VIQI: A New Approach for Visual Interpretation of Deep Web Query Interfaces

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Abstract—Deep Web databases contain more than 90% of pertinent information of the Web. Despite their importance, users don’t profit of this treasury. Many deep web services are offering competitive services in term of prices, quality of service, and facilities. As the number of services is growing rapidly, users have difficulty to ask many web services in the same time. In this paper, we imagine a system where users have the possibility to formulate one query using one query interface and then the system translates query to the rest of query interfaces. However, interfaces are created by designers in order to be interpreted visually by users, machines can not interpret query from a given interface. We propose a new approach which emulate capacity of interpretation of users and extracts query from deep web query interfaces. Our approach has proved good performances on two standard datasets.

Keywords-Web; Information Retrieval; Query Model; Query Extraction

I. INTRODUCTION

Deep Web is the part of web hidden behind query interfaces. Deep Web is growing and changing continuously, new web services are emerging at a high rate, they offer new and complementary services to existing ones. For commercial reason, web services are increasingly competitive. Hence, users are interested by asking services of many providers at the same time. However, web services have different query capabilities, users have to formulate a query for each web service separately. Moreover, as each web service query has its own meaning, results will be incoherent.

Classical Information Retrieval process has 4 steps. For example a student attending NCM 2012 conference in Seoul, Korea will be interested by flights to Seoul and will proceed as follows(see figure1):

1. He formulates a query using query interface,
2. The query is submitted to deep Web database,
3. Relevant information are extracted from database and encapsulated into web pages,
4. Finally web pages are returned to users.

We believe it is possible to make web services more sensitive to user’s needs. The system that we are working on collects querying capabilities of many web services and combines them in one query interface. Using this interface, user can formulate one query and obtains results satisfying his need from all web services. This interface is generic as it meets together many services and respects the autonomy of each service.

Figure 2 show on the left classic information retrieval process where user search information from each web service separately. On the right, the generic web service [1,2] where user formulates only one query, the system translates
the query \([3,4,5]\) to each local service and collects relevant results \([16, 17]\) from all web services at the same time.

Query interfaces are the natural representation of the query for visual user perception \([6, 7]\). Although query interfaces are easily interpreted by users, they are not the query supported server’s side. Query interfaces are used to map the query to URL which contains a list of attribute/value pairs. For example "http://www.expedia.com/FlightsSearch?trip="roundtrip"&leg1="from:TUN,to:ICN",departure="04/24/2012"..." is query which aims to find flights from departing city to destination city. Attribute/value pairs are listed as a sequence: trip="roundtrip", leg1="from:TUN,to:ICN", departure = "04/24/2012", etc. URL is the form of the query which is run by web server. However, users have great difficulty to interpret and to understand the meaning of such query because fields are represented by internal names which are concatenated and abbreviated. So, although query interface have rich semantic value, web server can not run it, while URL have poor semantic meaning, but it can be run by web server.

Then to resolve this challenge, we propose three main contributions:
1. A new model for query representation: this model provides matching between elements of query and elements of query interface.
2. A new approach of query interpretation and extraction: our approach emulates capacity of users to interpret query interfaces.
3. To evaluate our approach on two standard datasets.

Our paper is structured as follows. Section 2 is related works. We present a new model for query representation detailed in section 3, which provides matching between interface and query elements. In Section 4, we describe our approach to extract query from a given query interface based on our model of query representation. We evaluate performance of our approach in section 5. Finally we conclude and present our future work in section 6.

II. RELATED WORK

Related works have used two main query representation models: a flat model and a hierarchical model.

According Madhavan et al \([8]\), flat representation of query is represented by sequence of attribute/value pairs. This category of queries cannot be interpreted visually by user. Hence, users have difficulty to understand the meaning of query. However, they are indexed by standard search engines such as Google \([9]\) as static resources.

While flat queries are not understood by users, hierarchical queries \([10,11]\) are easily interpreted (see figure 2), they describe visual structure of query interface, i.e. all concepts of the query and semantic relations between them. As hierarchical query is not the query but its structure, they are not indexed by standard search engines. Despite their rich semantic values, hierarchical queries still unknown.

Approaches of query extraction can be classified in two categories: Approaches based on visual features \([12,13,14]\), and approaches based on HTML features \([15,16,17]\).

Visual features include topological relations between fields, direction, distance, etc. They are detectors of semantic concepts of query. For example, there is a high probability that two adjacent (distance and direction) fields form the attributes of the same concept.

While two fields are adjacent in web page space, they are too far from each other in HTML script because of HTML tags, field’s values, etc. HTML based approaches use linguistic features to extract concepts of the query. For example, ‘departure’ and ‘destination’ are attributes of the same concept because they are instance of the same linguistic concept ‘City’.

III. MODEL OF REPRESENTATION OF QUERY

We have chosen to represent query by a hierarchical model \([18]\) as this model reflects meaning of query (see figure 3). Concepts of query are rendered in query interface based on a spatial-locality paradigm: fields which form attributes of the same concept are close to each other.
in the interface and aligned (e.g. ‘Adults’ and ‘Children’),
while fields of different concepts are rarely adjacent and
aligned (e.g. ‘Adults’ and ‘ReturningMonth’).

Based on mapping between visual features and semantic
corcepts of the query (see figure 4), we have found the five
components of our model: field, RenderedGroup,
RenderedCollection, NotRenderedGroup, and VisualBox:

- **field**: this is the basic unit of information composing
the query, it is a query condition over one attribute
of the query. This component is rendered as a
rectangular box in web page space where user can
give some input information

- **RenderedGroup**: it represents one concept of the
query, it contains a list of attributes. Each attribute
may be recursively another RenderedGroup or a
field. It is rendered in web page as recursive
imbrications of rectangular boxes.

- **RenderedCollection**: it is the root of the query, it
meets all concepts of the query. It is rendered in
web page as the most external rectangular box.

- **NotRenderedGroup**: Some elements in web page
such as pictures and hyperlinks are not in the query.
There is no mapping between these elements and
attributes of the query.

- **VisualBox**: one internal element of the query may
contains concepts of different natures (field, group
of fields, super-group). Hence, in order to be
grouped together, all elements of the model extend
one abstract visual element: the VisualBox.

**Example**: Query in figure 2 is instance of our query model.
There is ten fields, four RenderedGroup (2, 3, Departing On,
Returning On), and one RenderedCollection (root).

IV. A NEW APPROACH OF QUERY EXTRACTION

The basic idea of VIQI (Visual Interpretation of Query
Interfaces) is based on User’s Interpretation. We call User’s
Interpretation the visual human capacity to distinguish
group of fields in web page space. Interpretation is closely
related to proximity and alignment between fields. For
example, the group of fields {'Leaving From', ‘Going To’} forms one concept of the query and are close to each
other and left aligned (see figure 3).

We measure closeness between fields by Euclidean
Distance between them. The Euclidean Distance between
two fields is the minimal distance between any pair of
points which belong respectively to each one of the fields
(see Equation 1).

\[
Dist_{Eucl}(f_1, f_2) = \min_{p_1 \in f_1, p_2 \in f_2} Dist_{Eucl}(p_1, p_2)
\]  

with p1 a point of f1 and p2 a point of f2

We calculate alignment between fields based on Align
function. We distinguish four classes of alignments:
Bottom, Top, Left, and Right. The function AlignX returns 1
when two fields are aligned, else it returns 0.

\[
AlignX(f_1, f_2) = \begin{cases} 1 & \text{if } f_1 \text{ and } f_2 \text{ are aligned} \\ 0 & \text{else} \end{cases}
\]

X takes the values ‘B’ (Bottom), ‘T’ (Top), ‘L’ (Left), or ‘R’
(Right).

\[
Align(f_1, f_2) = 2 \cdot AlignB(f_1, f_2) + AlignT(f_1, f_2) + AlignL(f_1, f_2) + AlignR(f_1, f_2)
\]

Over the alignment of fields is high, fields are more likely to
belong to the same concept. Bottom alignment is the most
descriptive to grouping of fields because reading order of
fields is per line (bottom alignment). Equation 4 gives the
measure Proximity. This measure depends on two factors:
Euclidian distance and Alignment. Over closeness of fields
is high, the Euclidean distance between them is small, then the proximity between fields is also small. Hence fields have high probability to be grouped together. In other hand, over alignment of fields is high, Align \((f_1, f_2)\) is High, then the proximity between fields is small. Hence probability to be grouped together is high.

\[
Proximity (f_1, f_2) = \frac{DistEucl(f_1, f_2)}{Align(f_1, f_2)} \quad (4)
\]

In order to calculate groups of fields, we have used a clustering algorithm based on density DBSCAN (Density-Based Spatial Clustering of Applications with Noise) [19]. The definition of cluster in DBSCAN is based on the concept of scope of density: a field \(f_1\) is in the scope of density of field \(f_2\) if the proximity between \(f_1\) and \(f_2\) is inferior to \(\epsilon\). We have fixed \(\epsilon\) to the minimal proximity value between any two fields not clustered, and Noise is orphan fields, i.e it has no other fields in its scope of density (e.g field ‘FlightClass’). DBSCAN algorithm is shown in Algorithm 1. In order to detect clusters, DBSCAN proceeds as follows:

- step1. Choose one field not clustered (Line 4)
- step2. Get its immediate neighbors (Line 5)
- step3. If field has no neighbors then mark it as Noise (Line 7), else expand the cluster recursively to the agglomeration of fields (Line 13)
- step4. Repeat step1, step 2, and step3 until all fields are clustered

Figure 4 is a running example of the algorithm on query interface of figure 2. Squares correspond to fields and circles show the scope of density of each field. One field is in the scope of density of a second field if its corresponding circle reaches the center of the second field’s square.

**Algorithm 1. Algorithme DBSCAN**

For example, ‘Adults’ scope of density reaches ‘Children’ field, and ‘Children’ scope of density reaches ‘Adults’ and ‘Infants’. One iteration of DBSCAN creates the group of fields ‘NumberPassengers’ as follows:
In step 1, field ‘Adults’ is chosen.

- In step 2, scope of density of ‘Adults’ reaches ‘Children’ (see ‘Adults’ green circle), so the cluster is {'Adults', 'Children'}.

- In step 3, the cluster is expanded to {'Children', 'Infants'} because scope of density of ‘Children’ reaches ‘Infants’ (see ‘Children’ green circle), so the cluster {'Adults', 'Children'} is expanded to {'Adults', 'Children', 'Infants'}.

- In step 4, choose next not clustered field.

We remark that circles having the same color form one group of fields which correspond to one concept of the query.

We have shown in the running example how to calculate group of fields. Super-groups are recursively obtained by running recursively DBSCAN on groups. Stop condition is reached when all fields are clustered into one super-cluster ‘root’.

V. EXPERIMENTAL RESULTS

We have tested performance of VIQI on two standard datasets ICQ and TEL-8 [20]. ICQ and TEL-8 are two collection of query interfaces collected from deep Web services. For each query interface, its manually extracted query is available on the dataset. Interfaces are classified into five classes of subjects: Airfare, automobile, Books, Real estate, and Jobs.

Our evaluation methodology is as follows: we extract query from query interface using VIQI, then we compare it to query extracted manually. If the two queries are the same, we say that VIQI have extracted the query correctly; else we say that VIQI have committed a mistake. Table 1 resumes our experimental results.

|                      | TEL-8 | ICQ |
|----------------------|-------|-----|
|                      | #interfaces | #fields | #correct query | #mistakes | Precision |
| Airfare              | 20    | 10.75 | 13           | 7         | 0.65      |
| Auto.                | 19    | 7.78  | 14           | 5         | 0.73      |
| Books                | 19    | 5.35  | 17           | 2         | 0.89      |
|                      |       | 10.70 | 13           | 7         | 0.65      |
|                      |       | 5.10  | 13           | 7         | 0.65      |
|                      |       | 5.30  | 16           | 3         | 0.84      |

We remark that the precision of VIQI depends on the average number of fields in each collection of interfaces. Over number of fields in query interface is high, the more the precision of our algorithm is low. It depends also on the complexity of query: the more the imbrications of concepts are high, the more the precision of VIQI is low. Hence queries of airfare subject are the more complex. Queries in Auto collection are less complex than airfare collection and more complex than Books’ queries. The latter are the most simple because many queries are flat, i.e. all fields are clustered in one cluster. For Books collection VIQI have the highest precision (~ 90% on TEL-8).

VI. CONCLUSION

In this paper we have presented two main contributions. The first one is a new technique to represent concepts of query and semantic relation between them. The second
contribution is a new approach of query extraction based on visual interpretation of interfaces, it extracts query from existing query interface. We have measured performance of our approach on two standard datasets ICQ and TEL-8 and we have proved that our approach achieves good precision.

Our future work is to propose an approach which integrates query interface of the same subject in one generic query interface. This approach is starting point to a new web service which facilitates Information Retrieval from Deep Web.

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