Capstone Project: Understanding 'Things' using Semantic Graph Classification

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Abstract. The abstract should summarize the contents of the paper and should contain at least 70 and at most 150 words. It should be written using the *abstract* environment.

Keywords: Ontology, Semantic Web, Graph Kernels, Graph Classification, Deep Learning

1 Definition

1.1 Project Overview

The world around us contains different types of things (e.g. people, places, objects, ideas, etc.). Predominantly, these things are defined by their attributes like shape, color, etc. These things are also defined by their relationships with other things. For example, Washington D.C. is a place and U.S.A is a country. But they have a relationship of Washington D.C. being the capital of U.S.A., which adds extra meaning to Washington D.C. This same role is played by Paris for France.

The Semantic Web is defined as "an extension of the current Web in which information is given well-defined meaning, better enabling computers and people to work in cooperation"[2]. It is an extention of the Knowledge Representation and Reasoning topic within Artificial Intelligence and deals with representing these things, their types, their attributes and their relationships using symbols and enabling the agent to reason about them. A common data structure used for the representation is graphs. In these semantic graphs the nodes, properties, and edges of graphs are very well suited to describe the things, their attributes, and their relationships of things in the domain. A few example domais where such graphs are used are:

- Linked Data - The web-scale semantic data graph that is part of the Semantic Web[4].
- Spoken systems - the output of Natural Language Processing is a parse tree [9].
- Social networks are graphs [1].

- Scene recognition - High level semantic information in images are graphs of arrangements of things can be a graph [9].
- Virtual & Augmented Reality environments can be represented as a semantic graphs [7].

Dataset: We use DBpedia[1] as an exemplary dataset as a starting point to study Semantic Graph Classification. DBpedia is a large-scale knowledge base extracted from Wikipedia[6]. It contains structured information extracted out of Wikipedia (e.g. page links, categories, infoboxes, etc.)[5]. The semantic data in DBpedia can be represented as a graph of nodes and edges. In this case, the nodes are *things* (i.e. entities) and the edges are links/relationships between the *things*. Each *thing* has one or more **types** & **categories** associated with it. The user community creating DBpedia maintains an Ontology[2] that specifies these types of each of the *things*.

We use the subset of DBpedia[3], which was generated from the March/April 2016 dump of Wikipedia. In this dataset, the *things*, their attributes and their relationships are extracted from the info-boxes (`infobox_properties_en.ttl`) using and the DBpedia Ontology (`dbpedia_2016-04.owl`). We also use the types associated with the *things*(`instance_types_en.ttl`) and the categories (`article_categories_en.ttl`) that they belong to.

Project Motivation: The project is motivated by our assumption that if an Agent is able to classify things by understanding its attributes and relationships into some types, we could in the future generalize it to an Agent that can act on the meaning of the things. Some examples applications for domains above are:

- Linked Data - Agents can understand and automatically assist users at web scale [2].
- Spoken systems - Understanding user intent by Virtual Assistants like Siri, Alexa, etc. for home automation [10].
- Predicting and Recommending links in Social Networks [1].
- Scene recognition - Urban scene understanding and its possible outdoor applications like understanding traffic, etc. [3].
- Virtural Assistants like Mara [8] in Virtual & Augmented Reality environments.

Our goal is to try and estimate the types and categories of the *things* from their attributes and relationships. For example, if you look at examples of categories in DBpedia, Achilies has been put into the categories - demigods, people of trojan war, characters in Illead, etc. What makes him part of those categories? Can we learn the definitions of these based on the attributes and relationships of Achilies?

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[1] http://wiki.dbpedia.org/

[2] An Ontology is defined as a formal specification of the types, properties, and relationships of the entities that exist for a particular domain. In other words, it is the schema definition of the semantic data.

[3] http://wiki.dbpedia.org/downloads-2016-04

Other Approaches:

1.2   Problem Statement

As mentioned earlier, the goal of this project is to apply Machine Learning to classify the *things* in DBpedia and identify their types and categories based on the semantic graph of their attributes andtheir relationships. To model this as a classification problem, we look at our algorithms available in Machine Learning. The classic algorithms in Machine Learning deal with feature vectors (e.g. the features used for classification, etc.) and are aimed at essentially discriminating between different inputs to those features to identify the target type/s.

Graph Classification:

Proposed Approach:

Expected Result:

2   Preprocessing

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