Quality Data for Data Mining and Data Mining for Quality Data: A Constraint Based Approach in XML

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Abstract

As quality data is important for data mining, reversely data mining is necessary to measure the quality of data. Specifically, in XML, the issue of quality data for mining purposes and also using data mining techniques for quality measures is becoming more necessary as a massive amount of data is being stored and represented over the web. We propose two important interrelated issues: how quality XML data is useful for data mining in XML and how data mining in XML is used to measure the quality data for XML. When we address both issues, we consider XML constraints because constraints in XML can be used for quality measurement in XML data and also for finding some important patterns and association rules in XML data mining. We note that XML constraints can play an important role for data quality and data mining in XML. We address the theoretical framework rather than solutions. Our research framework is towards the broader task of data mining and data quality for XML data integrations.

1. Introduction

Quality data is important for data mining in any data model[1]. To find some interesting patterns and rules in data mining with accuracy, semantically correct, consistent and complete data is necessary[2]. Oppositely, data mining processes can be used for some quality measurement of data with the help of some rules and patterns[9]. In quality measurement of data, integrity constraints play a significant role. Similarly, in data mining processes, use of constraints is useful for finding patterns and rules.

In recent years, XML[13] is a widely used data representation and storage format over the web and hence the issues of data quality and the task of data mining processes are getting significant attention to the database community[10, 11, 12]. We consider how XML quality data

is necessary to data mining in XML and also how XML data mining is important to qualify XML data. We investigate these issues in the light of XML constraints[7, 8]. In XML, the important integrity constraints are XML keys, XML functional dependency, XML foreign keys, XML inclusion dependencies, XML multi valued dependencies[15, 16, 17, 18, 19, 20, 21, 22, 24, 23, 25]. There are many standards and proposals for these constraints and the research of these constraints are still ongoing.

In some XML data quality measurements, some XML constraints are used but again the definitions for XML constraints are varied. Similarly, in some XML data mining, XML constraints are used with different approach of XML constraints. We give here examples to motivate the research issues.

We first give an example how data quality(due to constraints) affects data mining in XML.

Example 1. Consider the document type definition (DTD)[1] D in Fig.1 and its conforming XML document T in Fig.2. For simplicity, we omit the type $\#PCDATA$ from the DTD. We represent the customer information of a company using DTD. We want to know the following information from data:

"Classify the profession of customers and offer some credit rewards to them."

We see that the structure of the DTD allows missing values of "profession" in the conforming XML documents because of the notation '?' for "profession" element. In the XML document T, there are some missing values of profession. The missing or incomplete values in the document will surely affect in finding the professions of customers and hence classification.

Now our question is how can we restrict this incomplete data. Surely, we can do it by omitting '?' from the DTD(meaning that the profession must appear in the document) or using integrity constraints.

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[1]We assume that the reader is familiar with XML schema definitions such as XML DTD and XML Schema.

```
<!ELEMENT cust(custID, info, items+) >
<!ELEMENT info(name, addr, email, profession?) >
```
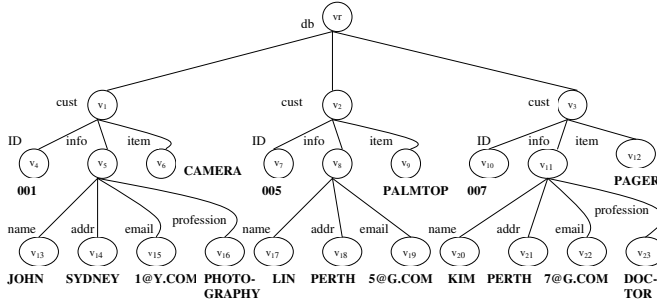
Figure 1. XML DTD D

Figure 2. XML Tree T **conforming to** D

We can impose some constraints on the DTD. For example, we say that `custID is the key` and `custID determines profession`. Then we restrict that profession values must appear in the document according to the definition of XML functional dependency. Thus imposing constraints helps to improve data quality of XML and hence helps efficient data mining in XML.

Observation 1: *Quality data can be measured by XML constraints and is also needed for data mining in XML.*

Now we give another example where data mining(with the help of constraints) is used for data quality measurement in XML.

Example 2. Consider the XML document T in Fig.1 that conforms to the DTD D in Fig.2. We want to mine data for finding some rules. For example we want the following association rule:

"If the profession is photography, it is likely that he should buy a camera."

This association rule means "profession→ item" where LHS is "profession" and RHS is "item". If we observe the XML document, we see that there is a missing LHS or profession for the customer "LIN". Surely the missing or empty values affects mining the association rules. However, if we impose the constraints like "ID functionally determines profession" and profession must appear in the document, then we don't get the missing values of profession. Note that we can't say "profession functionally determines item" because this dependency is not true in the document as, for example, a photographer can buy more that one item. Thus we see how constraints in data mining can help to check quality of data.

Observation 2: *Some quality of data can be determined by data mining using XML constraints.*

Our paper is organized as follows. In next section, we give the related research issues. In section 3, we give the basic definitions. We give the proposed research framework in section 4. We give the detailed proposed methods to solve the research issues in the framework in section 5. We conclude with some remarks in the last section.

2. Related Work

Data quality and data mining are well studied topic in relational database[3, 4, 5, 6, 9, 10]. Use of integrity constraints is appeared in some research[2]. In recent years, data quality and data mining issues in semi structured data, specifically in XML, are getting much importance[11, 12]. However the utilization and characterization of XML integrity constraints for data quality and data mining purposes respectively are still of limited use. Our research is close to some previous work[2, 9, 10]. But our research is very different in the sense that we use XML integrity constraints in data quality for mining purposes and reversely data mining techniques for measuring quality of data in XML.

3. Basic Definitions

We give some basic definitions and notation which are needed for the rest of the paper.

Definition 3.1 (Constraints,C) *By constraints, we mean keys, functional dependency, inclusion dependency and foreign key. We also mean constraints over schema and documents conformed to schema and also satisfied by constraints.*

Definition 3.2 (Data Quality,DQ) *By data quality, we mean the completeness and consistency of data which can be achieved by constraints, C.*

Definition 3.3 (Data Mining,DM) *We define data mining using some constraints, C. Constraints can be characterized as some association rules for mining purposes.*

4. Proposed Framework

In this section, we show the proposed framework for XML.

Definition 4.1 (XML Constraint Framework,XCF)
In XML, constraint framework consists of XML keys, XML functional dependency, XML inclusion dependency, and XML foreign key. Sometimes, XML multi-valued dependency can be used.

Definition 4.2 (XML Data Quality Framework,XDQF)
We use constraints in XCF to measure the quality of XML data. We consider completeness and consistency of XML data.

Definition 4.3 (XML Data Mining Framework,XDMF)
By XML data mining framework, we mean the use of constraints in XCF for some mining purposes.

5. Proposed Methods

We now show our proposed methods of solving problems found in the observations.

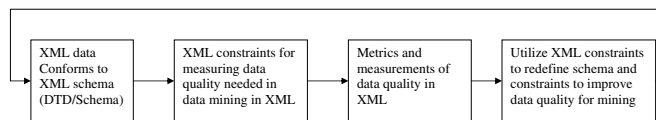### 5.1. Quality Data for Data Mining in XML

We show how quality data is needed for data mining in Fig.3. While we discuss the quality issues in data, we use the constraints to measure those issues.

XML schema: We consider the XML schema for XML data. The popular XML schema definitions are XML document type definitions(DTD)[13] and XML Schema[14]. The XML documents should conform to the XML schema.

XML Constraints: The important XML constraints like XML keys, XML functional dependency, XML multi-valued dependency, XML inclusion dependency etc. can be used to measure quality of data in XML. When we use these constraints, we need to define them in such a way that completeness and consistency issues in XML data are captured. Also, we need to consider that the definitions for XML constraints should be over the XML schema definitions.

XML Data Quality Metrics for Data Mining: In this stage, we need to identify the metrics for data quality in data mining XML. The outcome of this stage will be the analytical results for measurements of XML data quality in data mining.

Feedback for Redefining XML schema for Data Quality Improvements: This stage recommends improvements of designing the XML schema with some constraints to improve the data quality for data mining purposes in XML.

Figure 3. Processes of using quality data characterized by XML constraints for data mining in XML

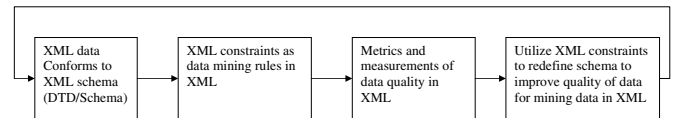### 5.2. Data Mining for Quality Data in XML

We discuss the processes how data mining techniques with the help of XML constraints are used for data quality measuring.

In this method, we also use XML schema and its conforming documents as inputs. However the use of XML constraints for mining purposes is different in the sense that we characterize XML constraints as mining association rules.

XML Constraints: We use XML functional dependency, XML multi-valued dependency etc. for finding some interesting patterns and association rules in the XML documents.

XML Data Mining Measurements: In this stage, we measure XML data mining parameters like support and confidence values. We then make an analytical result how data mining techniques contributed towards data quality measures.

Feedback to Redefine XML Constraints in Mining Data in XML: We further assess how XML constraints can be redefined over XML schema to enhance the data mining features and hence discovering data quality in XML.

Figure 4. Processes of data mining using XML constraints for data quality in XML

5.3. Process Iterations

We discussed how data quality data affects data mining and also how data mining can be used for quality data measurements. If we observe the figures 3 and 4, we see that both methods have iterative feedback mechanism that helps to improve either data quality or data mining processes in XML. This incremental and iterative process helps data quality and also helps data mining in XML.

6. Conclusions

We proposed a novel framework for data quality and data mining together in XML data model. While proposing, we consider XML constraints. The important XML constraints are characterized for both data quality and data mining processes. This paper is a theoretical framework where problems are identified, rather than solutions. We argue that the proposed framework can be implemented to solve the observations found in the introduction.

Our combined framework can work for XML data integration, XML data warehousing, XML data transformation, and XML data mediation. Moreover, this approach can have significant use in data cleaning that in turn helps in data quality and data mining.

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