

TOWARDS AN ONTOLOGY-BASED APPROACH FOR SOCIAL MEDIA ANALYSIS

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TOWARDS AN ONTOLOGY-BASED APPROACH FOR SOCIAL MEDIA ANALYSIS

Research in Progress

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Abstract

Social Media have emerged as an additional interaction channel for companies with their partners, employees and customers. However, the pace of interaction in this channel is as high as the data volume that may be relevant for businesses. Therefore, mechanisms other than manually monitoring and analyzing this data are needed. Basic approaches have emerged in the areas of Social Search and Social Media Monitoring, but searches based on keywords and simple grammar are limited in their results and deliver only first indications. The main challenge with more sophisticated approaches in the domain of ontology engineering is that they require considerable investments to establish domain-specific ontologies which has often prevented their use in many cases for Social Media Analysis. This research presents work in progress and suggests an approach which aims at increasing the efficiency of defining ontologies by automatically extracting knowledge from existing enterprise application systems. For this purpose, established ontology engineering approaches are evaluated and combined with a text mining tool. The ontology serves as a “dictionary” for the analysis of unstructured Social Media content and contributes to an efficient and adaptive monitoring and analysis of unstructured content.

Keywords: Social Media, Ontology, Ontology Engineering, Information Systems, Social Customer Relationship Management.

1 Introduction

The global number of Internet users has increased in the past years and is still expected to grow. According to the International Telecommunication Union there were approximately 394 million Internet users in the year 2000, whereas the number in 2012 has almost reached some 2.5 billion users (ITU, 2012; ITU, 2013). Important drivers of the development were applications that emerged on the Internet infrastructure, such as the World Wide Web and the Social Web, as well as mobile devices which generate particularly location-based and context-specific content (Alt and Reinhold, 2012). Today, the social networks Facebook and Twitter report more than one billion respectively 230 million monthly active users worldwide (Facebook, 2013; Twitter, 2013). Their content is also potentially relevant for companies (Kaplan and Haenlein, 2010; Heller and Parasnis, 2011; Woodcock et al., 2011; Mikalef et al., 2012): opinions on products or companies, complaints or suggestions are only some examples which could be helpful in improving customer satisfaction and the offerings in the market. Furthermore, tools for Social (Media) Intelligence, such as Social Media Monitoring, allow for collecting sentiment information on the company, its products, and services. In addition, frequently discussed topics, preferred communication channels, and most active users can be filtered more quickly and more accurate compared to classic market research approaches. For example, companies might realize quickly whether

a newly released product features problems. When the iPhone 4 was launched, some users reported difficulties in signal strength and discussions with negative sentiment appeared in several forums as well as other channels of the Social Web (e.g. Apple Support Community, 2011). If Apple had been able to realize this development earlier, the company would have had the opportunity to act proactively and avoid frustration among customers.

Although it is unknown whether Apple used any instruments of Social Intelligence, these tools still feature important shortcomings. First of all, they are primarily based on a user-defined keyword search (Sponder, 2012). Despite logic operators, searches mostly deliver high quantities of results in a low quality and are time consuming to harvest. A well-known example is the missing distinction between user names and product identifiers. For example, a search for “Nivea” may return postings regarding the product, the company Beiersdorf, but also regarding user names. Usually, a product has a specific name and is discussed in a product-specific context whereas a user name usually has no product identifiers or context. However, both keywords are found and analyzed by most analysis tools, even if the user name is the only indicator. Second, spam is mostly not marked automatically what mingles relevant information and irrelevant content. Third, the extraction of a “social reputation” of a company’s products (Agichtein et al., 2008) becomes difficult since most tools lack functionality to categorize Social Media messages into product-related and other categories. Consequently, a social reputation of products strongly depends on the accurate choice and combination of keywords. The fourth shortcoming is a missing interpretation of gained insights and their positioning into a company’s developments. This refers to a lacking “closed loop” from which insights from Social Media are returned to enterprise databases, processes, or the correct person for interaction purposes (Reinhold and Alt 2011).

This research suggests an approach that considers conceptual connections between keywords to improve the quality of results. Knowledge from existing corporate data models in enterprise systems, such as Enterprise Resource Planning (ERP), is recognized as valuable source to model connections between keywords. The data stored in enterprise databases describes domain-specific concepts, such as master data elements on the stakeholders, products or services. Following this idea, ERP data is extracted and stored in a ‘dictionary’ to support the analysis of Social Media based on text mining. The approach comprises two main elements: The first component aims at building an ontology automatically from existing data structures, such as ERP or CRM databases. An ontology formally represents domain concepts in an organized way and may be used as a suitable means of representing properties and interrelationships of a company’s concepts. Ontologies have been selected from a variety of possible knowledge representation techniques since they explicitly focus on interrelationships. The second is a text mining component which analyzes Social Media content by using the provided ontology as a dictionary. Both components are developed in more detail below.

2 Foundations and Related Work

The following section outlines related work in the areas Social Media, Social Customer Relationship Management, and Social Intelligence. Social Media channels are regarded as primary source for Social Media analyses with relevant content for business processes, such as CRM and SCRM. Text mining and ontology engineering are necessary foundations for analyzing qualitative content.

2.1 Social Media and Social CRM

With the emergence of the term Web 2.0, which refers to the creation and modification of content in a collaborative fashion among multiple users, the term Social Media emerged as well. Kaplan and Haenlein (2010) define the term Social Media as “*a group of Internet-based applications that build on the ideological and technological foundations of Web 2.0, and that allow the creation and exchange of User Generated Content*” (Kaplan and Haenlein, 2010, 61). The Web 2.0 offers a multitude of applications which can be associated with operational communication channels. This helps to classify

these applications and to determine their relevance to business. Among the categories to classify Social Media into channels are collaborative projects, blogs and micro blogs, content communities, and social networking sites (Kaplan and Haenlein 2010). . They may be further differentiated between Social Media provided by a company (e.g. Dell Ideastorm¹) and those hosted by an external provider (e.g. Facebook or Twitter) (Reinhold and Alt 2011). The remainder of this contribution specifically refers to textual Social Media channels as they are applicable to text mining technologies. Besides, attempts to automatically analyze other media types, such as audio, are underway as well.

The Customer Relationship Management (CRM) concept may be defined as a “*process that utilises technology as an enabler to capture, analyse and disseminate current and prospective customer data to identify customer needs more precisely and to develop insightful relationships*” (Paulissen et al., 2007, 1). An extensive knowledge about the customer needs (Grönroos, 1996; Muther, 2002) and the generation of this knowledge is recognized as key for supporting marketing, sales and service processes (Reinhold and Alt, 2011). From this background data from Social Media channels complements existing data in enterprise systems, such as CRM or ERP. CRM systems in many businesses provide process support in the areas of marketing, sales and service (Wahlberg, 2009) with dedicated functionalities for information aggregation and process specific presentation (Reinhold and Alt, 2011). Gebert et al. (2003) suggest a more detailed classification into campaign, opportunity, lead, offer, contract, complaint, and service or feedback management. With regard to Social Media, some CRM system providers have already made attempts to include Social Web functionalities in their CRM concepts (Enrico, 2007; Greenfield, 2008) which led to the use of Social Media within CRM processes and also to the term Social CRM (SCRM). Following Sarner et al. (2010) SCRM systems are applications that “*encourage many-to-many participation among internal users, as well as customers, partners, affiliates, fans, constituents, donors, members and other external parties, to support sales, customer service and marketing processes*” (Sarner et al., 2010, 2). Thus, SCRM systems bridge the process gap between Social Media on the one hand and enterprise applications on the other. At current, many separate applications are used to cover the functional areas within SCRM and an integrated SCRM solution that covers analysis and interaction purposes is still missing (Alt and Reinhold, 2012). This integration also refers to coordination with other communication channels (e.g. online/offline, call center) since Social Media often contributes an additional source of information. To enable this assessment, self-learning assessment tools for customer feedback are one possible solution to address this challenge.

2.2 Text Mining and Ontologies

Following Feldman and Sanger (2007), text mining uses techniques from several disciplines to solve the problem of the information overload. These techniques include data mining, machine learning, natural language processing (NLP), information retrieval (IR), and knowledge management. In view of the abundant amount of unstructured data involved in Social Media, text mining is a promising discipline for Social Media analysis tools. Text mining encompasses the preprocessing of documents, techniques to analyze these intermediate representations as well as the visualization of the results by using the above mentioned techniques. It may be defined as “*a knowledge-intensive process in which a user interacts with a document collection over time by using a suite of analysis tools*” (Feldman and Sanger, 2007, 1).

Research fields, such as IR, electronic commerce, and knowledge management, are also involved in ontology related research where the support in the export of data, information, and knowledge has become a key issue in current technologies (Fensel, 2004). Therefore, ontologies provide a means for the communication between different (software) agents on a semantic level. Studer et al. (1998) conceive an ontology as “*(...) a formal, explicit specification of a shared conceptualisation*” (Studer et al., 1998, 184). However, current approaches for manually creating ontologies have proved time consuming and error-prone, even for domain experts (Trinh et al., 2006; Park et al., 2010). This problem becomes even

¹ <http://www.ideastorm.com/>

more obvious when the underlying application system is large, changes frequently, and when a large number of participating systems is involved (Trinh et al., 2006). This motivates research on automated ontology creation which is implemented in several algorithms and toolsets (see section 3.2).

2.3 Related Work

Netzer et al. (2012) state that the usage of text mining for the extraction of user generated content from Social Media has primarily emerged from the computer science literature (see Feldmann et al., 1998; Dave et al., 2003; Hu and Liu, 2004; Liu et al., 2005; Glance et al., 2005; Akiva et al., 2008). This research on text mining provides insights into the mining of different document-types, such as emails, news articles, discussion forums, and consumer reviews (Abrahams et al., 2012). Several application domains are reported, among other the automotive industry (Rajpathak, 2013).

The approach of automatically creating or learning an ontology, particularly from existing relational databases, has emerged in the last decade (see Barrasa et al., 2004; Cimiano and Völker, 2005; Trinh et al., 2006; Cullot et al., 2007; Zhang et al., 2011; Deliyaska et al., 2012). Recently, the construction of ontologies from object-oriented database models extends former research in this field (e.g. Zhang et al., 2011). In addition, ontologies have even been constructed from entity relationship (ER) models (e.g. Xu et al., 2004; Upadhyaya and Kumar, 2005; Deliyaska et al., 2012).

3 Towards an Ontology-based Social Media Analysis

3.1 Overview

Contrary to expectations, the increasing amount of social data does not imply that information or even knowledge is derived from those data. Nowadays, algorithms for data analyses are capable on the one hand, but time consuming and expensive on the other. The following approach is based on the mentioned findings about the shortcomings of existing analysis tools and uses automated ontology engineering to improve both the ontology creation process and consequently Social Media analysis. The proposed solution consists at least of four main components (see Figure 1):

- First, *business databases* are the starting point as they contain basic information of a company, its structure, products, and processes. The reuse of already existing information stands in the foreground of this framework, as it allows the fast creation of an ontology, ideally without human interaction. These databases represent an essential prerequisite for the proposed solution.
- Second, an *ontology builder* is necessary to automatically derive an ontology from existing business application data sources, such as relational databases and other, structured or unstructured documents. This component extracts data from business databases by using appropriate database interfaces, such as JDBC or ODBC, and comprises algorithms to transform database structures into the resulting ontology. Among the examples for a simple mapping of relational database structures into an ontology are tables into classes, columns into properties, and relations into constraints mapping (Cullot et al., 2007). The resulting structured and formalized document serves as a dictionary for text mining tools. Algorithms for the mapping are considered in section 4. Sam and Chatwin (2012) describe in their work a similar idea, but use manually created ontologies which are not tailored to company specific items. Furthermore, this step would require expert knowledge and demands ongoing maintenance of the created ontology.
- Third, a *text mining* component is needed to analyze unstructured text from Social Media channels, such as consumer forums and social networking sites. This component is indispensable to Social Media Analysis tools as it provides key procedures to interpret given texts. It is assumed that the inclusion of a dictionary (e.g. the created ontology) helps by

“filtering” relevant content from irrelevant. Contained relations (constraints) help the text mining application by identifying items which are related to each other. For example, the items “Apple” and “iPhone 4” are mapped within the ontology and show an affiliation. By applying this procedure the authors assume better analysis results of the text mining application.

- Fourth, *Social Media* represent a mostly untapped source of information. By using existing interfaces from platforms, such as the Facebook or Twitter Application Programming Interface (API), social data gets accessible. Reinhold and Alt (2011) report restrictions regarding external and access restricted Social Media. However, it is aimed that information from Social Media is stored as an additional dataset (e.g. an overall product sentiment) at the corresponding product dataset in an ERP database.

The given list of components is not intended to be exhaustive, but shows the minimum of necessary components to implement the described purpose.

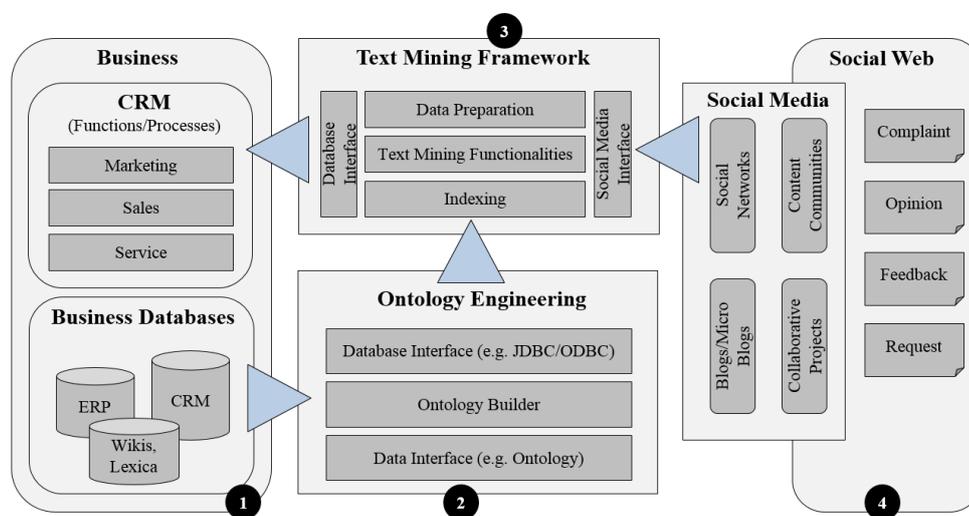


Figure 1. Proposed framework of an ontology-based Social Media analysis.

3.2 Ontology Transformation Algorithms

Based on the Ontology Engineering Component, an ontology is created from an ERP database and contains information, such as company information and information about its products or services. The final ontology is included in a text mining application which refers Social Media data from specified sources and is enabled to filter relevant from irrelevant keywords and concepts. The results of an analysis are stored in a machine-readable file format, such as XML. It is also possible to store sentiment information and complaints or positive feedback to particular products in an ERP database as a subset of the regular product dataset. Employees in the areas of marketing, feedback, and complaint management or in product management may, for example, refer to this new information to prepare customer pitches, product enhancements, or marketing campaigns.

To realize the proposed approach, mapping algorithms were analyzed in a first step. Therefore, appropriate literature connected with the automatic creation of ontologies and the mapping of relational databases to ontologies together with text mining applications was reviewed (see Cullot et al., 2007; Barrasa et al., 2004; Trinh et al., 2006; and Papapanagiotou et al., 2006 for the below listed algorithms). The evaluated mapping algorithms (DB2OWL, R2O, RDB2ONT, and RONTO) represent a partial selection of possible choices and are simple examples for the envisaged purpose (see Table 1). In a first step the algorithms were analyzed regarding the following aspects:

- *Interoperability* with existing business applications for ontology editing (e.g. Protégé) to assess whether they are part of a solution suite or standalone solutions. Moreover, there is a need to integrate the algorithms with existing text mining tools which may already be used to analyze social data.
- *Data Source Integration* should be possible from different, structured and unstructured business data sources (e.g. ERP or CRM database, wikis, or lexica) to gain maximal use of available information from different data sources. This requirement derives from the observation that data and knowledge is often highly distributed within a company.
- *Ontology creation* should occur automatically as manual creation is time consuming and error-prone.
- *Individualization* of the mapping result is regarded as an optional requirement as it provides the opportunity to adapt mapping results to changed or individual requirements (e.g. a partially automatic mapping process implies customizability of a resulting ontology).

Requirement	Requirement Description	DB2OWL	R ₂ O	RDB2ONT	RONTO
Interoperability	Interoperability with existing business applications	●	○	○	●
	Independent algorithm	○	●	●	○
Data Source Integration	Relational databases	●	●	●	●
	Unstructured data	●	○	○	○
	Semi-structured data	●	○	○	○
Ontology Creation	Delivering of a mapping description	●	●	○	●
	Creation of an ontology document	●	●	●	○
Individualization	Fully automated algorithm	●	●	●	○
	Partially automated algorithm	○	○	○	●
Legend:	● Aspect covered, ○ Aspect not covered				

Table 1. Evaluation of existing database to ontology transformation algorithms.

The choice of the selected algorithms is mainly based on the following criteria: first, the mapping process of each algorithm needs to be comprehensible, which means that mapping rules and the consideration of attributes with their relations should be considered, for example. Second, the described algorithm should have been practically implemented to proof the applicability of the underlying concept. Both criteria are substantial for the further evolution of the proposed framework. According to the given criteria, appropriate publications were selected via literature research.

Future research is planned for the evaluation of a larger set of algorithms to reveal differences and to assess their applicability. However, first results show that algorithms, such as DB2OWL, are automatically mapping a relational database schema as well as unstructured and structured data to ontologies. On the one hand, they require no human interaction, but on the other hand they lack any option for manually adapting the resulting ontology to individual needs. Furthermore, three of the analyzed algorithms are not supporting the use of other data sources than relational databases. Mostly,

knowledge within a company is distributed and the integration of semi-structured or unstructured sources can support the creation of ontologies. Therefore, sophisticated algorithms which create ontologies from multiple sources are required. Moreover, the presented algorithms differ regarding their degree of automation. Depending on the individual requirements of the ontology engineering process and on the need to customize an ontology, different algorithmic solutions are available. It has to be considered that no algorithms for the transformation of object-oriented databases are contained in the current analysis yet.

Further research is needed in assessing and enhancing existing algorithms. For example, the time to transform a given relational database scheme is assumed to be relevant for the transformation process. The quality of a created ontology is also a relevant factor for subsequent assessments as it may influence the quality of search results.

4 Conclusions and Outlook

This research in progress article presents an approach to enhance the quality of ontologies which are used when text mining tools are applied to efficiently analyze the qualitative data from Social Media platforms. It aims at providing data retrieved from different Social Media channels for business applications and furthermore for CRM and SCRM processes. Therefore, the feedback management of a company, as in the example from Apple, represents only one of the many possible use cases. Existing ontology creation approaches serve to improve the data quality of social data analyses, but are connected with much manually effort. As a consequence, automatic approaches are evaluated and presented. The proposed approach is based on the reuse of existing business application data and targets to derive ontologies from existing databases, such as an ERP or CRM database. The approach aims at the acceleration of Social Media analyses by using the created dictionary, respectively ontology, which provides relevant keywords and concepts for a social search and analysis.

Existing algorithms from the field of ontology engineering fulfill basic requirements as interoperability, integration of data sources, ontology document creation, and individualization. These requirements served for an evaluation of chosen algorithms and contribute to the transformation of database structures to ontologies (e.g. DB2OWL, R₂O, and RDB2ONT) respectively to the appropriate mapping (e.g. RONTO). The mentioned approaches have not been used within the field of business processes or SCRM. The presented framework (see Figure 1) is the fundament for further research activities. Research questions that emerge from this framework may focus on ontology-related questions, such as the choice and design of suitable ontology transformation algorithms and the efficiency of obtaining a first ontology from relational data structures in terms of time as well as manual preparation. A second set of research questions includes the selection of suitable criteria to determine the quality of Social Media data and how security and privacy issues can be addressed properly. Research on privacy issues considers, for instance, the anonymization and pseudonymization of datasets as two basic methods. Data privacy regulations are considered important for all analytical activities. Furthermore, the quality of social data (e.g. users review) needs to be assessed to ensure reliability. Methodologies dealing with this aspect are under research within a current project at the research group. An empirical comparison of state-of-the-art Social Media analysis tools and the proposed approach is also in the focus of ongoing research activities. This supports the statement of (Sponder, 2012, 283) who sees a large potential in the area of artificial intelligence: *“What will likely take place in the next few years in the Social Media analytics and social listening? For starters, I believe we will be moving beyond keyword-based queries into machine learning algorithms”*.

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