BUSINESS ONTOLOGY FOR EVALUATING CORPORATE SOCIAL RESPONSIBILITY

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Abstract
This paper presents a software solution that is developed to automatically classify companies by taking into account their level of social responsibility. The application is based on ontologies and on intelligent agents. In order to obtain the data needed to evaluate companies, we developed a web crawling module that analyzes the company's website and the documents that are available online such as social responsibility report, mission statement, employment structure, etc. Based on a predefined CSR ontology, the web crawling module extracts the terms that are linked to corporate social responsibility. By taking into account the extracted qualitative data, an intelligent agent, previously trained on a set of companies, computes the qualitative values, which are then included in the classification model based on neural networks. The proposed ontology takes into consideration the guidelines proposed by the "ISO 26000 Standard for Social Responsibility". Having this model, and being aware of the positive relationship between Corporate Social Responsibility and financial performance, an overall perspective on each company's activity can be configured, this being useful not only to the company's creditors, auditors, stockholders, but also to its consumers.

Keywords: corporate social responsibility, ISO 26000 Standard for Social Responsibility, ontology, web crawling, intelligent agent, corporate performance, POS tagging, opinion mining, sentiment analysis

JEL Classification: M14, L86

Introduction

In the new economy characterized by organizational interoperability, knowledge management, transparency, environment concern, efficient use of resources, etc it is not sufficient anymore to determine an organization's performance only by analyzing the financial figures, one must also take into account a new classification criterion: the "social responsibility".

The social responsibility nature of a company is a very complex feature and has to be analyzed by considering a wide variety of factors, actions and features. Therefore, it is very difficult to fully-classify a company based on its social responsibility level by taking into account the complete list of factors. ISO elaborated the „ISO 26000 Standard for Social Responsibility" for providing voluntary guidance on social responsibility and to highlight

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the most important characteristics that determine the level of social responsibility for an organization.

According to ISO, this standard is addressed to organizations of all types in both public and private sectors, in developed and developing countries.

At the level of the European Community, there is also an increased level of interest on corporate responsibility. "In line with these concerns, the European Union strategy for sustainable development has been adapted to permanently growing requirements of the society, demands embodied in the regulations becoming more stringent. In this respect an important step was the adoption of EU directives and the "New Approach" on technical harmonization and standardization, which attaches great importance to the essential requirements for the protection of life, health and environmental protection."(Olaru et al., 2010).

In this paper, we propose a software solution based on ontology that is targeted to cover as many factors as possible to determine the level of social responsibility by analyzing the company's web site, as well as other web sites that illustrate the company's role in the economic and social environment: financial sites, job offering, forums related to job finding, forums about customer satisfaction, etc. Documents that are taken into account are: Company Social Responsibility Report, the Mission Statement, Employment Structure (age groups, qualifications, sex, etc.), etc.

Information technology and the Internet are transforming service and quality management and also consumer and environment interaction within the knowledge-based economy. (Plumb and Zamfir, 2009). Why is it important to develop an ontology of corporate social responsibility? In recent years, research on ontology has become increasingly widespread in the fields of information science and business. In these fields ontologies provide formal specifications, and methodologically tractable standardized definitions of terms used to represent knowledge in ways that will enhance communicability. Also, a common ontology is needed to provide a unified communication framework, and an ontological foundation for measurement.

Some of the key reasons for developing an ontology, are to offer a common understanding of the structure of information among people and among different software applications and to enable domain knowledge reuse, as particular ontologies can be combined into more general ones. Given the variety of corporate practices that can be considered related to corporate social responsibility, developing an ontology would allow both people and applications to exchange information structured into a clear hierarchy of concepts.

By using ontologies, assumptions related to a particular domain can be expressed in an explicit manner. This is of particular importance for developing software applications because assumptions no longer have to be incorporated using written code. Thus, the assumptions can easily be modified or updated in order to reflect new discoveries or changes in the domain of interest. Ontologies can be incorporated both in classical programming applications as well as in applications that use neural networks and software agents. A neural network application was developed by the authors in order to automatically classify companies based on their commitment to CSR.

The term of ontology comes from the field of philosophy and was defined as "an explicit specification of a conceptualization" (Gruber, 1993).

However, in the field of computer studies ontology is not a theory of what exists, but rather it represents an abstract, simplified image of the real world concepts, meanings and semantic relationships.

In order to implement ontologies for the Semantic Web, the W3C has developed ontology specific language called OWL. The OWL language enables developers to implement all ontology components: classes that model real world concepts, instances, properties (or relations) and axioms.

Concepts are linked in a hierarchic structure according to the semantic real world relationships. Therefore, we can consider that concepts can be of two types: sub-concepts or super- concepts. Due to these semantic relationships between terms we can speak about inheritance and clustering properties.

Ontology can be considered as a predefined vocabulary of concepts. The purpose of such a "vocabulary" is to assure a higher level of knowledge based on semantics to define concepts and the semantic relations between them in order to disambiguate a specific domain.

1. Corporate Social Responsibility

1.1 Corporate Social Responsibility in Time

Corporate Social Responsibility (CSR) can be defined as being "the voluntary integration, by companies, of social and environmental concerns in their commercial operations and in their relationships with interested parties", (Commission of the European Communities 2001).

From a managerial point of view, the CSR concept can be divided into one of the following categories: health and safety, environmental activities, codes of conduct, better community relations, participation in affairs of public interest and human rights, long-life learning, socially responsible investments, support of deprived groups or ethnic minorities, charity giving, better relations with customers (Fafaliou, Lekakou and Theotokas, 2006).

The CSR activities are considered to be adopted based on growing evidence that customers are willing to give incentives to socially responsible companies (Brown and Dacin, 1997), (Murry and Vogel, 1997), (Ellen, Mohr and Webb, 2000), (Nelson, 2004), (Yoon, Gurhan-Canli and Schwarz, 2006).

Smith and Alcorn (1991) and Creyer and Ross (1997) demonstrate that consumers are willing to pay higher prices for products made by an ethical company or by a company that makes donations to non-profit organizations or supports charitable causes.

Having this in mind, the attention for CSR has increased significantly during the last decade (Zaharia, Stancu, Stoian and Diaconu, 2010) and many firms decided to start reporting their interest in ethics, society and environment.

In academic research, CSR has also become a topic of real interest (Scholtens, 2008) and the number of papers related to this topic is increasing. Many papers are focusing on the relation between financial and social performance (Orlitzky, Schmidt and Rynes, 2003), (Allouche and Laroche, 2006), (Lockett, Moon and Visser, 2006), etc.

Due to the numerous approaches related to the identification of a linkage between social and financial performance, Margolis and Walsh (2001) considered it interesting to offer an overview of the studies on this linkage, and they discovered that more than 50% of the

studies found a positive relationship between the two, 25% consider that there is no relationship, 20% found mixed results and only 5% of them believed that there was a negative relationship.

In a more recent study conducted on a sample of 289 firms, Scholtens (2008) found a positive and significant interaction between financial and social performance. Furthermore, the different themes of CSR (community involvement, employee relations, diversity, environment and product) might be critical in affecting financial and social performance.

1.2 CSR and Company's Activity

The economic, social and environmental benefits achieved when adopting socially responsible behaviors determine each company's activity and even succeed in going beyond these by involving larger communities. As Ciliberti, Pontrandolfo and Scozzi (2008) pointed out, "to be effective in terms of CSR, companies need all firms in their own supply chain to act in a socially responsible manner" and this is one of the reasons why we consider of great importance that each company has to be aware of its own CSR level, and at the same time, to be able to determine the CSR of the companies it interacts with.

Along with the well-known positive relationship between CSR and financial performance (widely studied in literature – see (Lin, Yang and Liou, 2009)), there are also other reasons that can lead to the initiation of the CSR activities (Fafaliou, Lekakou and Theotokas, 2006): improvement of employees' job satisfaction, better relations with community and public authorities, improvement of customer loyalty, relation with partners and investors, etc.

The relation between CSR and corporate financial performance is represented in figure no. 1, as it results from the study conducted by Lin, Yang and Liou (2009).

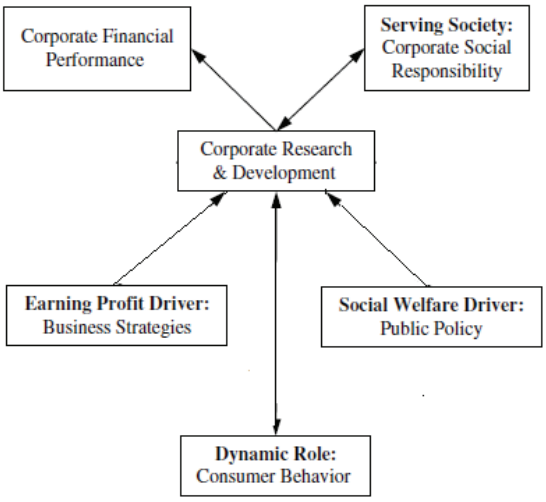

Figure no. 1: Linkage between CSR and financial performance

Source: Lin C.-H., Yang, H.-L. and Liou, D.-Z., 2009. The impact of corporate social responsibility on financial performance: Evidence from business in Taiwan. *Journal of Technology in Society*, 31(1), pp. 56-63.

1.3 Social Responsibility and ISO 26000

ISO 26000 aims to assist organizations and their networks in addressing social responsibilities and providing practical guidance related to operationalizing social responsibility, identifying and engaging with stakeholders and enhancing credibility of reports and claims made about SR. (Castka and Balzarova, 2008)

Furthermore, the standard aims to:

- emphasize results of performance and improvements;
- increase customer's satisfaction and confidence;
- promote common terminology in the SR field;
- be consistent, and not in conflict, with existing documents, treaties, conventions and other ISO standards.

Its key components are:

- human rights (universal declaration of human rights, ILO core conventions);
- workplace and employee issues including occupational health and safety;
- unfair business practices including bribery, corruption and anti-competitive practices;
- organizational governance;
- environmental aspects;
- marketplace and consumer issues;
- stakeholder involvement;
- social development.

It is expected that the ISO's effort in the area of social responsibility will lead to a global uptake—with a vast platform of stakeholders already supporting the development of ISO 26000 (including governments, industry, non-governmental organizations, labor and consumer organizations, and institutes of national standards).

1.4 Internet and CSR Indicators

The problem of identifying the main indicators that are better characterizing the CSR activity of a company becomes a central one when the needed information can only be taken using the Internet (data bases, online articles, documents, companies' web-sites, etc). This applies to our model, which is constructed to search for this type of information using web crawling.

Several studies have shown, "the importance of the Internet and of corporate websites as public relations tools and the growing relevance of corporate websites for communicating approaches to corporate responsibility" (Capriotti and Moreno, 2007).

The resources that companies are using to present the information in CSR are mainly "exhibitive" (the presence of graphic resources - written text and fixed images, photos, and graphics - that are used to transmit information on the CSR issues and the use of audiovisual resources - audio and video - even though, in many cases, these types of resources can be troublesome by slowing the website surfing) and in few cases they can be "interactive" resources - that permit information to be obtained through active interaction, with a mainly active and participative visitor. These include hypertexts, interactive graphics, charts, and similar resources.

Figure no. 2 presents a company's website with regard to the corporate social responsibility using expositive resources.

Figure no. 2: Example of website with expositive CSR

Also, a feedback resources category can be present for facilitating the identification of the systems available on corporate websites for visitors to ask questions, give opinions, or assess the CSR issues. The possible forms of feedback are: general email to the company, specific email linked to CSR issues and other forms of feedback (questionnaires, chats, forums, blogs, etc.) that allow an assessment of or opinions on any of the issues on CSR. The latter type implies an active incentive resource to generate opinions and assessments from visitors (Capriotti and Moreno, 2007).

In their study, Tang and Li (2009) identify four types of rationality having different frequencies: discretionary rationality, ethical rationality, legal rationality and economic rationality. This information can be found on companies' websites.

The philanthropy activities in which companies can be engaged are characterized by the presence and concern manifested on their web sites or internet databases, specialized

information web sites, press, etc. of some of the following issues (even though they are represented through expositive or interactive resources):

- financial assistance to primary and secondary education;
- financial assistance to higher education;
- poverty reduction;
- other contributions to education;
- arts and culture;
- sports

Also, the presence of CSR can be determined by:

- companies mention responsibilities towards/regarding suppliers on their websites;
- companies mention responsibilities towards shareholders;
- in terms of responsibilities towards customers, companies mention product quality and product safety;
- in terms of responsibilities towards employees, one company can mention:
  - employee health and safety;
  - employee welfare;
  - employee development;
  - equal opportunity for all employees (the company discusses about human rights, children labor, discrimination, etc.)
  - its systems of contract, promotion, evaluation and dismissal.

Taking into consideration the ways companies practice CSR (donation, company policy, sponsorship, volunteering, establishing foundations, building partnership with non-governmental organizations, universities and governments, publishing CSR report, and establishing awards), it can be easier to identify the presence or absence of CSR activities using web crawling as we can see in section 2.

2. Social Responsibility Ontology Construction Methodology

2.1 Short literature review of ontology methodologies

The process of ontology development is closely related to the knowledge discovery flow. Due to this fact it is an iterative process. There are many proposed methodologies for developing ontologies targeted to achieve different goals of applicability and to use centralized or decentralized techniques. The methodologies are also dependent on the ontology developers. Generally, ontologies development process is open-source and community based but there are ontologies developed by closed group of researchers for specific purposes. Furthermore, the current trends, for ontology development are characterized by an increased level of automation. Thus, we can speak about semiautomatic

or automatic ontology construction methodologies. These methodologies are based on data mining, text mining, user collaboration, etc.

Ontology can be considered as a structured form of knowledge. Valencia-Garcia, et al. (2008) present a semi-automatic method for acquiring knowledge from texts. This approach is based on three modules: ontology extraction, concept isolation and inconsistency detection.

The first module is based on the use of grammatical categories of words, an incrementally built relational knowledge base and an incrementally built conceptual knowledge base for performing inferences. Knowledge extraction is implemented by using three types of processes: POS tagging, search for concepts and inference. The inference process is capable of inferring many relationships and concepts by grammatical category. This is done by applying a set of rules (MCRDR) developed automatically from the knowledge entities extracted from one sentence. The main objective of the inference module is to model semantic relationships between concepts.

The second module tries to interconnect all the disconnected elements in the ontology obtained from the previous module using UMLS. The third module detects inconsistencies between relations based on the semantic relations properties of the ontological model. In order to improve the consistency checking process the authors are interested in using Ontology Web Language (OWL) for modeling the resulted ontology.

Another approach for ontology construction is developed by Lin, et al. (2007). Due to the fact that collaborative knowledge acquisition and representation is difficult, the authors implement an iterative convergence evaluation by means of the questionnaire analysis. Different situations of ontology conflicts are considered and converged by applying suitable questionnaire item templates. The proposed questionnaire item templates are usually used to compute the knowledge of multiple users in the Delphi-like method. Moreover, it can eliminate the noise and prevent the subjective or divergence of ontology.

Luong, Gauch and Wang (2009) have presented a general ontology learning framework including automated support for tasks such as retrieving documents, classifying, filtering and extracting relevant information for the ontology enrichment. The ontology development is mainly based on focused web crawling. This type of crawling enables retrieving requested information in a specific domain of interest. The crawlers are executed on specialized sites such as digital library websites and also on search engines. The paper presents an evaluation of the SVM-based (Support Vector Machines) filtering technique that automatically selects documents that offer a lower level of relevance for the requested search criteria. The remaining documents are than used in the information retrieval process. Although the automatic collection is quite accurate, over 77.5%, this classifier could be used semi-automatically in the future in order to allow experts to do further filtering.

2.2 Proposed Methodology for "Social Responsibility Ontology"

This paper proposes an iterative methodology for developing ontologies in a semi-automatic manner. This methodology is in accordance with the above-presented approaches. In the proposed methodology the phrases that are processed are parsed and terms are compared within the same grammatical category, the so- called POS tagging process.

However, in our vision it is better to apply a semantic similarity algorithm rather than an automatic rule-based module that is focused mainly on the grammatical and syntactical features rather than on meaning.

The iterative, collaborative approach used especially in the ontology refinement phase has as main advantage the improved quality of the resulted ontology. However, the approach presented by this paper, will not be using questionnaires but rather intelligent agents 'evaluations and previous experiences.

The semantic similarity algorithm queries the WordNet database to classify terms under a specific Subsumer based on the context and the semantic relationships from the database. The similarity computation is also based on classification but not fully on SVM (Support Vector Machine). The major disadvantage of the vector-space model methods comes from the fact that each word does not have unique, unambiguous meaning. If we are to consider homonyms, they have different meanings but the same spelling. Furthermore, one word may have a series of synonyms. In these situations, the vector representation of different texts may resemble, but the subject or the semantic understanding can differ a lot, thus obtaining inconsistent similarity metrics. Moreover, the lack of common terms in two documents does not necessarily mean that the documents are not related. The information retrieval process that is based only on classical models such as probabilistic Naïve Bayesian Classifier, Vector Space or Boolean, consists of lexicographic term matching. However, two terms can be semantically similar (e.g., can be synonyms or have similar meaning) although they are lexicographically different. Therefore, retrieval by classical retrieval methods will fail to retrieve documents with semantically similar terms. This is exactly the problem this work is addressing. In our approach, we will be using web crawling as the main means to obtain data. The main steps that are taken in the process of ontology development are listed below and can be grouped under the following categories:

STEP 1: Ontology Construction

A. Defining and Understanding the Ontology Environment

This section requires a top-down approach from the most general understanding to the most particular.

1. DOMAIN understanding – the area of interest for developing a specific ontology;

2. SECTOR understanding- which parts of the domain the ontology models;

3. DATA understanding- the available data, the business logic and how this data can be processed in a semiautomatic approach;

B. Classifying data

4. TASK based document classification- based on the available data, identify the tasks and try to relate data to particular tasks. This can be achieved by using a document classification algorithm. The future section will insist upon this aspect.

C. Semantic Similarity Matching for Existing Ontology

5. Enriching the ontology by adding extra semantic relations based on a semantic similarity algorithm, which will be presented in the next section.

Steps B and C, represent the actual information retrieval process. Information retrieval is to be implemented by using a hybrid similarity measurement method. This method is a combination of two similarity measurement methods:

- edge counting - that is using a similarity function based on the length of the path linking concepts
- information content methods, that measure the difference in information content of the two terms as a function of their probability of occurrence. This class of methods guarantees that the information content of each term is less significant than the information content of its subsumed terms.

STEP 2: Ontology Refinement

6. The refinement is performed under domain expert supervision. Intelligent agents are to reiterate on the previously presented steps in order to improve the quality of the resulted ontology.

7. Intelligent agents also supervise the entire process and record previous experiences in a knowledge database.

The first phases are to be closely monitored by human experts so that to obtain a better quality for the ontology. Furthermore, these phrases require an increased level of human intervention. Phases four, five and six can be implemented in an automatic manner but the process is to be supervised by experts.

2.3 Semantic similarity algorithm

In order to group terms based on their semantic meaning and context, we use intelligent agents. Agents are trained and then continuously learn based on their previous experience. They query the WordNet database and try to group terms under specific synsets by analyzing the semantic relationships. Afterwards, when reiterating they add the terms and relationships in the ontology.

To measure the semantic similarity between two synsets, the most appropriate relations that are to be used are the semantic hierarchic ones such as hyponym/hypernym. By using this type of semantic relations, the "Least Common Subsumer" can be computed.

However, due to the limitation of "is-a" hierarchies, the algorithm only works with the same part of speech.

As it is stated by Liu et al. (2009), if we consider the set of more generic concepts directly linked to a given X concept of the same synset and a function that returns the parents of the given X. In case of single inheritance, the function always returns a single term, but for multiple inheritances, two distinct ancestor nodes may both be minimal upper bounds ("the least common sub summer"). Those two nodes might have very different values for information content, so Parents(X) can return more than one term (concept). In order to determine the similarity measurement function, we have to take into account the path between concepts.

$$Paths(X_A, X_B) = \{(X_1, \dots X_n) | (X_A = X_1) \wedge (X_B = X_n) \wedge (\forall i: (1 \leq i \leq n) \wedge (xi \in Parents(xi + 1))) \} \quad (1)$$

Where:

X_A - concept A

X_B - concept B

The set of Ancestors of a concept is represented by the elements that are linked by at least one path by the concept in question.

The information content is inversely proportional to its frequency in a dictionary (Liu et all. (2009)). The frequency of concept defines the number of times the concept and all its descendents occur. Starting from the frequency we can determine the probability of observing an instance of the concept:

$$P(X) = \frac{F(x)}{N} \quad (2)$$

Where:

F(x) = frequency of appearance for X concept

N = the total number of concepts in the synset

Based on this probability the information content (IC) of X concept can be determined:

$$IC(X) = -\log_2 (P(X)) \quad (3)$$

Where:

IC(X) = information content (IC) of X concept

F(x) = frequency of appearance of X concept

N = the total number of concepts in the synset

By using the "information content" we can compute the semantic similarity distance. The semantic similarity is related to the degree of shared information. The degree of shared information can be computed like this:

$$S(X_1,X_2) = \max\{IC(p) \mid p \in Subsumer(X_1,X_2)\} \quad (4)$$

Where:

$S(X_1, X_2)$ = the degree of shared information for X_1 and X_2 concepts

X_1, X_2 = concepts 1 and 2

In order to compute the semantic similarity there were many proposed formulas: Conrath, Lin, Resnik. In this algorithm Lin formula was chosen as it fully takes into account the information content:

$$Sim_{Lin}(X_1,X_2) = \frac{2*S(X_1,X_2)}{(IC(X_1)+IC(X_2))} \quad (5)$$

Where:

$Sim_{Lin}(X_1, X_2)$ = the level of similarity between concepts 1 and 2 computed by Lin formula

$S(X_1, X_2)$ = the degree of shared information for X_1 and X_2 concepts

X_1, X_2 = concepts 1 and 2

IC(X) = information content (IC) of X concept

3. Applying the Proposed Ontology in CSR Evaluation

In order to create a suitable ontology for classifying companies based on their social responsibility, we first crawled the websites of around 100 companies. We also took into consideration responsibility reports from several large British companies. The ontology was created and refined as presented in the methodology above.

Figure no. 3 presents the main classes from the first two levels of the proposed Company Social Responsibility Ontology. All classes are connected using "is-a" relations. Thus, the concepts become more particular as we move away from the root (the most general concept, called "Thing"). The ontology is extensible as new concepts can be added during the refinement stage.

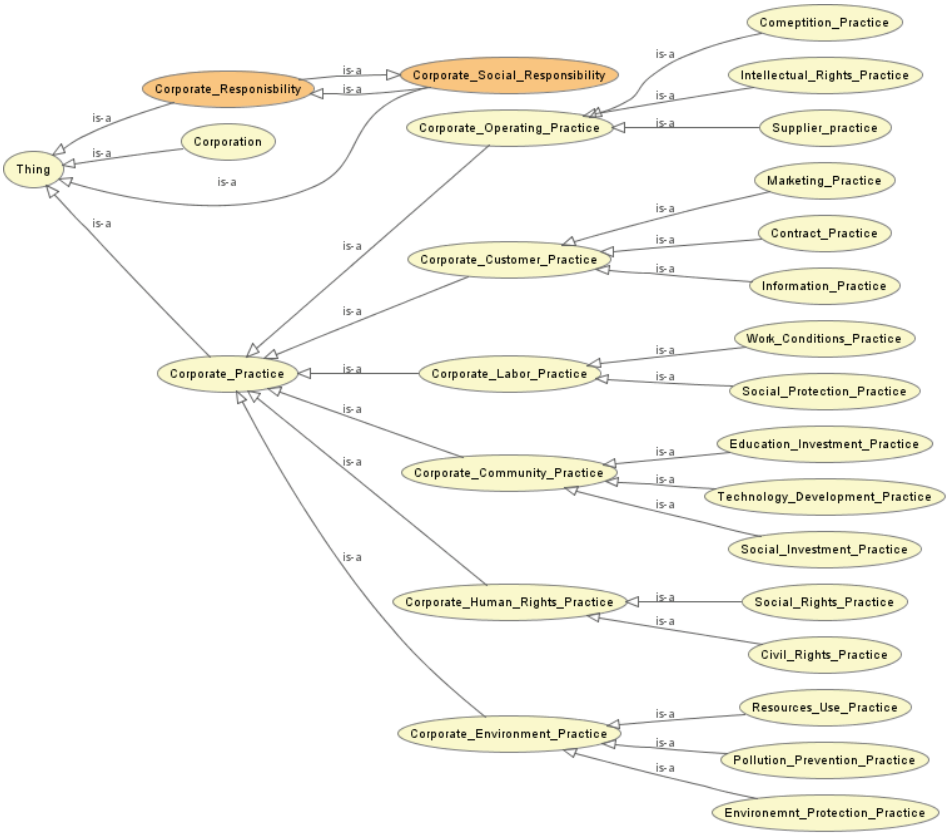

Figure no. 3: Main classes of the proposed CSR Ontology

The ontology is used when crawling new websites in order to find words that suggest the company's involvement in CSR. Different words can be associated to the same concept in the ontology, based on the semantic relationships in the context of social responsibility,

assuring at the same time the continuous development of the initial ontology. Moreover, taking into account that the concepts in the ontology are structured using inheritance relations we can look for a word on the company's website, and determine which are the corresponding concept, as well as the more general concepts to which it relates. Thus, starting from a particular word we can identify what general types of social responsibility practices are applied in a certain company. The general responsibility types are the ones derived directly from the "Corporate_Practice" concept.

In order to classify new companies into ones that apply or not social responsibility practices, we implemented a neural network module. Supervised training was applied in order to train the network and allow it to adjust the weights associated with the connections between the neurons. The input to neural network is represented by the social responsibility concepts that were found at previous iterations and that are already present in the ontology. For each concept a Boolean value is passed to show if the concept was found or not.

Based on the proposed ontology, opinion mining and sentiment analysis applications, capable of extracting explicit opinions from implicit texts available on blogs, forums and other online sources can be developed. Such applications not only identify the presence of certain concepts from the ontology, but can also extract opinions related to these concepts. A typical example is extracting from a text if a specific corporate social responsibility indicator had a positive or a negative evolution.

Being aware of the fact that in order to be effective in terms of CSR, companies need all firms in their own supply chain to act in a socially responsible manner, a model can be developed for determining which firms can become possible business partners for a company that is giving a high importance to CSR.

Conclusions

In this paper we present an approach based on ontologies and neural networks that is applied to determine if a company acts in a socially responsible way. Taking into account the vast amount of information available on the internet we propose a methodology for building a corporate responsibility ontology. The machine-interpretable ontology is then used to develop a neural network application that classifies companies based on their social responsibility.

Further developments include implementing opinion mining and sentiment analysis in order to extract explicit information from implicit texts like the ones found on blogs, forums and other online sources. In this manner, we will try to create a company profile as complete as possible from the company responsibility point of view.

Acknowledgement

This article is a result of the project „Doctoral Program and PhD Students in the education research and innovation triangle". This project is co-funded by the European Social Fund through The Sectorial Operational Programme for Human Resources Development 2007-2013, coordinated by The Bucharest Academy of Economic Studies (project no. 7832, "Doctoral Program and PhD Students in the education research and innovation triangle, DOCECI").

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