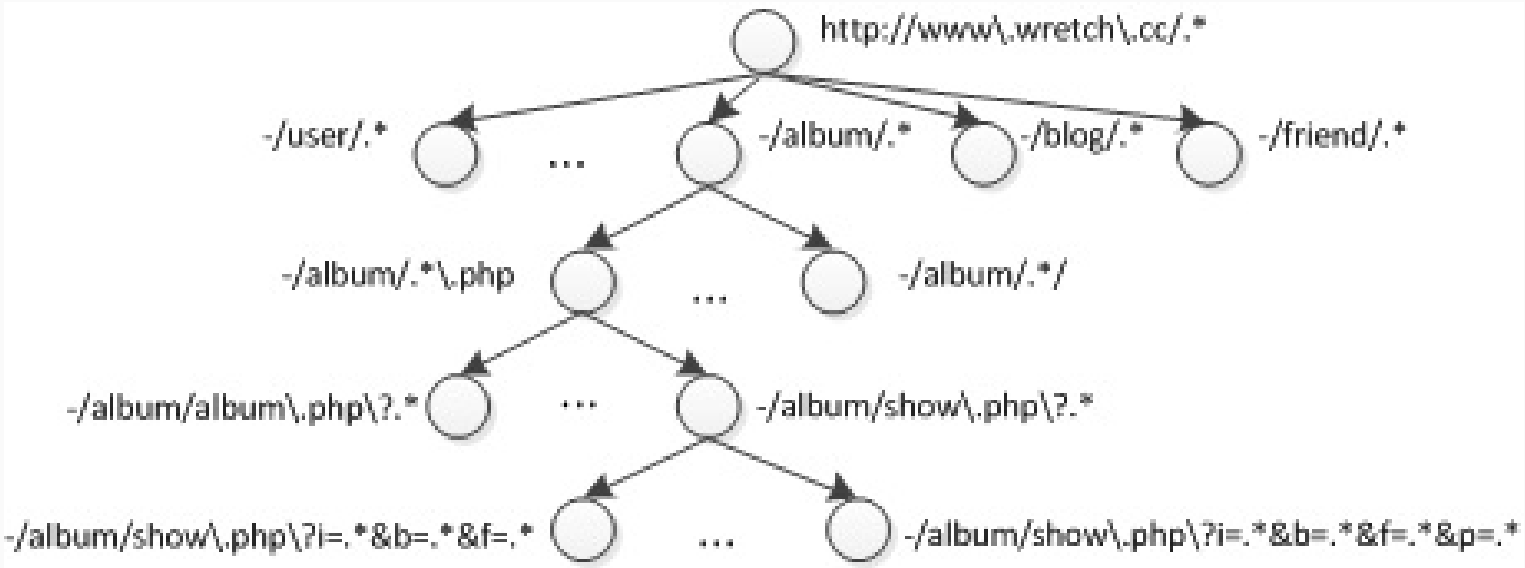
URL-Patterns

What are URL Patterns? A regular expression matching the URLs of a group of related pages.

- `http://manipal.edu/*` matches all pages related to Manipal University
- `http://manipal.edu/mit/*` matches all pages related to MIT, Manipal

Pattern Tree

A `Suffix Tree` like structure, instead for regexes.



Pattern Tree Node

Each node contains a key-value representation of the decomposed components of the URLs that matches the corresponding regex.

Example *https://google.com/search?q=regex*

- *Protocol* : HTTPS
- *Authority* : google.com
- *Path* : /search
- *q* : regex

The Algorithm

Pattern Tree Construction

Algorithm 1 pattern tree algorithm

Input: The set of URLs,S_{url}; The set of keys that have been processed K_{done};

Output: A root node for URLs in S_{url},N_{root};

1: Calculate entropy H(K) for keys that occur in over β percent of URLs of N_{root};
2: Select the new partition key K^* that minimize H(K);
3: $V \leftarrow$ salient values in K^*, trivial values as '*';
4: **if** all values in V are trivial values or size of $S_{url} < \tau$ **then**
5: **return** N_{root};
6: **end if**
7: **for all** v in V **do**
8: $S_v \leftarrow$ URLs whose value of K^* equals to v in S_{url};
9: $N_{new} \leftarrow$ pattern-tree construction(S_v,$K_{done} \cup K^*$);
10: Add N_{new} to children of N_{root};
11: **end for**
12: **return** N_{root};

Pattern Tree Construction

- For each key decomposed from the URL set, we determine entropy

Shanon Entropy

$$H(K) = \sum_{i=1}^{T} \frac{n_i}{N} log \frac{n_i}{N} \tag{1}$$

We choose the K^* which minimizes this value as the splitting variable.

Pattern Tree Construction

- We select all values for the key K^* and divide them as salient or trivial
- Division based on probablistic methods to find the decline of the frequency
- Recursively apply for all salient values of K^*
- Stop if either only trivial values left or number of URLs less than threshold

Problems

- Recursive - inefficient
- Not incremental

Improvement

- An incremental modification to the algorithm

Incremental Pattern Tree Construction

- Only reconstruct tree if the K^*_{new} is different from K^*_{old}
- Check if the new URLs match an existing node
- If yes, add to matching node and recursively update
- Create new nodes only if no match found for new URLs

Pros

- Only update a subtree of the whole tree

Pattern Generation

- Relationship between keys are determined
- Pattern is generated by topologically sorting the set of keys
- Final pattern set is constructed by looking at the patterns of leaf nodes

Classification

Binary

- Pattern for only one of the classes are matched with the URL
- Useful for tasks like sentiment analysis

MultiClass

- Patterns for all classes generated in advance
- Pattern weight w_{ij} determines class of URL
- w_{ij} is the number of URLs matching $pattern_j$ in $class_i$
- The longest matching pattern for the URL with each $class_i$ is selected as $candidate_i$

$$label_{url} = \max_{i \in class_m} (w_{candidate_i}) \tag{2}$$

Evaluation

Performance Measures

In terms of Information Retrieval, if the problem is to retrieve relevant documents from a dataset,

- Precision is the fraction of retrieved documents which are relevant
- Recall is the fraction of relevant documents that are retrieved
- F1 score is the harmonic mean of precision and recall

$$F1 = 2 \cdot \frac{precision \cdot recall}{precision + recall} \tag{3}$$

- Running Time

Setup

- WebKB dataset
- Comparison with *Web Classification Using N-gram Based URL Features* by *R.Rajalakshmi*
- And *Rule Based Method*
- 90-10 Training-Test split

Functional Classification

To validate effectiveness and efficiency in classification

Results

Category	NBUF Method with SVM			NBUF Method with ME			UPCA		
	P	R	F1	P	R	F1	P	R	F1
student(1641)	79.0%	94.2%	85.9%	80.6%	79.7%	80.1%	80.8%	93.0%	**86.5%**
faculty(1124)	83.6%	54.5%	65.9%	66.1%	64.3%	65.2%	85.5%	63.4%	**72.8%**
course(930)	97.5%	77.0%	**86.0%**	86.6%	84.0%	85.3%	97.2%	70.0%	81.4%
project(504)	96.0%	45.3%	61.5%	70.8%	64.2%	**67.3%**	93.1%	50.9%	65.9%
average	89.03%	67.5%	74.8%	76.0%	73.1%	74.5%	89.2%	69.3%	**76.7%**

Take aways

- UPCA is about 10X faster than NBUF
- Achieves an improvement of 2% on F1
- Performs better on larger datasets

High Quality Page Identification

Prove effectiveness on a dataset with much noise.

Results

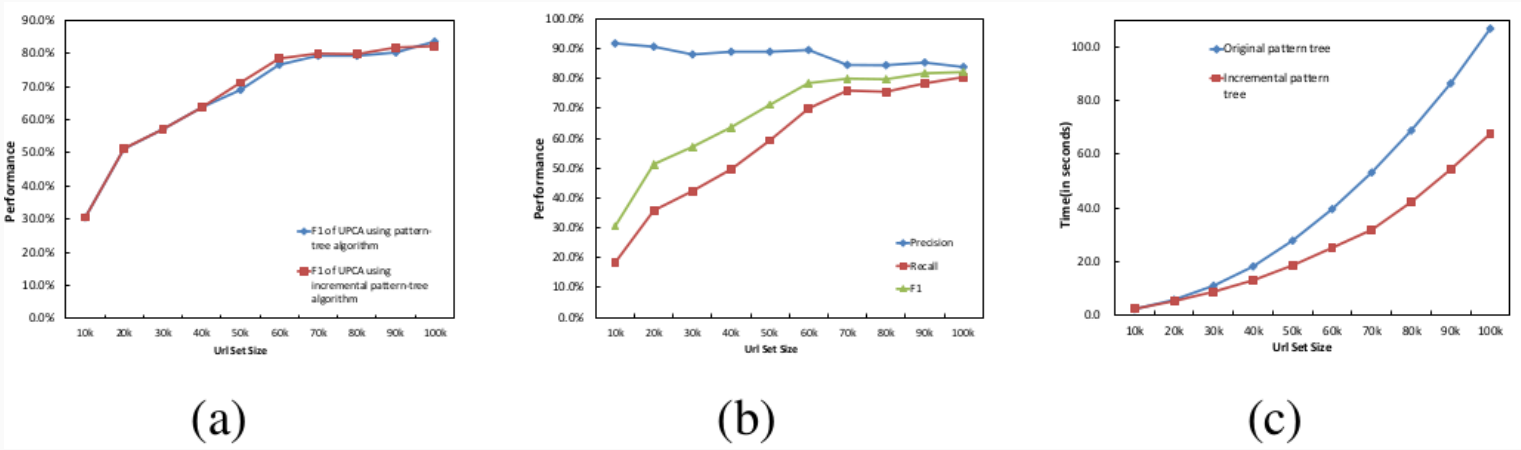
Hosts	Rule-Based Method			NBUF(SVM)			UPCA		
	P	R	F1	P	R	F1	P	R	F1
3g.ifeng.com	99.14%	47.5%	64.25%	96.15%	30.49%	46.30%	79.2%	82.1%	**80.6%**
m.dangdang.com	16.9%	53.6%	25.6%	-	-	-	17.8%	90.5%	**30.0%**
wap.ganji.com	58.7%	37.0%	45.5%	61.90%	13.54%	22.22%	64.4%	100%	**78.4%**
wap.lashou.com	88.0%	66.1%	75.7%	25.00%	3.87%	6.70%	89.9%	98.7%	**93.6%**

Take aways

- UPCA is clearly superior to the *Rule Based Method* approach

Conclusion

Performance Comparison



- UPCA provides a much more efficient way to classify web pages based on URLs
- The incremental algorithm achieves a performance gain on the recursive one
- A distributed version required for processing very large data sets

Resources and References

References

- Tao Lei, Rui Cai, Jiang-Ming Yang, Yan Ke, Xiaodong Fan, Lei Zhang. *A Pattern Tree-based Approach to Learning URL Normalization Rules.* In Proc. of the 19th International World Wide Web Conference (WWW 2010)
- Y. Lin, T. Zhu, X. Wang, J. Zhang, and A. Zhou. *Towards online review spam detection.* In WWW, pages 341–342. IW3C2, 2014.
- R. Rajalakshmi and C. Aravindan. *Web page classification using n-gram based url features.* In Advanced Computing (ICoAC), pages 15–21. IEEE, 2013.