

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

Fuwei Cui, Qian Cui, and Yongduan Song[✉], *Fellow, IEEE*

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.

Manuscript received July 27, 2019; revised January 18, 2020 and March 5, 2020; accepted March 28, 2020. Date of publication April 27, 2020; date of current version April 5, 2021. This work was supported by the National Natural Science Foundation of China under Grant 61803053, Grant 61833013, Grant 61860206008, and Grant 61773081. (Corresponding author: Yongduan Song.)

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Digital Object Identifier 10.1109/TNNLS.2020.2985588

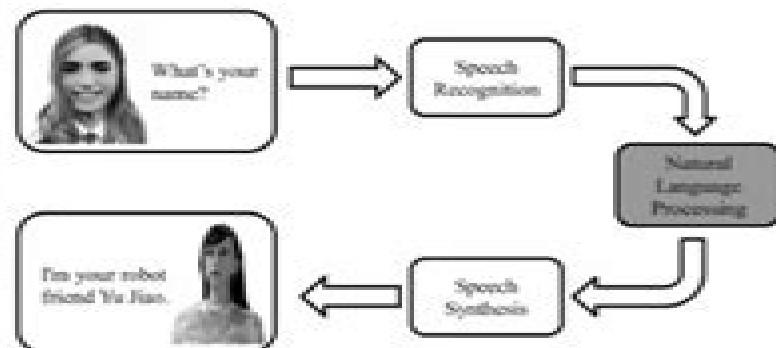


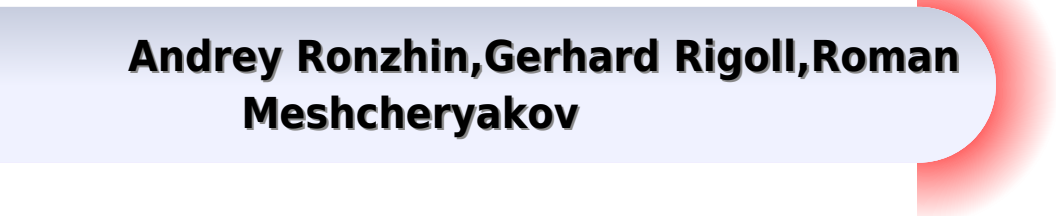
Fig. 1. Composition of dialog system.

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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researchers and developers from industry and academia alike met to discuss and compare their implementation experiences analyses and empirical findings Text, Speech and Dialogue Petr Sojka,Aleš Horak,Ivan Kopeček,Karel Pala,2010-08-30 This book constitutes the refereed proceedings of the 13th International Conference on Text Speech and Dialogue TSD 2010 held in Brno Czech Republic September 2010 The 71 revised full papers presented together with 3 invited papers were carefully reviewed and selected from 144 submissions The topics of the conference include but are not limited to text corpora and tagging transcription problems in spoken corpora sense disambiguation links between text and speech oriented systems parsing issues multi lingual issues information retrieval and information extraction text topic summarization machine translation semantic web speech modeling speech recognition search in speech for IR and IE text to speech synthesis emotions and personality modeling user modeling knowledge representation in relation to dialogue systems assistive technologies based on speech and dialogue applied systems and software facial animation as well as visual speech synthesis

Advances in Commercial Deployment of Spoken Dialog Systems David Suendermann,2011-06-04 Advances in Commercial Deployment of Spoken Dialog Systems covers the peculiarities of commercial deployments of spoken dialog systems from the tools standards and design principles to build them the infrastructure to deploy them techniques to monitor evaluate and analyze them and most importantly effective strategies to adapt tune and optimize them The book shows to what extent academic spoken dialog system research converges with real world applications This academic and practical synergy can be leveraged to build successful and robust spoken dialog applications that are useful when dealing with the dynamics of the ever changing future user *Quality of Telephone-Based Spoken Dialogue Systems* Sebastian Möller,2005-12-28 Quality of Telephone Based Spoken Dialogue Systems is a systematic overview of assessment evaluation and prediction methods for the quality of services such as travel and touristic information phone directory and messaging or telephone banking services A new taxonomy of quality of service is presented which serves as a tool for classifying assessment and evaluation methods for planning and interpreting evaluation experiments and for estimating quality A broad overview of parameters and evaluation methods is given both on a system component level and for a fully integrated system Three experimental investigations illustrate the relationships between system characteristics and perceived quality The resulting information is needed in all phases of system specification design implementation and operation Although Quality of Telephone Based Spoken Dialogue Systems is written from the perspective of an engineer in telecommunications it is an invaluable source of information for professionals in signal processing communication acoustics computational linguistics speech and language sciences human factor design and ergonomics **Interactive Collaborative Robotics** Andrey Ronzhin,Gerhard Rigoll,Roman Meshcheryakov,2016-08-15 This book constitutes the proceedings of the First International Conference on Interactive Collaborative Robotics ICR 2016 held in Budapest Hungary in August 2016 The 29 papers presented in this volume were carefully reviewed and selected from 48 submissions **Designing Interactive Speech Systems** Niels O. Bernsen,Hans

Dybkjaer,Laila Dybkjaer,2012-12-06 Designing Interactive Speech Systems describes the design and implementation of spoken language dialogue within the context of SLDS spoken language dialogue systems development Using an applications oriented SLDS developed through the Danish Dialogue project the authors describe the complete process involved in designing such a system and in doing so present several innovative practical tools such as dialogue design guideline s in depth evaluation methodologies and speech functionality analysis The approach taken is firmly applications oriented describing the results of research applicable to industry and showing how the development of advanced applications drives research rather than the other way around All those working on the research and development of spoken language services especially in the area of telecommunications will benefit from reading this book

Dialogue Processing in Spoken Language Systems Elisabeth Meier,Marion Mast,Susann Luperfoy,1997-06-11 This book constitutes the strictly refereed post workshop documentation of the ECAI 96 Workshop on Dialogue Processing in Spoken Language Systems held in Budapest Hungary in August 1996 during ECAI 96 The volume presents 16 revised full papers including a detailed introduction and survey paper by the volume editors The papers are organized in sections on foundations of spoken language dialogue systems dialogue systems and prosodic aspects of spoken dialogue processing spoken dialogue systems design and implementation and evaluation of systems The book reports on work being pursued both in academia and in industry as a crucial issue in speech processing

Building Dialogue POMDPs from Expert Dialogues Hamidreza Chinaei,Brahim Chaib-draa,2016-02-08 This book discusses the Partially Observable Markov Decision Process POMDP framework applied in dialogue systems It presents POMDP as a formal framework to represent uncertainty explicitly while supporting automated policy solving The authors propose and implement an end to end learning approach for dialogue POMDP model components Starting from scratch they present the state the transition model the observation model and then finally the reward model from unannotated and noisy dialogues These altogether form a significant set of contributions that can potentially inspire substantial further work This concise manuscript is written in a simple language full of illustrative examples figures and tables

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