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Natural Language Generation using Dependency Tree Decoding for Spoken Dialog Systems

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ABSTRACT In this paper, we propose a new natural language generation method for spoken dialog systems and demonstrate its capacity. Studies on natural language generation often employ sequence decoding, which generates the words comprising a sentence in sequential order and uses the input generated by each word in the previous step. In contrast, we propose a decoding method that employs a sequence generated by traversing a dependency tree with feed input to a pair consisting of a parent and sibling in the dependency tree. As a result, the most important words are generated first, thereby enabling words with greater relevance to be fed into the process. At prediction time, our model generates dependency trees and converts the trees into sentences. The proposed decoding method was evaluated by re-implementing a semantically controlled Long Short-Term Memory (SC-LSTM) structure for natural language generation, and the input and predicted sequence were converted to allow dependency tree decoding. The experimental results indicated that our suggested approach, i.e., dependency tree decoding, dramatically elevates the BLEU-score and naturalness. Furthermore, when creating sentences with n-best using dependency tree decoding, the word-diversity of the output sentences was increased by approximately 6%, offering a more diverse sentence pattern.

INDEX TERMS Machine learning, Multi-layer neural network, human computer interaction, natural language processing, dependency parsing, spoken dialog system

I. INTRODUCTION

The spoken dialog system (SDS) is a computer system that was designed to converse with users using speech and natural language, and plays a crucial role in human-machine interaction. As shown in Fig. 1, SDS is generally composed of automatic speech recognition (ASR), natural language understanding (NLU), dialog management (DM), natural language generation (NLG), and text-to-speech synthesis (TTS) [1][2]. NLG in SDS components generates natural language sentences that correspond to structured semantic representations. The semantic expression includes the intention and the information an SDS intends to convey. Thus, effective NLG dramatically improves the usability of human-machine interaction.

In recent years, various deep neural network (DNN) technologies have been applied to natural language processing tasks. Specifically, the recurrent neural network

(RNN) has demonstrated unequivocal advantages in tasks such as machine translation [3][4], image captioning [5][6], video captioning [7][8][9], video action recognition [10][11], video retrieval [12], information extraction [13][14], and NLG [15][16]. Among these applications, NLG is a particularly challenging task in an SDS. In this scenario, RNN-based approaches have not yet replaced the template-based approach because they do not provide stable performance. Template-based NLG provides reliable performance and is conceptually intuitive [17]. However, template-based NLG requires the construction of templates for each type of dialog act the dialog manager could potentially return as output. Furthermore, responses obtained from template-based NLG are constrained to the same type of dialog act as the input, which can be tedious for an SDS user. We suggest that the adaptation of DNN-based NLG to

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