

# A Survey on Learning-Based Approaches for Modeling and Classification of Human–Machine Dialog Systems

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**Abstract**—With the rapid development from traditional machine learning (ML) to deep learning (DL) and reinforcement learning (RL), dialog system equipped with learning mechanism has become the most effective solution to address human–machine interaction problems. The purpose of this article is to provide a comprehensive survey on learning-based human–machine dialog systems with a focus on the various dialog models. More specifically, we first introduce the fundamental process of establishing a dialog model. Second, we examine the features and classifications of the system dialog model, expound some representative models, and also compare the advantages and disadvantages of different dialog models. Third, we comb the commonly used database and evaluation metrics of the dialog model. Furthermore, the evaluation metrics of these dialog models are analyzed in detail. Finally, we briefly analyze the existing issues and point out the potential future direction on the human–machine dialog systems.

**Index Terms**—Artificial intelligence (AI), deep learning (DL), dialog model, machine learning (ML), reinforcement learning (RL), sequence to sequence (Seq2Seq) model.

## I. INTRODUCTION

ONE of the original research purposes of the human–machine dialog system is to pass the Turing test. And human beings have been studying dialog systems for half a century. Early dialog systems were based on artificial rules, such as Eliza (1966) [1], Parry (1975) [2] which passed the Turing test, and Alice (2009) [3] which won the Loebprize three times recently. Although the rule-based dialog system has achieved good results, the establishment of rules is laborious, and its transferability is poor. Most importantly, many rules eventually lead to the software system either too costly or seldom practical.

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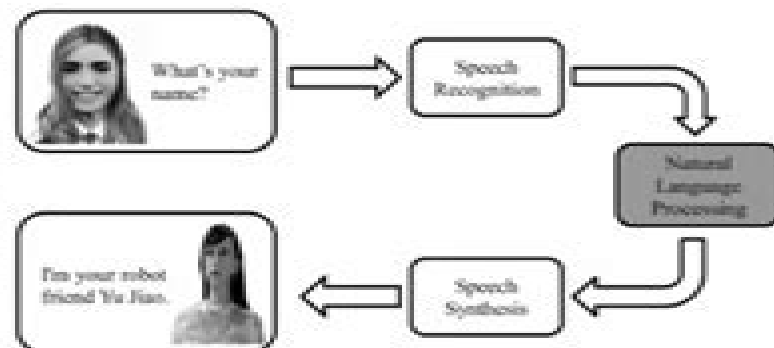


Fig. 1. Composition of dialog system.

With the development of speech recognition [4]–[6], speech synthesis [7], [8], natural language processing [9], [10], and information retrieval (IR) [11], [12], especially deep learning (DL) [13]–[15] and reinforcement learning (RL) [54], some data-driven-based models that use DL or RL have been proposed, such as IR models, generation models, RL models, and hybrid models. And so far, many human–machine dialog products have emerged, such as Cortana and Microsoft Xiaobing in 2014, Baidu Duer and Ali Xiaomi in 2015, Apple Siri and Google Assistant in 2016, Tencent tinkling in 2017 and so on. Although the existing dialog system can communicate with human beings in some occasions, the system itself is not intelligent enough, calling for the implementation of much strong artificial intelligence (AI). Therefore, it is crucial to carry out extensive research on the dialog system, which makes it necessary to have a general grasp of the current research situation of the dialog system.

The dialog system is generally composed of speech recognition, natural language processing, speech synthesis (early template-based dialog model without speech recognition and speech synthesis module), as conceptually shown in Fig. 1, where the function of the speech recognition module is to convert human speech signal into text signal for the natural language understanding module. Next, the natural language

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