論 文 内 容 の 要 旨

博士論文題目　Learning and adaptation of end-to-end multimodal dialog management
（エンドツーエンドマルチモーダル対話制御の学習と適応）

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（論文内容の要旨）

Goal-oriented dialog system is gaining a lot of attention from the machine learning research community recently, due to its practical application to various tasks. In the work flow of a dialog system with a user, the management process is of utmost importance. This is because the dialog management process directly governs the system's behavior, which decides whether the system successfully achieves its goal or not. In many tasks, non-verbal information from different modalities is essential for the success of the system. As a result, there are multiple studies attempted to incorporate this multimodal information into the dialog management.

However, the current studies mostly follow the modular-based approach when creating multimodal dialog systems, with additional components to process the multimodal features are needed. These components are usually built for a specific task and cannot be reused in a different dialog system. Thus, systems built using the modular-based approach are difficult to be overhauled and adapted to new tasks. In this research, I study the application of end-to-end approach using neural networks for dialog management of multimodal goal-oriented systems. There are a vast number of challenges in this topic, my research tackles the following problems:

- **Multimodal information fusion:** In many tasks, handling of multimodal information is important to achieve success. However, existing works in multimodal dialog management only use simple concatenation of input features as the fusion method, which is inefficient, leading to undesired performance. There are two main challenges when considering the multimodal fusion problem: abstraction level of the input modalities and features interactions. In this research, I propose a neural network-based

fusion method for combining features of multimodal input, which is termed **Hierarchical Tensor Fusion Network**. This method can be viewed as a combination of two existing fusion methods of multi-modal features, hierarchical fusion, and tensor fusion. Experimental results show that the proposed hierarchical tensor fusion network outperforms existing fusion methods in terms of accuracy in the deception detection task.

- **Data sparsity**: A popular approach for dialog management is the reinforcement learning (RL) framework, in order to learn a dialog policy that governs the system's action selection procedure. However, the amount of samples needed to learn an optimal solution is usually prohibitive, especially in the case of multimodal dialog tasks, where data sparsity is a huge challenge. In such a situation, policy adaptation is an effective solution, since it allows us to take advantage of knowledge from learning a policy in an existing task (the source task) to improve the training of the policy in a new task (the target task). Current works in policy adaptation for dialog management use a "weight initialization" strategy, which requires RL training of the target policy. While this method is shown to be effective, the adaptation process is time-consuming and the learned policy can still have inferior performance due to the small amount of data available. In this paper, I propose a novel approach for dialog policy adaptation that does not require training by reinforcement learning on the target task, which is termed **Dialog Policy Reuse Algorithm - DPRA**. Experiments show that DPRA requires much shorter time for training, and the learned policy achieves superior performance in comparison to polices trained by existing method in the case where the target task's dataset is limited.

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（論文審査結果の要旨）

In goal-oriented dialog system, the management process is of utmost importance. This is because the dialog management process directly governs the system's behavior. In many tasks, non-verbal information from different modalities is essential for the success of the system. In this research, he studies the application of end-to-end approach using neural networks for dialog management of multimodal goal-oriented systems. The thesis studied the following two problems.

Multimodal information fusion: There are two main challenges when considering the multimodal fusion problem: abstraction level of the input modalities and features interactions. In this research, a neural network-based fusion method is proposed for combining features of multimodal input, which is termed **Hierarchical Tensor Fusion Network**. This method can be viewed as a combination of two existing fusion methods of multi-modal features, hierarchical fusion, and tensor fusion.

Data sparsity: A popular approach for dialog management is the reinforcement learning (RL) framework, in order to learn a dialog policy that governs the system's action selection procedure. However, the amount of samples needed to learn an optimal solution is usually prohibitive, especially in the case of multimodal dialog tasks, where data sparsity is a huge challenge. In such a situation, policy adaptation is an effective solution. In this paper, a novel approach is proposed for dialog policy adaptation that does not require training by reinforcement learning on the target task, which is termed **Dialog Policy Reuse Algorithm - DPRA**. Experiments show that DPRA requires much shorter time for training, and the learned policy achieves superior performance in comparison to polices trained by existing method.

Multimodal fusion and dialogue policy adaptation are challenging tasks and inevitable technologies in real systems. This thesis research proposed solutions to these problems, and a series of his research resulted in two high quality peer-reviewed journal papers, two peer-reviewed international conference papers, and one domestic conference paper. As a result, the thesis is sufficiently qualified as a Doctoral thesis of Engineering.