# 論 文 内 容 の 要 旨

博士論文題 Neural Network Approaches to Coordination Disambiguation
（ニューラルネットワークによる並列構造解析）

氏　　名　寺西　裕紀

（論文内容の要旨）

Coordination is a syntactic phenomenon in which two or more elements, known as conjuncts, are linked together typically by a coordinating conjunction. Coordinate structures frequently occur in natural language and are the major source of ambiguities which cannot be resolved easily even by humans. Coordination has puzzled linguists for decades because it imposes a number of exceptions on theories of syntax such as phrase structure grammar. Due to its intractability, many natural language processing (NLP) applications, such as syntactic parsing, named entity recognition, and machine translation, suffer from the presence of coordination. Recent advances of deep artificial neural networks have greatly improved the performance on many NLP tasks. However, coordination is a still difficult problem to be taken into account.

This research focuses on identifying the conjuncts of coordinate structures, especially in English text. Two methods are investigated for the task: (1) a *top-down approach* and (2) a *bottom-up approach*, both of which utilize deep neural networks.

The top-down approach first identifies a coordinate structure and then retrieves the individual conjuncts from it. In this approach, the similarity and replaceability properties of conjuncts are exploited. For instance, “The company provides [language instruction] and [translation services] in 25 countries” has symmetry between the two conjuncts and can be said that “The company provides [translation services] and [language instruction] in 25 countries.” The proposed neural networks incorporate those characteristics of conjuncts as features without external thesauri, language models, or syntactic parsers, which are used in most previous researches. The lightweight model enables the system to examine all possible coordination spans. Although this approach outperforms existing methods, detail analysis reveals that the system is not good at finding conjuncts in coordination.

The bottom-up approach, in contrast, first finds individual conjuncts and then constructs a coordinate structure from them. In this approach, coordinate structures for a given sentence are identified in the form of a syntactic tree, which is produced by a context-free grammar designed for recognizing coordination. This ensures that any two of the coordinate structures are disjoint or nested and thus never conflict each other. The neural network model consists of submodels, each of which is specialized in capturing different parts of coordinate structures. Using the models in the process of the CKY algorithm, the system efficiently produces coordinate structures as a tree with great accuracy.

The main contribution of this research is to demonstrate the effective frameworks of neural networks and algorithms for coordination disambiguation. Experimental results show that the proposed methods achieve state-of-the-art results with no dependence on external resources, ensuring that the global structure of coordination is consistent.

| 氏　名 | 寺西　裕紀 |
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（論文審査結果の要旨）

Coordination is a syntactic phenomenon in which two or more elements, known as conjuncts, are linked together typically by a coordinating conjunction. Coordinate structures frequently occur in natural language and are the major source of ambiguities. The research in this thesis focuses on identifying the conjuncts of coordinate structures in English text. Two neural network modeling approaches are investigated: (1) a *top-down approach* and (2) a *bottom-up approach*.

The top-down approach first identifies a coordinate structure and then retrieves the individual conjuncts from it. The proposed neural networks incorporate the similarity and replaceability properties of conjuncts as features without external thesauri, language models, or syntactic parsers, and examine all possible coordination spans. Although this approach outperforms existing methods, detail analysis reveals that the system is not good at finding conjuncts in coordination, and thus, an alternative approach is investigated.

The bottom-up approach, in contrast, first finds conjuncts and then constructs a coordinate structure from them. In this approach, coordinate structures for a given sentence are identified in the form of a syntactic tree, which is produced by a context-free grammar especially designed for coordination. The neural network model consists of sub-models, each of which is specialized in capturing different aspects of coordinate structures. Using the models with the CKY algorithm, the system efficiently produces coordinate structures.

The proposed methods achieve the state-of-the-art results without exploiting additional resources by simple yet effective methods to extract feature representations from neural networks and by efficiently combining those representations to score coordination candidates with sophisticated algorithms. Manual evaluations also reveal the improved performance for complex coordination structures, which are difficult even for well-trained linguists. The task is very important and would have large influence to downstream tasks, such as named entity recognition or syntactic parsing. The research in this thesis is published in two high quality peer-reviewed journal papers and two peer-reviewed international conference papers, and would have an impact to spur further researches in this field. As a result, the thesis is sufficiently qualified as a Doctoral thesis of Engineering.