Presentation 1

The Deep Web: Surfacing Hidden Value

Michael K. Bergman, 2001, Journal of Electronic Publishing

Searching for Hidden-Web Databases

Luciano Barbosa & Juliana Freire, 2005, Proceedings of WebDB

John Berlin

September 15, 2016

Old Dominion University
Introduction to Information Retrieval
CS734/834

Table of contents

1. Introduction

2. The Deep Web: Surfacing Hidden Value

3. Searching for Hidden-Web Databases

4. Conclusion

Introduction

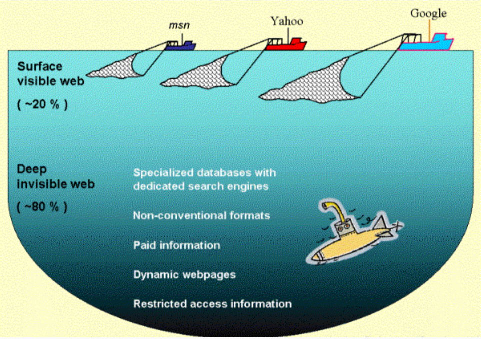
What is the Deep Web?

Content not indexed (crawled) by search engines

This content is characterized as *dynamic* and is generally generated as the result of a specific query

Where does the dynamic content come from?

- Databases
- Forms



The Deep Web: Surfacing Hidden Value

Bergman’s Contribution

- A quantification for the size of the deep Web
- A characterization of the deep Web’s contentent
- Initial enumeration of the difficulties for retrieving deep web content

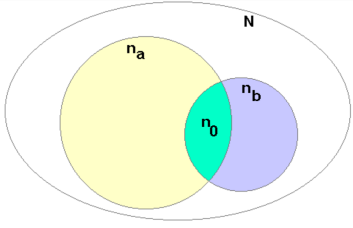
Quantification of the deep web

To quantify the deep web a pool of 53,220 urls was used

43,348 retrieved and 700 were randomly selected

13.6% $\approx$ 100 were found not to be search sites i.e. Google like

but provided a lower bounds size estimation by content overlap



Remember Lecture 1 WebSci
Figure 3 page 4

Quantification of the deep web

Another 100 random sites were chosen for content analysis

The html documents (records) per site was retrieved

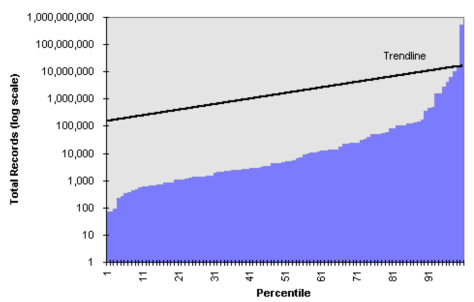
Mean size of 13.7KB, median 19.7KB

Mean #documents of 5.43 million, median 4.95 thousand

From this they estimated > 200,000 total deep web sites

For a total of 543 billion documents

Inferred Distribution of Record Size
Figure 4 page 8



Quantification of the deep web

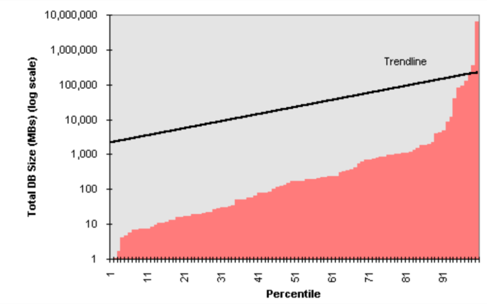
Along with the documents the databases were retrieved

Mean size 74.4 MB with median of 169 KB

Estimated total database size of 7.44 petabytes

Compared to 18.7 terabytes of the surface web at the time

60 deep web sites had already known database size totaling 750 terabytes



Inferred Distribution of Database Size
Figure 5 page 9

Characterization of the deep web

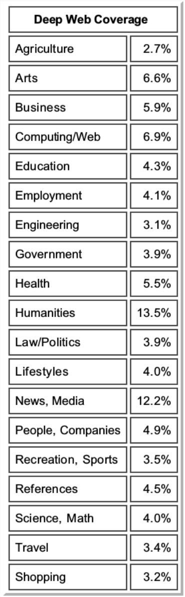
Revisiting the initial 43,348 urls

17,000 sites were selected

For subject and content analysis

It was found that they contained an uniform subject distribution

Table 6, page 9 seen left shows these findings



Deep Web Coverage	
Agriculture	2.7%
Arts	6.6%
Business	5.9%
Computing/Web	6.9%
Education	4.3%
Employment	4.1%
Engineering	3.1%
Government	3.9%
Health	5.5%
Humanities	13.5%
Law/Politics	3.9%
Lifestyles	4.0%
News, Media	12.2%
People, Companies	4.9%
Recreation, Sports	3.5%
References	4.5%
Science, Math	4.0%
Travel	3.4%
Shopping	3.2%

Characterization of the deep web

Topical databases, internal site documents and archived publications make up 80% of all deep web sites

E-commerce along with auction and classified sites 10%

Remaining sites 10%

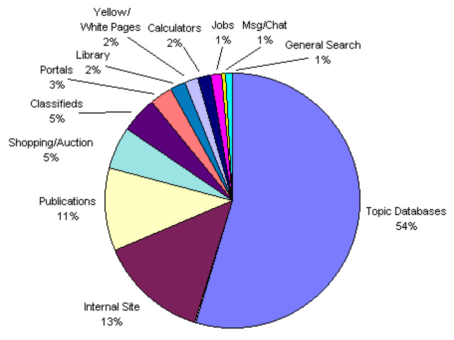


Figure 6 page 10

Difficulties in retrieving deep web content

Database Content Retrieval Used In Study

Directed queries are necessary using 21m terms, 430k unique

For each new database 430k queries are needed

To get all of their contents

An infeasible task at scale

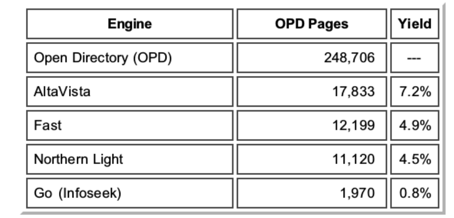
Difficulties in retrieving deep web content

Search Engines Use Breath Crawls

The query *URL:dmoz.org* was made to four major search engines

Dmoz or Open Directory had at the time subject structure of 248k categories

The search engines returned only a small percentage of expected results



Engine	OPD Pages	Yield
Open Directory (OPD)	248,706	---
AltaVista	17,833	7.2%
Fast	12,199	4.9%
Northern Light	11,120	4.5%
Go (Infoseek)	1,970	0.8%

Table 7 page 10

Difficulties in retrieving deep web content

Leaving the question of how to effectively access the contents of the deep web databases and crawl sites in order to find links to the deeper content open

Searching for Hidden-Web Databases

Barbosa & Freire’s Contribution

New Crawling Strategy to automatically discover hidden-web databases

Form-Focused Crawler

Depth Focused Crawling

Avoid links that lead to off-topic regions

Back the crawler with a classifier to determine what is relevant

The classifier is trained on the pages belonging to topics in a taxonomy e.g. *dmoz.org*

Links are then given to another classifier to select the most promising links in the selected page.

Form-Focused Crawler

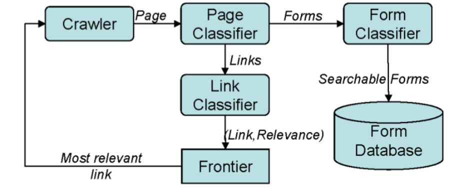
Crawler that understands form interfaces

Deep web use forms as the front end to databases

Must know what forms are searchable or not e.g. logins

And be domain-independent

To do this the crawler uses a third classifier for forms



Form Crawler Architecture

Figure 1 page 3

Classifier Setup

Link Classifier

Forms are sparsely distributed

Selecting links with immediate benefit means you miss forms

This classifier identifies links that bring *delayed benefit*

Or links that will *eventually* lead to forms

In order to know what links will do that depends on training

Classifier Setup

Link Classifier - Feature space by back crawling

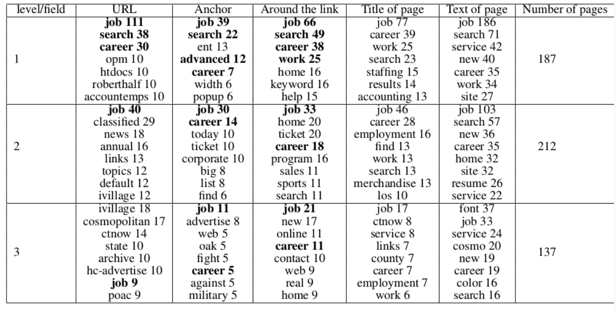
Approximation of the connectivity graph for a site

Using Google’s “link:” searches conduct bread-first crawl

Starting with pages that have a searchable form *level 1*

Find links that point to the form level+1

Count features in url string and document text



level/field	URL	Anchor	Around the link	Title of page	Text of page	Number of pages
1	**job 111**	**job 39**	**job 66**	job 77	job 186	187
	search 38	**search 22**	**search 49**	career 39	search 71	
	career 30	ent 13	**career 38**	work 25	service 42	
	opm 10	**advanced 12**	**work 25**	search 23	new 40	
	htdocs 10	**career 7**	home 16	staffing 15	career 35	
	roberthalf 10	width 6	keyword 16	results 14	work 34	
	accountemps 10	popup 6	help 15	accounting 13	site 27	
2	**job 40**	**job 30**	**job 33**	job 46	job 103	212
	classified 29	**career 14**	home 20	career 28	search 57	
	news 18	today 10	ticket 20	employment 16	new 36	
	annual 16	ticket 10	**career 18**	find 13	career 35	
	links 13	corporate 10	program 16	work 13	home 32	
	topics 12	big 8	sales 11	search 13	site 32	
	default 12	list 8	sports 11	merchandise 13	resume 26	
	ivillage 12	find 6	search 11	los 10	service 22	
3	ivillage 18	**job 11**	**job 21**	job 17	font 37	137
	cosmopolitan 17	advertise 8	new 17	ctnow 8	job 33	
	ctnow 14	web 5	online 11	service 8	service 24	
	state 10	oak 5	**career 11**	links 7	cosmo 20	
	archive 10	fight 5	contact 10	county 7	new 19	
	hc-advertise 10	**career 5**	web 9	career 7	career 19	
	job 9	against 5	real 9	employment 7	color 16	
	poac 9	military 5	home 9	work 6	search 16	

Feature Space For Job Domain ,Table 1 page 4

Classifier Setup

Page Classifier

Uses the Rainbow classifier, naïve Bayes

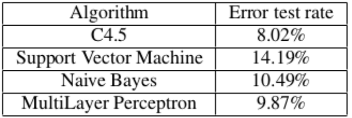
Trained on pages from *dmoz.org*

Gives a score if the page belongs to the focus topic

Form Classifier

Decision Tree classifier (C4.5) to determine searchability

Trained by finding number of tags, input fields, size of text and submission method (post or get)



Algorithm	Error test rate
C4.5	8.02%
Support Vector Machine	14.19%
Naive Bayes	10.49%
MultiLayer Perceptron	9.87%

Test error rates for different learning algorithms
Table 2 page 4

Crawl Strategy

Frontier Generation

N queues determined by the number of levels used by the link classifier

Prioritize links closer to target page

Queues ordered by likelihood of belonging to a level

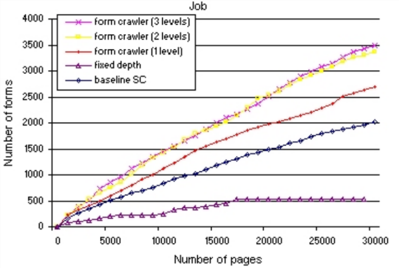
Stopping Criteria

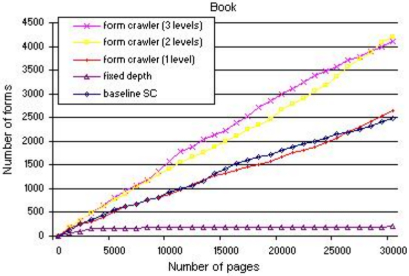
When a predetermined number of forms has been retrieved

Estimated 4.2 query interfaces (form) on any given deep web site

Visited maximum number pages on a site

Crawler Performance





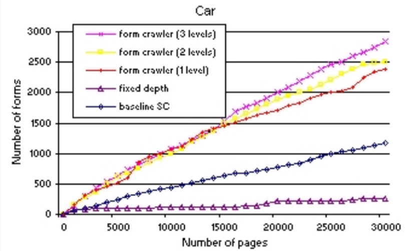


Figure 2 page 5

Using 3 vs 1 level configuration

Gain improvements of

20% to 30%

Conclusion

Conclusion

The Deep Web: Surfacing Hidden Value
Bergman provided a measurement for the deep web
Showed its content is highly relevant to surface web searches
Enumerated on the difficulties of crawling and extracting the content

Searching for Hidden-Web Databases
Barbosa & Juliana built a crawler to address the issue of database discovery that Bergman highlighted