Focused crawling: a new approach to topic-specific Web resource discovery

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Outline

- Why Focused Crawling?
- Contributions
- Applications
- System Architecture
- Evaluation
- Related Work
- Comments

Why Focused Crawling?

- Current general crawlers operate with high cost.
- They have a limited coverage of the web.
- Huge web growth should not affect users with specific interests.
- Huge index size is undesired when the task is to find focused resources.

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Contributions

- Reduce network and hardware crawling costs.
- Provide the ability to manage web content using a distributed team of focused crawlers.
- Control the crawler behavior using other integrated hypertext mining processes:
  - Classifier
  - Distiller

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Potential Applications

- Discovering linkage sociology.
- Locating highly relevant sites.
- Enriching training base for human-supervised topic learning.
- Detecting community behavior.
- Estimating topic change rate.

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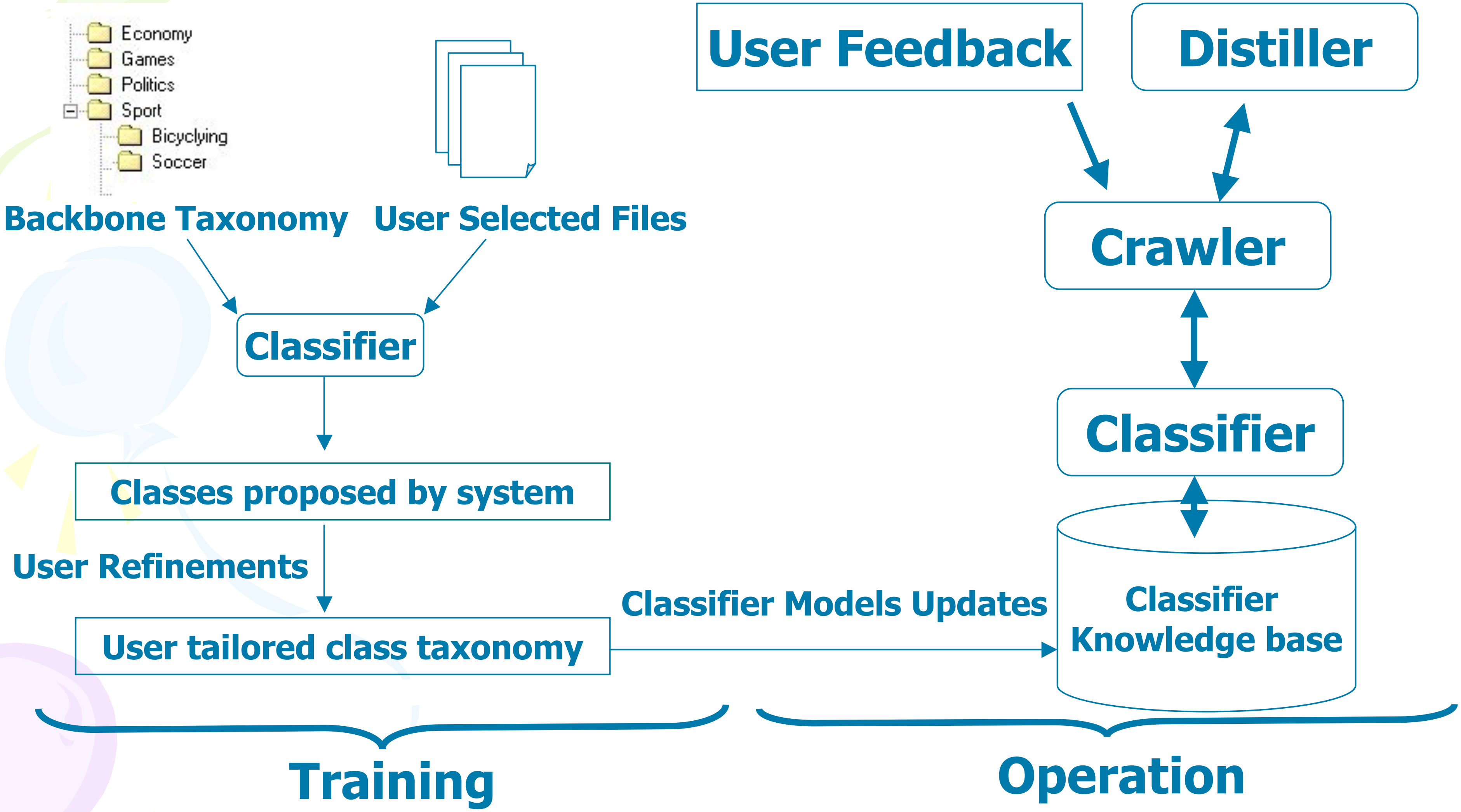
Focused Crawler (User’s View)



Economy
Games
Politics
Sport
Bicycling
Soccer

Backbone Taxonomy

User Selected Files

Classifier

Classes proposed by system

User Refinements

User tailored class taxonomy

Classifier Models Updates

User Feedback

Distiller

Crawler

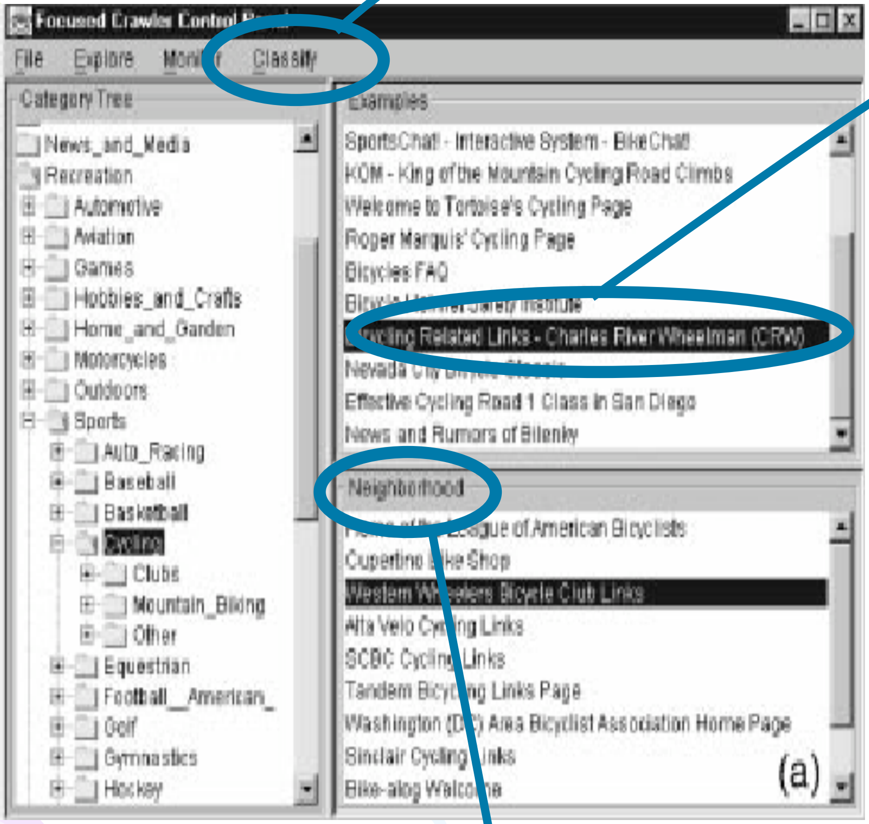
Classifier

Classifier Knowledge base

Training

Operation

Focused Crawler (User’s View)



News_and_Media
Recreation
Automotive
Aviation
Games
Hobbies_and_Crafts
Home_and_Garden
Motorcycles
Outdoors
Sports
Auto_Racing
Baseball
Basketball
Cycling
Clubs
Mountain_Biking
Other
Equestrian
Football_American_
Golf
Gymnastics
Hockey

SportsChat! - Interactive System - BikeChat!
KOM - King of the Mountain Cycling Road Climbs
Welcome to Tortoise's Cycling Page
Roger Marquis' Cycling Page
Bicycles FAQ
Bicycle Helmet Safety Institute
Cycling Related Links - Charles River Wheelman (CRW)
Nevada City Bicycle Classic
Effective Cycling Road 1 Class in San Diego
News and Rumors of Bilenky

Home of the League of American Bicyclists
Cupertino Bike Shop
Western Wheelers Bicycle Club Links
Alta Velo Cycling Links
SCBC Cycling Links
Tandem Bicycling Links Page
Washington (DC) Area Bicyclist Association Home Page
Sinclair Cycling Links
Bike-alog Welcome

Classify

Page currently viewed

Examples from selected topic

Neighboring pages can be added to examples by drag and drop

Interesting topics are marked

Neighborhood

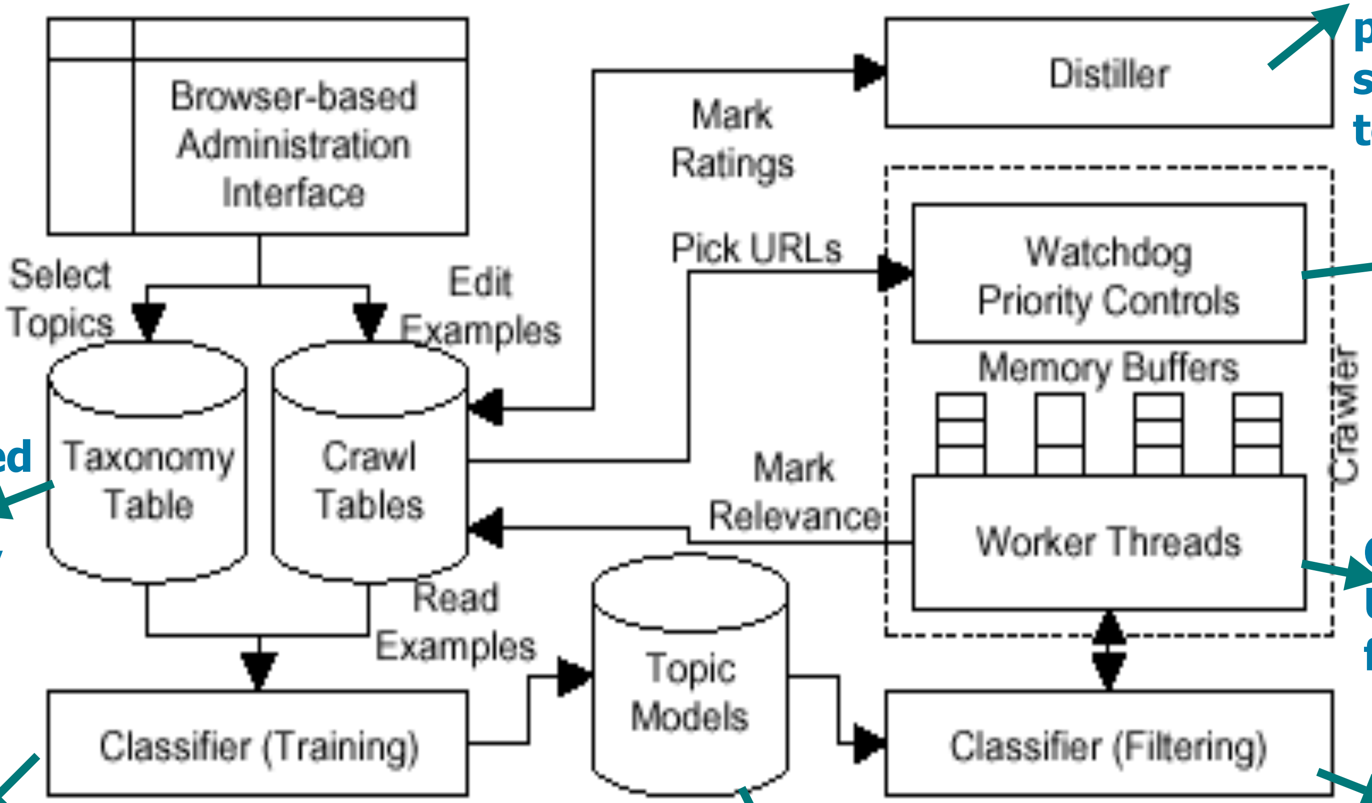
System Architecture

- **Classifier**: makes relevance judgments on pages crawled to decide on expanding links found in these pages.

- **Distiller**: determines a measure of centrality of crawled pages to determine visit priorities.

- **Crawler**: allows dynamically reconfigurable priority controls by the classifier and distiller.

System Architecture



Operates periodically to select top hubs to visit

Get new URLs to be crawled

Predefined class hierarchy

Crawl new URLs received from Watchdog

Calculate words probabilities within different classes contexts

Words statistics

Calculate relevance scores for new pages

Classifier

- Given a document, what is the probability that it belongs to some class ?
  - Given a document *d* and a set of predefined classes {c_i ; i=1..n}, calculate Pr(c_i|*d*) ; i=1..n
- **Hard Classification**: Select the class with the maximum probability.
- **Soft Classification**: Produce a ranked list of classes according to probabilities.

Classifier

Bayes Classifier[McCallum, 1998]

- Pr(class|doc)=Pr(doc|class)*Pr(class)/Pr(doc)
  - Pr(class): frequency of class documents inside collection.
  - Pr(doc)= $\sum_{i=1}^{n} \Pr(doc \mid c_i) * \Pr(c_i)$
  - Pr(doc|class) ??

Classifier

Bayes Classifier [McCallum, 1998]

- Multinomial Model
  - Document is generated by independently selecting words from a *bag of words* representing combined vocabulary for all classes.
  - A document occurrence probability, given some class, is the product of occurrence probabilities of its words within the context of that class.

Classifier

Bayes Classifier [McCallum et al., 1998]

- Multinomial Model

$$\Pr(d \mid c_i) = \Pr(|d|) * |d|! * \prod_{t \in d} \frac{\theta(c,t)^{n(d,t)}}{n(d,t)!}$$

  - n(d,t): Number of occurrences of word *t* inside document *d.*
  - θ(c,t): Occurrence probability of word *t* inside class *c*.
  - For each class, the classifier stores θ(c,t) for each vocabulary word *t*, and uses that to calculate the tested document occurrence probability.

Distiller

- For each visited document *d,* the classifier produces a relevance score R(d) that is used to give future crawl priorities.
- In addition, hub pages that point to authoritative sources need to be located.
- Due to web authorship diversity, relevant pages could point to irrelevant ones, e.g. pointing to famous search engine or html editors.

Distiller

- Assign non unit weights to edges.
- Edges are grouped into forward and backward:
  - $E_F[u,v]=R(v)$
  - $E_B[u,v]=R(u)$
- Iterate over graph nodes updating edges weights.
- A threshold ρ is used to include potential authorities with high enough relevance scores.

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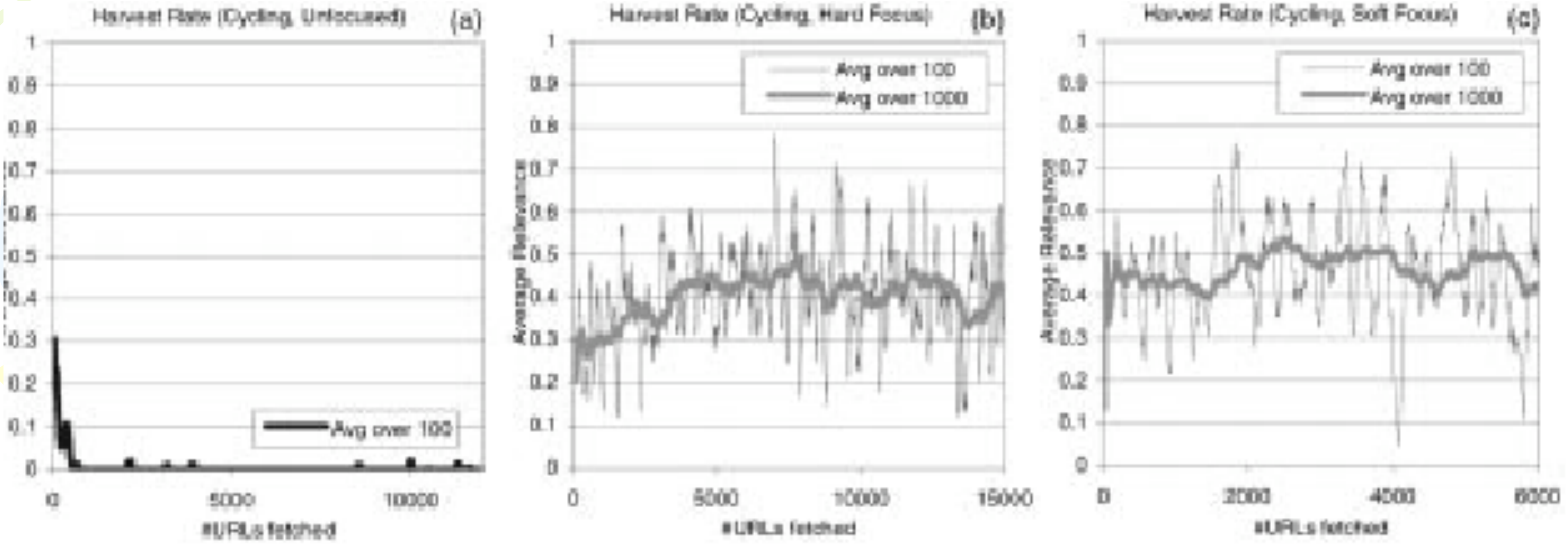
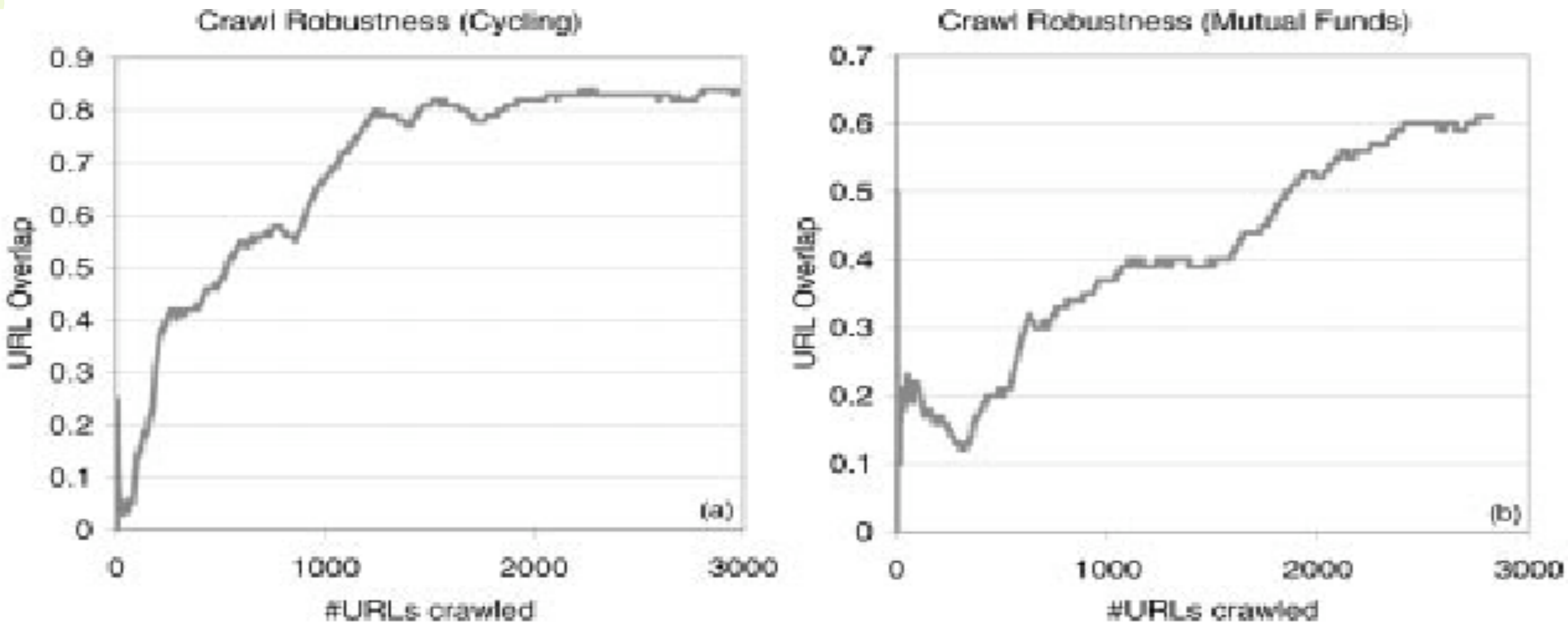
Evaluation



Unfocused Hard Focused Soft Focused

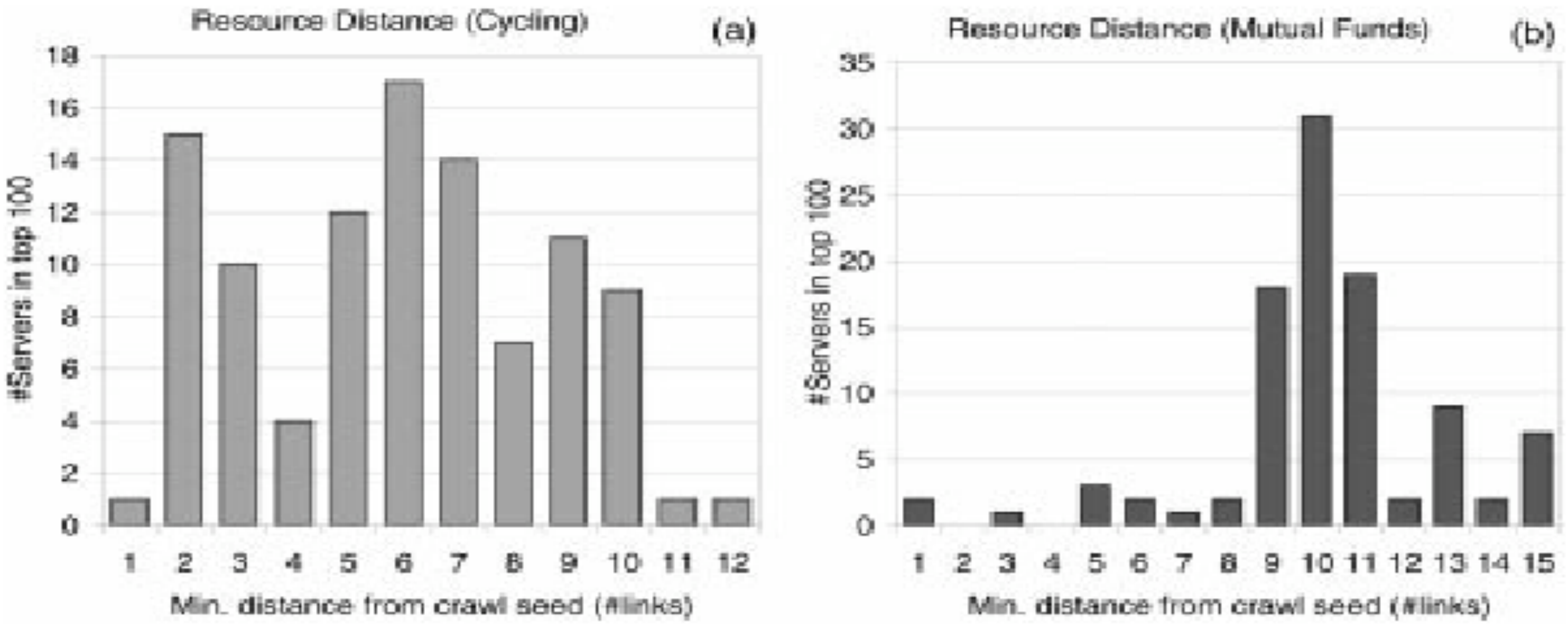
Moving Average of Relevance

Evaluation



URL overlap between 2 crawlers using disjoint startup URL sets

Evaluation



Distance between top servers and seed URL sets

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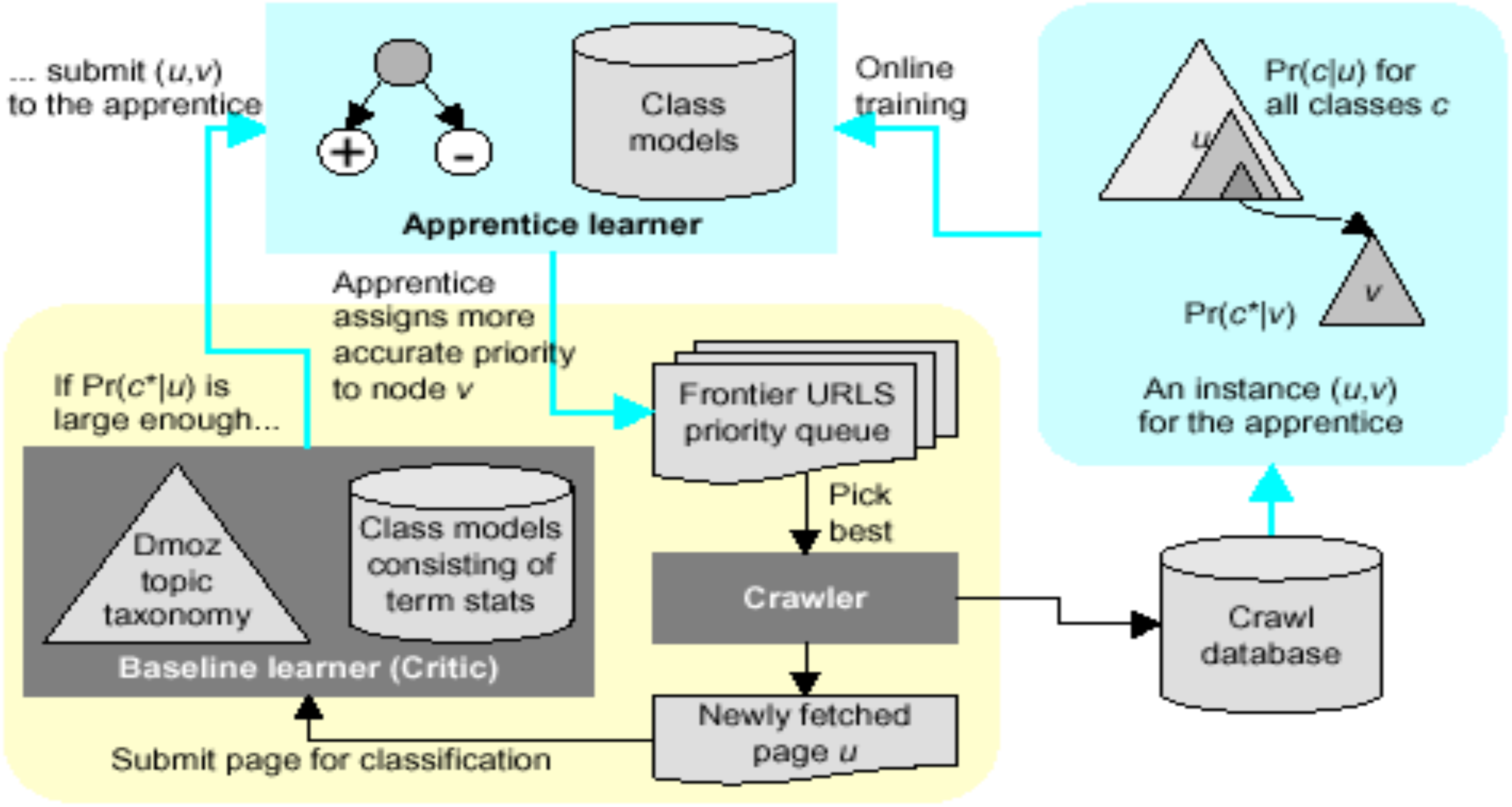
Related Work

Accelerated Focused Crawling [Chakrabarti et al., 2002]

- Only a fraction of out-links from a page are worth following.
- Documents were modeled as tag trees using DOM (Document Object Model).
- The text surrounding hyperlinks is used to decide on the relevance of target pages to be crawled before actually crawling them.

Related Work

Accelerated Focused Crawling [Chakrabarti et al., 2002]



Related Work

Classifying Web Pages using Links only

[Furnkranz, 2001]

- Hyperlinks that point to test documents are used as indicators for the classes of these documents.
- Diversity of web authorship is used to make good predictions.
- Different combinations of anchor, headings, paragraph and phrases feature sets derived from hyperlinks were used to make class predictions.
- Accuracy ranged from 57% to 87% for different methods used for combining links predictions.

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Comments

- No consideration was made to using different kinds of text classifiers.
- Using the embedded classifier to judge crawl relevance is unconvincing.
- The scheme used by the crawler to refresh the contents of crawled pages is not described.
- Results were illustrated using mainly two classes although calculating overall estimates using all classes was possible.

References

- Chakrabarti S., Berg M., and Dom B., Focused Crawling: A New Approach to Topic-Specific Web Resource Discovery, Computer Networks, 31(11-16), 1999.
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