Integrating Linguistic and World Knowledge for Domain-Adaptable Natural Language Interfaces

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Abstract. Nowadays, natural language interfaces (NLIs) show strong demands on various smart devices from wearable devices, cell phones, televisions, to vehicles. Domain adaptation becomes one of the major challenging issues to support the applications on different domains. In this paper, we propose a framework of domain-adaptable NLIs to integrate linguistic knowledge and world knowledge. Given a knowledge base of a target domain and the function definition of a target smart device, the corresponding NLI system is developed under the framework. In the experiments, we demonstrate a Chinese NLI system for a video on demand (VOD) service.

Keywords: Domain Adaptation, Knowledge-Driven Approach, Knowledge Graph, Natural Language Interface.

1 Introduction

Smart devices like smartphones, tablets, smart televisions, and intelligent appliances are widely popular nowadays. The most attractive feature of avant-garde smart devices is natural language interface (NLI), which makes many services such as controlling the devices and accessing the knowledge bases with natural languages feasible.

Constructing an NLI for a specific domain is a challenging task because the domain dependent linguistic knowledge and world knowledge have to be considered. For example, the entities used in an NLI to a traffic information system on a GPS client and in an NLI to a music on demand service on a cellphone are different. Besides, the terms to express the needs and the actions triggered by the terms to meet the needs for the two types of services are also different. Thus, how to adapt a system from one application domain to another is an important and urgent task.

This paper presents a framework for constructing domain-adaptable NLI systems. Section 2 examines the domain dependent issues in a framework of NLI to a knowledge base. Section 3 demonstrates a Chinese NLI system for a video on demand (VOD) service to show the feasibility of the methodology.

E. Métais, M. Roche, and M. Teisseire (Eds.): NLDB 2014, LNCS 8455, pp. 237–241, 2014.

2 Domain-Dependent Issues in NLI Systems

Assume the intent of a user in an NLI to a VOD service is to watch the movie "Romeo + Juliet", in which Leonardo DiCaprio acts the role Romeo. The user may submit a query like "I want to see Leonardo as Romeo". There are two entities in this query, i.e., the name of an actor (i.e., Leonardo) and the name of his role (i.e., Romeo) in a movie. The NLI system takes the following steps for this query: (1) to analyze the user's intent, (2) to check if there are any programs satisfying the need, (3) to identify which channel plays the program, and (4) to move to this channel.

To achieve the goal, the NL query is sent to a query processing module, where a query is segmented into a sequence of words, each word is labelled with a part-of-speech tag, and a dependency tree is generated for the query. The retrieval module tries to find the relevant information from the domain-specific knowledge base according to the analysis results. If the user intent is completely specified in the query, the corresponding action frame is triggered by the smart device. Otherwise, the human-device interaction is initiated to accumulate enough information.

In the above process, both linguistic knowledge and world knowledge are indispensable. Fundamental query processing needs the supports of linguistic knowledge from different levels. Entities, their properties, and relationships among entities are interesting targets to users. The domain-specific world knowledge, which is different from one domain to another, is created anytime and anywhere. The dynamic property makes linguistic analysis challenging.

To deal with this domain adaptation issue, knowledge in different domains can be formulated as a universal representation. With a uniform scheme, we can define common operations for all the domains. The concept of knowledge graph (KG) [1] is adopted. Entities are not only fundamental things in a KG, but also fundamental units in linguistic analysis. They serve as bridges between semantics and knowledge. Functions of smart devices are also domain dependent. Query term in a query implicitly triggers some function of a device. For example, the query term "see" requests an implicit action "move to a channel". Which query terms act as actions and how to map query terms into actions of devices should be defined for domain adaptation.

Furthermore, words unique to a specific domain will affect the performance of segmentation, part of speech tagging, and dependency parsing. Those domain-specific words are out-of-vocabulary (OOV) relative to a generic lexicon. Word forms and their POS are often adopted as features for a dependency parser. OOV words will affect the parsing results, and thus the subsequent retrieval performance. We adopt the knowledge-driven approach to collect domain-specific words from KG to decrease OOV problems. Besides, POS-based and word-rephrasing strategies proposed in our previous work [2] are explored to adapt a dependency parser.

3 An NLI System for a VOD Service

A Chinese NLI system for a VOD service is taken as an example. We will deal with the domain dependent issues discussed in the above in the following subsections.

3.1 Knowledge Base

The target domain data in the VOD service contain TV channels, news, movies, music, and other multimedia items. These items can be ordered and played on users' televisions. In addition, the metadata include the cast and crew of a movie, the singer of a song, the presenter of a television program, and so on. All the topics are the vertices in the KG, and the properties are the edges denoting the relations between topics. Fig. 1 shows the type of the topic "*The Dark Knight*" is *Movie*, and the associated topics including actors, directors, genres, subjects, released, and alias are the properties of this topic.

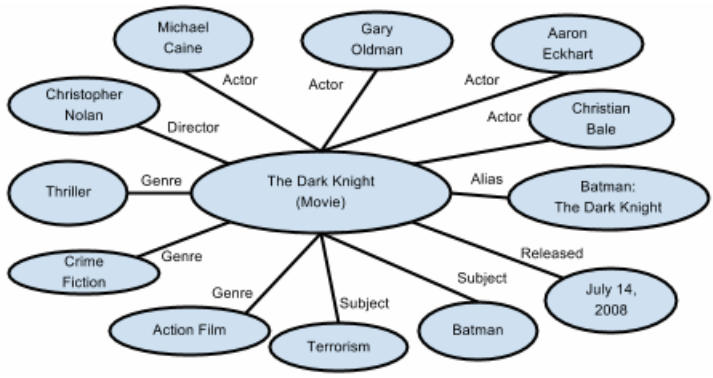

Fig. 1. The Movie "The Dark Knight" represented in a Knowledge Graph

3.2 Linguistic Analysis

In the experimental domain, the NLI should handle a lot of domain-specific named entities (NEs) like movie titles and actor names. Most of the NEs are created dynamically and are OOV terms in linguistic analysis. We integrate a named entity recognizer (NER) with Chinese word segmentation and part-of-speech tagging. The NE lexicon referred by the NER is derived from the KG for the specific domain. The NEs are not directly determined by the dictionary-based NER, but extracted from the decision of a learning-based segmenter.

Dependency parser determines the structure of a user query and labels the relations between the tokens. Fig. 2 shows the dependency tree of a Chinese query "我想看昨天的棒球經典賽" (I want to watch yesterday's World Baseball Classics). Dependency parser helps identify the core verb "watch" and the target entity "World Baseball Classics" in a query. We train a Chinese dependency parser with ZPar [3],

an implementation of the transition-based dependency parser. OOVs have been segmented and tagged with the tag NR (proper noun) in the earlier steps. Referring to the KG, a sentence rephrasing approach [2] replaces an OOV word in a sentence with the thing of the same NE type in the training set, e.g., “baseball game”, so that the knowledge of the word form can be used for parsing.

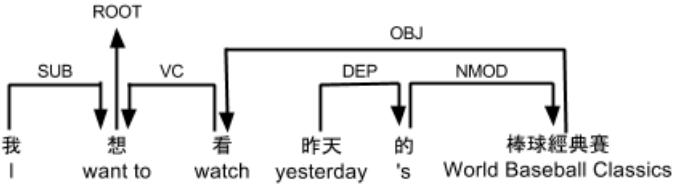

Fig. 2. A Dependency Tree of the Query “我想看昨天的棒球經典賽”

3.3 Action Frames

The action frames describe the functions of the target smart device. In the demonstration, the smart device is the controller of the VOD service attached to user’s television. The functions of controllers include changing the TV channel, playing a movie or a song on demand, reporting the weather, and so on. One of the challenging issues is how users express their intents in this domain. Mining terms from users’ query logs may be a solution, but logs are not always available before developing an NLI for a specific domain. Knowledge-driven approach is adopted to deal with this problem. Because entities, properties, and relationships in the KG are targets for retrieval, we consult external corpora to extract their collocated words, in particular, verbs. For example, “Romeo + Juliet”, which is an entity in the KG, is a movie. The words such as “see” and “watch” are collocated with “movie” frequently, thus they are included in the intent list. Referring to the Chinese proposition bank (LDC2013T13), the verbs and their frame elements are collected, and mapped into actions for the smart device.

4 Conclusion

A knowledge-driven approach integrates linguistic knowledge and world knowledge for domain adaptation. Entities and their relationships in real world, which are usually domain-specific, serve as the complementary knowledge for linguistic analysis. Knowledge for the OOV words and the potential intents are extracted. A Chinese NLI application on a VOD service demonstrates the feasibility of the framework.

Acknowledgments. This research was partially supported by National Science Council, Taiwan under NSC101-2221-E-002-195-MY3 and 102-2221-E-002-103-MY3.

References

1. Singhal, A.: Introducing the Knowledge Graph: things, not strings. Official Google Blog (May 2012), http://googleblog.blogspot.com/2012/05/introducing-knowledge-graph-things-not.html
2. Huang, H.H., Chen, H.Y., Yu, C.S., Chen, H.H., Lee, P.C., Chen, C.H.: Sentence Rephrasing for Parsing Sentences with OOV Words. In: The 9th International Conference on Language Resources and Evaluation (LREC 2014), Reykjavik, Iceland (2014)
3. Zhang, Y., Clark, S.: Syntactic Processing Using the Generalized Perceptron and Beam Search. Computational Linguistics 37(1), 105–151 (2011)