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Smart Web Crawler to Harvest the Invisible Web World

Nimisha Jain[1], Pragya Sharma[2], Saloni Poddar[3], Shikha Rani[4]

B.E. Student, Dept. of Computer Engineering, MIT College of Engineering, Pune, India[1,2,3,4]

ABSTRACT: In a growing world of internet, thousands of web pages are added daily. But only approx. 0.03 percent fraction of web pages are retrieved by all the search engines. The remaining pages are deep websites. Deep web is that part of web which is hidden and unrecognizable by the existing search engines. It has been a longstanding challengefor the existing useful crawlers and web search engines to harvest this ample volume of data. This paper surveys on different methods of crawling deep-web. Density and rapidly changing nature of deep-web has posed a big hurdle in front of researchers. To overcome this issue, we propose a dual-layer framework, namely *Smart Web Crawler*, for efficiently harvesting deep web interfaces. Smart crawler consists of two layers: *Site-discovery* and *In-depth Crawling*.*Site-discovery* layer finds the sparsely located deep websites from given known *parent site*s using *Reverse Searching* and focused crawling. The *In-depth Crawling* layer makes use of *Smart Learning* and *Prioritizing* to crawl hyperlinks within a site to ensure wider coverage of web directories.

KEYWORDS: Deep Website, HTML Form, Reverse Searching, Prioritizing, Smart Learning, Categorizing, Pre-querying, Post-querying

I. INTRODUCTION

The basic motive behind web crawler is to retrieve web pages and add them to a local repository. Such repositories are used with web search engines. Basically it starts from a parentsite and then uses hyperlinks and sub-links contained in it to reach other pages. It records every hypertext link in every page they index crawling.It keeps on repeating until it reaches a predefined value.

Today Internet can be considered as a vast pool of information from which any data can be found. But still there is so much data which cannot be retrieved by any search engine. Such data is called deep web pages.The deep web refers to the contents that lie behind HTML forms and cannot be identified by normal crawlers.This data is buried deep down on dynamic web pages and hence cannot be found by any search engines. They include dynamic web pages, blocked sites, unlinked sites, private site content and limited-access networks. The information available on deep web is approximately 400-550 times larger than the surface web. More than 200,000 deep websites presently exist [1].

Current-day crawlers can retrieve only websites which are indexed, i.e., the webpages that can be reached by following hypertext links, ignoring webpages that need authentication or registration. So, they ignore a large amount of high quality content hidden behind search forms, in large searchable electronic databases. Deep web contains huge amount of valuable information which is highly scattered. This information may be required to build index in a given domain by entities such as Infomine, Clusty. But these entities do not have access to the licensed web indices of standard search engines. So, there is a need of a proficient crawler which can mine deep web interfaces quickly and accurately. Traditional search engines cannot retrieve content in the deep Web as they are created dynamically. The Deep Web offers a certain level of obscureness of identity that makes it more vulnerable to be used for illegal purposes. The various activities that take place in it, such as illegal drug selling, child pornography etc., show what people would do if their identities would be hidden.Instead of just considering the search results from individual we can train a crawler to learn fromfeatures collected from path of connected links.

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II. RELATED WORK

In [2, 3], author outlined that crawler is a program which is used to download or store web pages by indexing them. Mainly it starts with maintaining a set of URLs to be retrieved and prioritized in a queue. From this queue, the crawler gets a URL to be downloaded. Each URL is called a *parent.* It checks if the URL or page is allowed to be downloaded and also reads the header of the page to check if any exclusion instructions were provided. It extracts all hyperlinks from the page and add them to the queue used for storing the URLs to be downloaded. This queue is termed as *crawl frontier*. Using a set of rules and policies the URLs in the frontier are visited individually. Then it downloads different pages from the internet by the parser and generator. These pages are stored in the database system of the search engine. The URLs are then placed in the queue and later scheduled by the scheduler and can be accessed one by one by the search engine one by one whenever required. Various algorithms are used for finding the relevant links. These relevant links are prioritized according to the page ranks. Page ranks are assigned according to the relevance of the page. The algorithms used are Breadth first algorithm, Naïve Best first algorithm, Page ranking algorithm,Fish search algorithm etc. [4] There are various types of crawlers currently available for various operations such as *Internet archive Crawler, Google Crawler, Mercator Web Crawler, Web Fountain crawler, IRLbot Web crawler, Hidden Web Crawler etc.*[5]**.**

In [6], the goal of a focused crawler is to select topic-specific pages that are relevant. Instead of crawling and indexing entire web, it focuses on traversing the links within the predefined boundary and thus avoids crawling irrelevant regions. This leads to efficient usage of hardware and network resources. Use of multiple focused crawlers result in entire coverage of web at a faster rate as each crawler is dedicated to a particular domain and later guided by a classifier and a distiller.

In [7], the issues related to dual essential tasks are demonstrated: First, for *exploration*, our *macro* study surveys the deep web at large: It studies web databases in a broader sense, without giving much details about them, such as: What is its scale? How many databases are there? Where to find entrance to them? How many are structured databases? What is the coverage of deep-web directories?Second, for *integration*, our *micro* study surveys domain characteristics in much detail, such as: How hidden are web sources? How do search engines cover their data? How complex are their directories? What is the category distribution of sources?

In [8], author addresses the problem of designing a crawler which can be used to crawl the concealed web world. To achieve this, a simple operational model which describes the steps that a crawler must take to process and submit HTML forms. Based upon the working of this model, a prototype crawler HiWE (Hidden Web Exposer) is introduced. It ensures feasibility and effectiveness of our form processing and matching techniques. This model makes use of a new **L**ayout-based **I**nformation **E**xtraction **T**echnique (LITE) to automatically extract pertinent information from search forms and response pages.

In [9], it is discussed that as the scale and heterogeneity is increases, the traditional data integration techniques are no longer valid. Thus, we propose a new data integration architecture, the PAYGO architecture which is inspired by the concept of dataspaces [10]. It comprises of two steps based on pay-as-you-go data management: First, we focus our work on searching the deep web. This approach leaves the data at the sources and directs queries to appropriate web pages, attempts to add data from the deep web to surface web and also tells about the first study of the deep web which is based on a commercial index. Second, we consider Google Base and define how a model can be used to improvise user's search experience.

In [11], the problem of distributed information retrieval and its corresponding solutions are discussed. We describe a technique for identifying search forms, which builds the base for a next-generation distributed search problem. It provides a unified search experience to the users using available search interfaces and displays the results of the queries into an integrated list. Automatic feature generation technique is used to generate candidate forms and C4.5 decision trees to classify them. This improves the accuracy as well as the precision.

This [12] resolves the major challenges in building Deep Web integration system using VisQI (VISual Query interface Integration system). VisQI is a framework-like reusable architecture that compares generated data structures against gold standard. It transforms the HTML query interfaces into ecclesiastic structure, classifies them into different domains and matches the elements of various interfaces.

In [13], the author talks about a new crawling strategy to automatically discover concealed web databases to achieve a balance between the two opposingrequirements of this problem: that is performing a broad search while avoiding the need to crawl a large number of insignificant pages. It performs focused crawling using appropriate stopping criteria

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crawler to avoid excessive speculative work in a single website.For ranking we use the algorithm based upon the function of the number of pages visited by theuser.We usebackward crawling facilities in order to approximate web graphs.

III. PROPOSED WORK

In this paper we are proposing a *Smart Web Crawler*,which is a dual-layeredarchitecture to harvest the deep and hidden web interfaces. To rank unexplored links on priority basis, *Site Prioritizer* is used in the first layer. When the crawler finds a new deep website, its URL is added into the *Database*. A *Smart Learning*technique is used where crawler learns from the URL path leading to relevant forms, thus enhances the performance of the Prioritizer.

To ensure wide coverage of deep web interfaces and efficient crawling, our crawler consists of two layers: *Site-discovery* and *In-depth Crawling*.*Site-discovery*layer finds the sparsely located deepwebsites from given known *parent site*s using *Reverse Searching* and focused crawling. The *In-depth Crawling*layer makes use of *Smart Learning* to crawl hyperlinks within a site to ensure wider coverage of web directories.To improve accuracy of *HTMLform categorizer*, two approaches are used:*Pre-querying*and *Post-querying*.

A. *Design:*

For efficiently harvesting deep web data directories, *Smart Web Crawler* is designed for deep websites. It has a dual-layered architecture. The first layer is *Site-discovery* and the second layer is *In-depth Crawling* as shown in figure. *Site-discovery* layer finds the most appropriate and relevant sites for a given query by user, and in the second layer *In-depth Crawling* layer covers hidden HTML forms from the site

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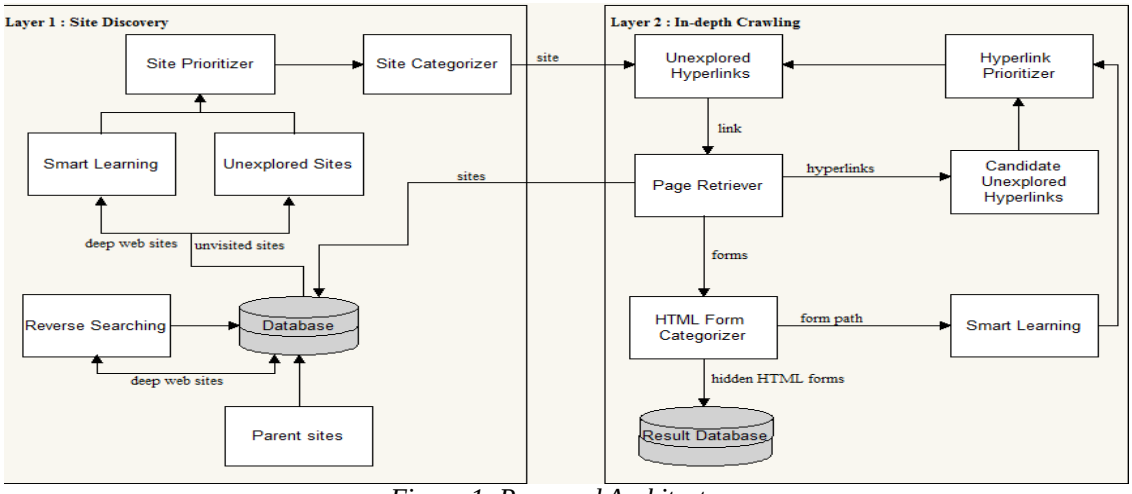

Figure 1: Proposed Architecture

1) Site Discovery

Initially, the *Site-discovery* layer begins with a *parent URLs* of sites in database. *Parent URLs* are primaryURLs given to *Smart Web Crawler* to start crawling. Itstarts by following URLs from selected*parent site*s to search available web pages and domains. *Reverse Searching*is performed when the number of *Unexplored URLs* becomes less than the predefined value. In *Reverse Searching*, it performs the crawling of the known deep websites to find highly ranked center pages which point to several other hyperlinks/domains and adds them into *Database* simultaneously. The *Unexplored URLs* are ranked by the *Prioritizer* and visited URLs are added into the retrieved site list. The *Prioritizer* associates a value with each unexplored site based upon its content with respect to the already discovered deep web interfaces. Meanwhile, the *Prioritizer* is improved during crawling by a *Smart Learner* which continuously learns from features of already searched deep websites. To improve the accuracy of the search results,*Categorizer*classifies URLs into useful or useless for a given topic with respect to the homepage content.

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- *Parent Sites:* These are the URLs of deep websites given as input to start the crawling process.
- *Unexplored Sites*: It fetches homepage URLs from the *Database*, which are then ranked by *Prioritizer* according to the relevance. It also prioritizes the sub-links of visited web pages.
- *Reverse Searching*: When the number of unexplored sites decreases to a predefined value**,** *Reverse Searching* is triggered. The idea of *Reverse Searching* is to find center pages of unexplored websites starting from the lastextracted hyperlink or sub-link to reach the initial *Parent Site* by crawling backwards. It ensures that there is enough number of unexplored URLs in the database.
- *Smart Learning:* The performance of the *Prioritizer* is improvised during the crawling process by using *Smart Learning* technique. It gradually learns from features of deep websites found and from the URL path leading to relevant hyperlinks.
- *Prioritizer:* The *Prioritizer* allocates a value to each and every unexplored site according to relevance in comparison with already discovered deep web sites.
- *Site Categorizer:* The crawler maintains a priority queue for all the sub-links and hyperlinks which are classified by *Categorizer* according to the relevance.

2) In-depth Crawling

After the most relevant site is found in the previous layer, this layer performs efficient *In-depth Crawling* for extracting hidden HTML forms. Hyperlinks pointed by the site are stored in the *Unexplored Hyperlink* section. And thus corresponding pages are fetched and then classified by *HTML form Categorizer* to retrieve hidden HTML forms [14, 15, 16, 17 and 18].

Additionally, the links in extracted centre pages from the previous layer are fetched into *Candidateunexplored URLs*. Here, they are prioritized by the *hyperlink Prioritizer*. Whenever a new site is discovered, it is first added into the Database and then ranked according to the relevance. The *Prioritizer* is improvised by using *Smart Learner* which gradually learns from the URL path leading to relevant websites.

To improve accuracy of *HTML form Categorizer,Pre-querying* and *Post-querying* approaches for classifying deep-web forms are combined. *Pre-querying* basically triggers before the query executes and is fired once while you try to query. With the help of this *Pre-querying* section, 'where' clause part can be changed dynamically. This query is fired only once. Whereas, *Post-querying* is triggered after the query executes gets fired for every row fetched. That is, if query fetches 10 rows then *Post-querying* will be fired for 10 times. Hence it is fired almost every time at the time of execution successfully during crawling.

- *Unexplored Hyperlinks:* Hyperlinks pointed by the most re0levant sites fetched from previous layer are stored in this section and subsequently classified by *HTML Form Categorizer* to give hidden HTML forms.
- *Hyperlink Prioritizer:* It prioritizes the hyperlinks based upon the relevance of hidden HTML forms. It assigns relevance score to each hyperlink depending upon similarity with parent link.
- *Page Retriever:* It fetches the centre pages of websites. These pages are further classified to give relevant hidden HTML forms.
- *Candidate Unexplored Links:* It contains the *unexplored hyperlinks* of the *parent site*. These hyperlinks are prioritized and classified by the *Hyperlink Prioritizer*.
- *HTML Form Categorizer:* It ranks the *candidate unexplored hyperlinks* to give relevant hidden HTML forms and accordingly assigns a priority value. It filters out irrelevant or off-topic links.
- *Smart Learning:* It keeps on learning and adapting from the URL path leading to relevant HTML forms.
- *Result Database:* It is collection of all the relevant websites received by *HTML form Categorizer* at the end of whole process of crawling.

Smart Crawler implements a unique strategy to retrieve relevant hidden HTML forms by using various classifiers. It consists of two classifiers, a hidden HTML form classifier (HFC) and a field-specific form classifier (FFC). Hidden HTML form classifier is used to filter out irrelevant forms by matching their features with the standard layout. It is domain-independent. Field-specific form classifier fetches relevant forms using focused crawling.

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IV. RESULTS

A. *Analysis of Proposed Algorithm:*

In this subsection, we are analyzing the proposed algorithm in terms of time complexity. As quoted by Mathematician Alan Turing, "It is convenient to have a measure of the amount of work involved in a computing process, even though it be a very crude one. We may count up the number of times that various elementary operations are applied in the whole process", we are performing analysis to determine the cost of each basic operation and hence develop a realistic model for the input. The total running time of any algorithm can be calculated as follows:

$$\sum \text{frequency}(a) * \text{cost}(a)$$

Where a= Operation

Following figure shows our prototype time-complexity analysis:

1. Begin		
2. Pick a site from the list of parent sites	C_1	
3. Extract the page source	**d**	
4. Parse the page source	**O(n)**	
5. Get hyperlinks from the page source	**O(n)**	
6. While(sites in hyperlink list is not empty)	Loop is executed 'p' times	**O(m*p)**
7. If keyword is found in hyperlink, append it into result list		**O(m)**
8. Else discard it	C_2	
9. Return hyperlink	C_3	

Table 1: Prototype time-complexity analysis

From the above analysis, we have found time-complexity of our crawler as **[2O(n)+O(m*p)+d]**. Now that we know 'm*n' is always << n, the above complexity can be re-written as **[2O(n) + d]**.

B. *Comparison Analysis of Different Crawlers:*

In this subsection, we are comparing the strengths and weaknesses of the proposed crawler with some of the other crawlers. The purpose behind this comparison is to analyze and confront theirperformances.This gives the clear idea about feasibility and the efficiency of the crawler with respect to other crawlers.

Paper	Strength	Weakness
Raghavan et.al.[21]	The feasibility of HiWE algorithm and effectiveness of form processing and matching techniques.	1) Inability to recognize and respond to simple dependencies between form elements. 2) Lack of support for partially filling out forms
Liddle et.al.[22]	Automatically retrieves the data behind a given Web form.	1) Determining how best to partition the search space. 2) Do not consider detection of forms inside result pages.
Garvano et.al.[23]	1) Designed meta-search toolsuseful in searching over non-crawlable contents that are "hidden" behind search interfaces. 2) Content-summary construction technique	1) Query chosen only by using hierarchical categories as in Yahoo! and does not consider flat classification.
Bergholz et.al.[24]	1) Automatic identification of domain-specific Hidden Web resources. 2) Domain- specific crawling technique	1) Only deal with full text search forms. 2) Initialized with pre-classifieddocuments and relevant keywords
Our Proposed Crawler	1) Use of Breadth-first search leads to wider coverage of web and achieves higher harvest rate. 2) By ranking collected sites and by focusing the crawling on a topic, it achieves more accurate results.	1) Crawling large amount of data causes time consumption.

Table 2: Comparison of Different Crawlers

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At the end of this comparison we can conclude that the despite of having some limitations, proposed crawler is feasible to implement as well as more efficient than others. We still need to find a way to reduce the time consumption.

V. CONCLUSION AND FUTURE WORK

This Paper surveys on different methods of crawling. Previous systems face many challenges such as efficiency, end-to-end delay, qualityof link, failure to find the deep websites as they are unregistered with any crawler, scattered and dynamic. Thus, we proposed an effective and adaptive framework for retrieving deepwebpages, namely Smart web Crawler. This approach accomplisheswide spread coverage of deep web and implementsproficient crawling technique. We have used a focused crawler that comprises of two layers: Site-discovery and In-depth Crawling. It performs Site-discovery using Reverse Searching technique to fetch center pages from the known deep web pages and hence relevantlyfinds many data sources from several domains. Smart Web Crawler achieves more accuracy by correctly prioritizingthe gathered sites and concentratingon the given domain. The In-depth crawling layer uses Smart Learning to perform search within a site and design a link hierarchy for avoiding biasness towards certain directories of a website for wider coverage of web. The comparative study shows the effectiveness of the proposed crawler which achieves higher harvest rates and wider coverage than other crawlers combining the Pre-querying and Post-querying approaches.

In future, we can incorporate this crawler with machine learning techniques to act and think like humans. This will enable the crawler to give results based upon the context. In addition to this, there is a need to expand the deep web dataset to crawl more number of websites giving maximum possible search results.

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BIOGRAPHY

Nimisha Jain is a student in the Computer Engineering Department, MIT College of Engineering, SavitribaiPhulePune University. She is currently pursuing her Bachelor of Engineering.

Pragya Sharma is a student in the Computer Engineering Department, MIT College of Engineering, SavitribaiPhule PuneUniversity. She is currently pursuing her Bachelor of Engineering.

Saloni Poddar is a student in the Computer Engineering Department, MIT College of Engineering, SavitribaiPhulePune University. She is currently pursuing her Bachelor of Engineering.

Shikha Rani is a student in the Computer Engineering Department, MIT College of Engineering, SavitribaiPhulePune University. She is currently pursuing her Bachelor of Engineering.