A Rule-Based Natural Language Interface to Data Warehouse

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Abstract—Data Warehouse Systems are used for decision-making. It is difficult for casual users to write their request in technical language because they may not have knowledge of technical structure of Database or Data Warehouse. Writing questions in user’s natural language are easy. In this work, a Natural Language Interface to Data Warehouse has been presented. A set of rules are going to be proposed to understand accurate aggregations in user input natural language question. When user input query in natural language format (English language is scope of this work), system split it into keywords. It performs splitting for the purpose of matching. With the help of rules, the aggregation elements are precisely identified from the user query. Finally, empirical analysis has been carried out to evaluate the proposed system. The help of this mechanism, system can easily find the aggregate elements from the user input query.

Keywords—Natural Language Interface, Aggregate functions, Data Dictionary, Data Warehouse and Mapping Rules

I. INTRODUCTION

The main objective of this research is the identification of accurate aggregate elements from the user input query which is written in natural language format. When user input query in natural language format (English language is scope of this work), system split it into keywords. It performs splitting for the purpose of matching. According to best of our knowledge, a very little research is carried out to find accurate aggregate elements from the user input natural language query. The application rules are created for the matching of user input query keywords. The keywords are matched by the given list of the mapping rules. By application of these rules, it becomes easier to identify the aggregation elements from the query. The aggregation elements include dimensions, facts, dimension attributes, fact measures, aggregation functions and grouping sequence.

Further, a dictionary is maintained that hold synonyms of domain keywords. The keywords of query are initially searched in the dictionary. Later these are matched with the application rules. After successful matching of keywords with mapping rules, aggregation elements are returned. Finally, identified elements are mapped into Online Analytical Processing (OLAP) query which is executed and results are retrieved.

This paper is arranged in this order: section II gives literature survey which provides information about the natural language processing, existing natural language interfaces and their comparison. Later, Section III describes architecture of the system and each of its components in detailed form. Section IV discusses mapping rules while Section V presents system evaluation and research findings. Finally, section VI concludes the work and provides future directions.

II. LITERATURE SURVEY

By Natural Language Processing (NLP), useful information is accessed from user input question and results are generated accordingly [1]. NLP provides easy and attractive way of communication between the users and the computer. With the use of NLP, the users can easily generate their questions and can retrieve required information. Natural Language Interfaces is a broad term now and is of immense importance due to its simplicity and modern simple ways for human being to convert their inputs towards the system in their own language. It has been the area of research to help people interacting with various systems and to facilitate the technology. The objective of Natural Language Interface is to access desired results of the users in their native language. Natural Language Interfaces to Databases (NLIDB) is an area in which user natural language query is converted into the query well and truly understandable by the system. Work on such study has been in progress well back in sixties but yet this is still an attractive area to be explored. This will benefit us in many ways like it can help save time as well as better commands and quick work. So this is still an area to work on [2].

The system LUNAR [3] was brought in 1971 and built for the purpose of seeking answers of questions regarding rock samples. These samples were collected from the moon. This system uses two databases for two different jobs i.e. Substance analysis and text reference. This was quite an achievement for this system. According to [4], the LUNAR system managed to respond 78% queries without an error and further improved the bar to 90% when dictionary mistakes were eliminated. Woods procedures and Augmented Transition Network parser have been used in the LUNAR System. By using questions, Hendrix introduced in 1978 the databases for changing NLI into the information recognized by the databases. But the down side of LIFER/LADDER was that the system was only able to understand with restricted join conditions [5]. In 1977, Philips Question Answering system used various layers to rectify syntactic parser errors.
This system is composed of a syntatic parser having three split layers in it. The three layers are Database Language, World Model Language and English Formal Language [6]. Database administrator with the help of TEAM was effortlessly configuring the database with no information of NLIBDs [7], [8]. A big division of investigation of that point in time was committed to portability issues. The improvement of NLIBDs was carried on and several such systems have been developed. These systems include Banks [9], Discover [10], DBXplorer [11], and others [12], [13].

In a large data warehouse, the single most impressive way to influence presentation is an appropriate record of aggregate functions that jointly exist with the main records. Aggregates directly influence in major cases speeding queries of one hundred or even up to one thousand [14]. Aggregate navigator functionality should be implemented to explore the right table with the right grain when requests to Data Warehouse are made. The numbers of possible aggregations are determined by every possible combination of dimension granularities. By monitoring queries, we can decide that which aggregations will match our query patterns [15].

Rules are regulation or principles that are made to do work under some criteria. Rules are used to represent the knowledge or information in some allowable condition. In data mining field, different association rules are used. These association rules are Multilevel, Multidimensional and Quantitative. The knowledge of different level of abstraction is represented in the multilevel association rule, more than one dimension involvement is represented in the multidimensional rule and the numeric values of the attributes are represented in the Quantitative association rules. There is certain classification of rules in data mining. Further, rules are built from the Decision trees, case-based reasoning, and lexical analyzing. There are different ways of developing the rules on the basis of condition and requirements [16].

III. SYSTEM ARCHITECTURE

User input query is parsed down into keywords. With the support of synonyms maintained in the Data Dictionary, keywords are matched to elements by using the application rules. User input query is finally converted into Structured Query Language (SQL) query. The system executes the query and generates result. The proposed system architecture is shown in Fig. 1.

The detail of each component is given below:

A. Natural Language User Input Query

The user input the query in natural language form (such as English) users have no knowledge to write the queries in the SQL syntax. The query input interface of this system is similar to Google search engine.

B. Query Parser

The Query Parser breaks the natural language query into keyword on the basis of space character. So the query is split down into keywords and a list is generated.

C. Data Dictionary

Data dictionary is a collection of words generated for the elements exist in logical schema. It contains set of synonyms for each schema element. It further includes synonyms of aggregation functions. The user query keywords are searched in the Data Dictionary to retrieve target schema element. We have developed a dictionary for the elements that are present in the Data Warehouse schema. In addition, Data Dictionary is updated at run-time as unknown keywords are appeared in the query. The synonyms of such unknown keywords are generated from Word Net.

D. Aggregation Rules

The aggregation rules are stored in three component format i.e., Rule, Rule notation and Rule explanation. The detail of aggregation rules is given in section IV.

E. Rules Mapping

The Mapping rules are made to map the user query statement. We have made rules for the recognition of the tables and attributes words in the user input statement. When there is a Dimension/Fact table word in the query that specific table is mapped with the help of rules. With the help of mapping rules, the aggregate words are also identified (AVG, MIN, MAX, COUNT, SUM and so on) in the user query and synonyms of the aggregate functions. The OLAP query is finally built according to identified elements with the use of rules.
The procedure of rules mapping is as follows: Each keyword and its synonyms maintained in the Data Dictionary are matched with the rules. The result of rules mapping returns aggregation elements i.e., aggregation functions, Dimensions/Fact Tables, attributes and measures.

F. Aggregation Elements

1) Dimension/Fact Attribute
The dimensions and fact tables, their attributes and measures respectively are identified with the help of dictionary and application rules.

2) Aggregation Function
To identify the aggregate function from the user input query, the application rules have been generated. These application Rules automatically identify the aggregate functions. Here Aggregation Functions like AVG ( ), MIN ( ), MAX ( ), COUNT ( ), SUM ( ) are recognized.

3) Aggregation Measure
The synonyms are generated for fact measures and application rules are also stored to precisely identify them.

4) Grouping Sequence
The correct grouping sequence is generated to format results according to the requirement of the user.

G. SQL Template
We have developed a general SQL template that has the following syntax for the template.

- Select attributes, aggregation functions/aggregation Measures From dim/fact tables
- Where conditional expressions
- Group by Grouping Attributes

H. Data Warehouse Schema
The Data Warehouse logical schema is used to match the query keywords with schema elements. System directly accesses the schema during keyword matching and explores it with the help of Domain Dictionary and mapping rules.

I. OLAP Query
After identification of aggregation elements, system maps them in the SQL template. In next step, OLAP query is easily built which is executed on OLAP engine.

J. Results
The generated OLAP query using SQL template is executed and results are displayed.

IV. STRUCTURE OF MAPPING RULES
The mapping rules have been developed for the schema. The dimension and fact tables that are available in the schema, rules have been developed for the tables and the attributes of tables. With the help of these rules, the tables and attributes of the tables are identified from the user input query. In this way, required tables and attributes of the tables can accurately be identified. Mapping rules for one of the dimension is given Table I.

The mapping rules have been developed for the Aggregate functions and synonyms of the aggregate functions. Some rules of aggregate function Max ( ) and its synonyms are depicted in Table II.

V. EXPERIMENTS AND RESULTS
The proposed method has been evaluated on the AdventureWorksDW which is data warehouse developed in MS SQL Server. For experiments, core i3 machine has been used with 2 GB RAM. The part of Data Warehouse schema is depicted in Fig. 2.

<table>
<thead>
<tr>
<th>Rule</th>
<th>Rule Notation</th>
<th>Rule Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>EnglishProductName</td>
<td>attrib-EnglishProductName</td>
<td>Rule to show attribute EnglishProductName of Product Table</td>
</tr>
<tr>
<td>EnglishProduct Name</td>
<td>attrib-EnglishProductName</td>
<td>Rule to show attribute EnglishProductName of Product Table</td>
</tr>
<tr>
<td>english product name</td>
<td>attrib-EnglishProductName</td>
<td>Rule to show attribute EnglishProductName of Product Table</td>
</tr>
<tr>
<td>englishproduct name</td>
<td>attrib-EnglishProductName</td>
<td>Rule to show attribute EnglishProductName of Product Table</td>
</tr>
<tr>
<td>SpanishProduct Name</td>
<td>attrib-SpanishProduct Name</td>
<td>Rule to show attribute SpanishProductName of Product Table</td>
</tr>
<tr>
<td>FrenchProduct Name</td>
<td>attrib-FrenchProduct Name</td>
<td>Rule to show attribute FrenchProductName of Product Table</td>
</tr>
</tbody>
</table>
The Analysis of Aggregation functions and Synonyms of the Aggregation function is performed in Table III. The five aggregation functions and its synonyms are taken. Thus most relevant synonyms are taken that are required and suitable for the Aggregate functions. The results are also shown graphically in Fig. 3.

### VI. CONCLUSIONS

In this work, a Natural Language Interface to Data Warehouse has been proposed. The architecture of the system provides detail about participating modules in the system. It develops rules based on underlying schema with the support of the domain dictionary. The rules are then used to interpret natural language query. Empirical analysis has been performed to evaluate the proposed system. As future work, it is required to generate limited rules according to user interestingness measure.

### REFERENCES


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Saliha Zahoor is MS scholar and functioning as Lecturer in University of Gujrat- Gujrat Pakistan since September 2007. During her 6 years stint as lecturer at university of Gujrat she is been involved in helping her students on various research issues. She is taking research projects on NLI for data warehouse and on software engineering as well. This paper is the result of her constant efforts on NLI for data warehouse project and is a part of the uncontaminated work done on her final thesis report. She started working on this paper in early 2012.

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