

# Bibliography for Tutorial on Statistical Approaches to Spoken Dialogue Systems

Jason Williams, Blaise Thomson, and Steve Young

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## 1 Algorithmic foundations

### 1.1 Reference and overview texts

#### References

- [1] AR Cassandra, LP Kaelbling, and ML Littman. Acting optimally in partially observable stochastic domains. In *Proc Conf on Artificial Intelligence, (AAAI), Seattle*, 1994.
- [2] F Jensen. *Bayesian networks and decision graphs*. Springer Verlag, 2001.
- [3] L Kaelbling, ML Littman, and AR Cassandra. Planning and acting in partially observable stochastic domains. *Artificial Intelligence*, 101:99–134, 1998.
- [4] J Pearl. *Probabilistic Reasoning in Intelligent Systems*. Morgan Kaufmann Publishers, 1998.
- [5] ML Puterman. *Markov Decision Processes*. John Wiley and Sons, 1994.
- [6] R Sutton and A Barto. *Reinforcement Learning: an Introduction*. MIT Press, 1998.
- [7] SJ Young. Probabilistic methods in spoken dialogue systems. *Philosophical Trans of the Royal Society (Series A)*, 1769(358):1389–1402, 2000.

### 1.2 Important algorithms and recent work

#### References

- [1] J Hoey and P Poupart. Solving POMDPs with continuous or large observation spaces. In *Proc Intl Joint Conf on Artificial Intelligence (IJCAI), Edinburgh, Scotland*, pages 25–34, 2005.

- [2] Michail G. Lagoudakis and Ronald Parr. Least-squares policy iteration. *Journal of Machine Learning Research*, 4:1107–1149, 2003.
- [3] J Peters, S Vijayakumar, and S Schaal. Natural actor-critic. In *Proc ECML, Porto, Portugal*, pages 280–291, 2005.
- [4] J Pineau, G Gordon, and S Thrun. Point-based value iteration: an anytime algorithm for POMDPs. In *Proc Intl Joint Conf on Artificial Intelligence (IJCAI), Acapulco, Mexico*, pages 1025–1032, 2003.
- [5] D Shapiro and P Langley. Separating skills from preference: using learning to program by reward. In *Proc Intl Conf on Machine Learning (ICML), Sydney, Australia*, 2002.
- [6] H. S. Sim, K. Kim, and J. Kim. Symbolic heuristic search value iteration for factored POMDPs. In *Proceedings of AAAI*, 2008.
- [7] MTJ Spaan and N Vlassis. Perseus: randomized point-based value iteration for POMDPs. *Journal of Artificial Intelligence Research*, 24:195–220, 2005.

### 1.3 Historical development

#### References

- [1] KJ Astrom. Optimal control of markov decision processes with incomplete state estimation. *Journal of Mathematical Analysis and Applications*, 10:174–205, 1965.
- [2] AR Cassandra. “solve-pomdp” software package. As of January, 2006.
- [3] A Drake. *Observation of a Markov process through a noisy channel*. PhD thesis, Massachusetts Institute of Technology, 1962.
- [4] EA Hansen. Solving POMDPs by searching in policy space. In *Proc Conf on Uncertainty in Artificial Intelligence (UAI), Madison, Wisconsin*, 1998.
- [5] GE Monahan. A survey of partially observable Markov decision processes: Theory, models, and algorithms. *Management Science*, 28(1):1–16, 1982.
- [6] K Murphy. A survey of POMDP solution techniques. Technical report, U. C. Berkeley, 2000.
- [7] K Sawaki and A Ichikawa. Optimal control for partially observable Markov decision processes over an infinite horizon. *Journal of the Operations Research Society of Japan*, 21(1):1–14, 1978.
- [8] RD Smallwood and EJ Sondik. The optimal control of partially observable markov processes over a finite horizon. *Operations Research*, 21:1071–1088, 1973.

- [9] EJ Sondik. *The optimal control of partially observable Markov decision processes*. PhD thesis, Stanford University, 1971.
- [10] EJ Sondik. The optimal control of partially observable Markov processes over the infinite horizon: Discounted costs. *Operations Research*, 26(2):282–304, 1978.
- [11] CJCH Watkins. *Learning from delayed rewards*. PhD thesis, Cambridge University, 1989.
- [12] CC White and D Harrington. Application of Jensen’s inequality for adaptive suboptimal design. *Journal of Optimization Theory and Applications*, 32(1):89–99, 1980.

## 2 Tracking multiple dialogue states

### 2.1 Exact updating

#### References

- [1] E Horvitz and T Paek. A computational architecture for conversation. In *Proc 7th International Conference on User Modeling (UM), Banff, Canada*, pages 201–210, 1999.
- [2] E Horvitz and T Paek. DeepListener: Harnessing expected utility to guide clarification dialog in spoken language systems. In *Proc Intl Conf on Spoken Language Processing (ICSLP), Beijing*, pages 226–229, 2000.
- [3] Cheongjae Lee and Gary Geunbae Lee. Robust dialog management with n-best hypotheses using dialog example and agenda. In *Proc Association for Computational Linguistics Human Language Technologies (ACL-HLT), Columbus, Ohio*, 2008.
- [4] T Paek and E Horvitz. Uncertainty, utility, and misunderstanding: A decision-theoretic perspective on grounding in conversational systems. In *AAAI Fall Symposium on Psychological Models of Communication, North Falmouth, MA, USA*, pages 85–92, 1999.
- [5] T Paek and E Horvitz. Uncertainty, utility, and misunderstanding: A decision-theoretic perspective on grounding in conversational systems. In *Proc AAAI Fall Symposium on Psychological Models of Communication in Collaborative Systems, North Falmouth, Massachusetts, USA*, 1999.
- [6] T Paek and E Horvitz. Conversation as action under uncertainty. In *Proc Conf on Uncertainty in Artificial Intelligence (UAI), Stanford, California*, pages 455–464, 2000.
- [7] T Paek and E Horvitz. Grounding criterion: Toward a formal theory of grounding. Technical Report MSR-TR-2000-40, Microsoft Research, 2000.

- [8] T Paek, E Horvitz, and E Ringger. Continuous listening for unconstrained spoken dialog. In *Proc Intl Conf on Spoken Language Processing (ICSLP)*, Beijing, 2000.
- [9] Jason D Williams. Demonstration of a POMDP voice dialer. In *Proc Demonstration Session of Association for Computational Linguistics Human Language Technologies (ACL-HLT)*, Columbus, Ohio, 2008.
- [10] Jason D Williams and Steve Young. Partially observable Markov decision processes for spoken dialog systems. *Computer Speech and Language*, 21(2):393–422, 2007.
- [11] JD Williams. *Partially Observable Markov Decision Processes for Spoken Dialogue Management*. PhD thesis, Cambridge University, 2006.
- [12] JD Williams, P Poupart, and SJ Young. Partially observable Markov decision processes with continuous observations for dialogue management. In *Proc SIGdial Workshop on Discourse and Dialogue*, Lisbon, Portugal, 2005.
- [13] JD Williams and SJ Young. Scaling POMDPs for spoken dialog management. *IEEE Trans. on Audio, Speech, and Language Processing*, 15(7):2116–2129, 2007.

## 2.2 Network based approximations

### References

- [1] TH Bui. *Toward Affective Dialogue Management using Partially Observable Markov Decision Processes*. PhD thesis, University of Twente, 2008.
- [2] TH Bui, M Poel, A Nijholt, and J Zwiers. A POMDP approach to affective dialogue modeling. In *Proceedings workshop on The Fundamentals of Verbal and Non-verbal Communication and the Biometrical Issue*, Amsterdam, pages 349–355, 2007.
- [3] TH Bui, M Poel, A Nijholt, and J Zwiers. A tractable DDN-POMDP approach to affective dialogue modeling for general probabilistic frame-based dialogue systems. In *Proc Workshop on Knowledge and Reasoning in Practical Dialogue Systems, Intl Joint Conf on Artificial Intelligence (IJCAI)*, Hyderabad, India, pages 34–37, 2007.
- [4] TH Bui, M Poel, A Nijholt, and J Zwiers. A tractable hybrid DDN-POMDP approach to affective dialogue modeling for probabilistic frame-based dialogue systems. In *Proceedings of the 20th Belgian-Netherlands Conference on Artificial Intelligence*, Enschede, The Netherlands, October 2008.
- [5] TH Bui, M Poel, A Nijholt, and J Zwiers. A tractable hybrid ddn-pomdp approach to affective dialogue modeling for probabilistic frame-based dialogue systems. *Natural Language Engineering*, 15(2):273–307, 2009.

- [6] TH Bui, BW van Schooten, and DHW Hofs. Practical dialogue manager development using pomdps. In *Proc SIGdial Workshop on Discourse and Dialogue, Antwerp, Belgium*, pages 215–218, 2007.
- [7] TH Bui, J Zwiers, M Poel, and A Nijholt. Toward affective dialogue modeling using partially observable markov decision processes. In *Proceedings of the 1st workshop on Emotion and Computing Current Research and Future Impact, Bremen*, pages 47–50, 2006.
- [8] H.M. Meng, C. Wai, and R. Pieraccini. The use of belief networks for Mixed-Initiative dialog modeling. *IEEE Transactions on Speech and Audio Processing*, 11(6):757–773, November 2003.
- [9] S. Pulman. Conversational games, belief revision and bayesian networks. In *Proceedings of the 7th Computational Linguistics in the Netherlands meeting.*, 1996.
- [10] B Thomson, J Schatzmann, and SJ Young. Bayesian update of dialogue state for robust dialogue systems. In *Proc Intl Conf on Acoustics, Speech, and Signal Processing (ICASSP), Las Vegas, USA*, 2008.
- [11] B Thomson and SJ Young. Bayesian update of dialogue state: A pomdp framework for spoken dialogue systems. *Computer Speech and Language*, To appear, 2009.
- [12] Jason D Williams. Using particle filters to track dialogue state. In *Proc IEEE Workshop on Automatic Speech Recognition and Understanding (ASRU), Kyoto, Japan*, 2007.
- [13] JD Williams. Applying POMDPs to dialog systems in the troubleshooting domain. In *NAACL-HLT Workshop on Bridging the Gap: Academic and Industrial Research in Dialog Technologies, Rochester, New York, USA*, pages 1–8, 2007.
- [14] B Zhang, Q Cai, J Mao, E Chang, and B Guo. Spoken dialogue management as planning and acting under uncertainty. In *Proc Eurospeech, Aalborg, Denmark*, pages 2169–2172, 2001.
- [15] B Zhang, Q Cai, J Mao, and B Guo. Planning and acting under uncertainty: A new model for spoken dialogue system. In *Proc Conf on Uncertainty in Artificial Intelligence (UAI), Seattle, Washington*, pages 572–579, 2001.

## 2.3 M-Best methods

### References

- [1] Dan Bohus and Alex Rudnicky. A ‘K hypotheses + other’ belief updating model. In *Proc American Association for Artificial Intelligence (AAAI) Workshop on Statistical and Empirical Approaches for Spoken Dialogue Systems, Boston*, 2006.

- [2] Dan Bohus and Alexander I Rudnicky. Constructing accurate beliefs in spoken dialog systems. In *Proc IEEE Workshop on Automatic Speech Recognition and Understanding (ASRU), San Juan, Puerto Rico, USA*, pages 272–277, 2005.
- [3] J Henderson and O Lemon. Mixture model POMDPs for efficient handling of uncertainty in dialogue management. In *Proc Association for Computational Linguistics Human Language Technologies (ACL-HLT), Columbus, Ohio*, 2008.
- [4] H Higashinaka, M Nakano, and K Aikawa. Corpus-based discourse understanding in spoken dialog systems. In *Proc Association for Computational Linguistics (ACL), Sapporo, Japan*, 2003.
- [5] Kyungduk Kim, Cheongjae Lee, Sangkeun Jung, and Gary Geunbae Lee. A frame-based probabilistic framework for spoken dialog management using dialog examples. In *Proc SIGdial Workshop on Discourse and Dialogue, Columbus, Ohio, USA*, 2008.
- [6] Kyungduk Kim and Gary Geunbae Lee. Multimodal dialog system using hidden information state dialog manager. In *Proceedings of the ninth international conference on multimodal interfaces (ICMI 2007) Demonstratio Session, Nagoya*, 2007.
- [7] B Thomson, J Schatzmann, K Welhammer, H Ye, and SJ Young. Training a real-world POMDP-based dialog system. In *Proc Human Language Technologies: The Annual Conference of the North American Chapter of the Association for Computational Linguistics (NAACL-HLT) Workshop on Bridging the Gap: Academic and Industrial Research in Dialog Technologies, Rochester, New York, USA*, pages 9–17, 2007.
- [8] Sebastian Varges, Silvia Quarteroni, Giuseppe Riccardi, Alexei V. Ivanov, and Pierluigi Roberti. Combining POMDPs trained with user simulations and rule-based dialogue management in a spoken dialogue system. In *ACL-IJCNLP Demonstrations*, 2009.
- [9] SJ Young, J Schatzmann, K Weilhammer, and H Ye. The hidden information state approach to dialog management. In *Proc Intl Conf on Acoustics, Speech, and Signal Processing (ICASSP), Honolulu, Hawaii, USA*, pages IV149–IV152, 2007.
- [10] SJ Young, JD Williams, J Schatzmann, MN Stuttle, and K Weilhammer. The hidden information state approach to dialogue management. Technical Report CUED/F-INFENG/TR.544, Cambridge University Engineering Department, 2006.
- [11] Steve Young, Milica Gašić, Simon Keizer, François Mairesse, Jost Schatzmann, Blaise Thomson, and Kai Yu. The hidden information state model: a practical framework for POMDP-based spoken dialogue management. *Computer Speech and Language*, 2009. To appear.

- [12] Steve Young, Jost Schatzmann, Blaise Thomson, Karl Weilhammer, and Hui Ye. The hidden information state dialogue manager: A real-world POMDP-based system. In *Proc Demonstration Session of Human Language Technologies: The Annual Conference of the North American Chapter of the Association for Computational Linguistics (NAACL-HLT)*, Rochester, New York, USA, 2007.

### 3 Automatic action selection for dialogue systems

#### 3.1 MDP-based methods

##### References

- [1] Heriberto Cuayáhuitl, Steve Renals, Oliver Lemon, and Hiroshi Shimodaira. Reinforcement learning of dialogue strategies with hierarchical abstract machines. In *Proc Workshop on Spoken Language Technologies (SLT)*, Aruba, pages 182–185, 2006.
- [2] M Denecke, K Dohsaka, and M Nakano. Learning dialogue policies using state aggregation in reinforcement learning. In *Proc Intl Conf on Spoken Language Processing (ICSLP)*, Jeju, Korea, pages 325–328, 2004.
- [3] Matthias Denecke, Kohji Dohsaka, and Mikio Nakano. Fast reinforcement learning of dialogue policies using stable function approximation. In *Natural Language Processing IJCNLP 2004*, pages 1–11. 2005.
- [4] M Frampton and O Lemon. Learning more effective dialogue strategies using limited dialogue move features. In *Proc Association for Computational Linguistics (ACL)*, Sydney, pages 185–192, 2006.
- [5] D Goddeau and J Pineau. Fast reinforcement learning of dialog strategies. In *Proc Intl Conf on Acoustics, Speech, and Signal Processing (ICASSP)*, Istanbul, pages 1233–1236, 2000.
- [6] P Heeman. Combining reinforcement learning with information-state update rules. In *Proc Human Language Technologies: The Annual Conference of the North American Chapter of the Association for Computational Linguistics (NAACL-HLT)*, Rochester, New York, USA, pages 268–275, 2007.
- [7] E Levin and R Pieraccini. A stochastic model of computer-human interaction for learning dialog strategies. In *Proc Eurospeech, Rhodes, Greece*, pages 1883–1886, 1997.
- [8] E Levin, R Pieraccini, and W Eckert. Using Markov decision process for learning dialogue strategies. In *Proc Intl Conf on Acoustics, Speech, and Signal Processing (ICASSP)*, Seattle, pages 201–204, 1998.

- [9] E Levin, R Pieraccini, and W Eckert. A stochastic model of human-machine interaction for learning dialogue strategies. *IEEE Trans on Speech and Audio Processing*, 8(1):11–23, 2000.
- [10] E Levin, R Pieraccini, and W Eckert. A stochastic model of human-machine interaction for learning dialogue strategies. *IEEE Transactions on Audio, Speech and Language Processing*, 8(1):11–23, 2000.
- [11] DJ Litman, M Kearns, S Singh, and MA Walker. Automatic optimization of dialogue management. In *Proc Association for Computational Linguistics (ACL), Hong Kong*, 2000.
- [12] O Pietquin. *A framework for unsupervised learning of dialogue strategies*. PhD thesis, Faculty of Engineering, Mons (TCTS Lab), Belgium, 2004.
- [13] O Pietquin and S Renals. ASR modelling for automatic evaluation and optimisation of dialogue systems. In *Proc Intl Conf on Acoustics, Speech, and Signal Processing (ICASSP), Florida, USA*, pages 46–49, 2002.
- [14] Olivier Pietquin. A probabilistic description of man-machine spoken communication. In *Proc IEEE International Conference on Multimedia and Expo, Amsterdam*, 2005.
- [15] Olivier Pietquin. Learning to ground in spoken dialogue systems. In *Proc Intl Conf on Acoustics, Speech, and Signal Processing (ICASSP), Honolulu, Hawaii, USA*, 2007.
- [16] Olivier Pietquin and Thierry Dutoit. A probabilistic framework for dialog simulation and optimal strategy learning. *IEEE Transactions on Audio, Speech and Language Processing*, 14(2):589–599, 2006.
- [17] Verena Rieser and Oliver Lemon. Learning dialogue strategies for interactive database search. In *Proc Eurospeech, Antwerp, Belgium*, 2007.
- [18] K Scheffler. *Automatic design of spoken dialogue systems*. PhD thesis, Cambridge University, 2002.
- [19] K Scheffler and SJ Young. Probabilistic simulation of human-machine dialogues. In *Proc Intl Conf on Acoustics, Speech, and Signal Processing (ICASSP), Istanbul*, 2000.
- [20] K Scheffler and SJ Young. Corpus-based dialogue simulation for automatic strategy learning and evaluation. In *Proc North American Association for Computational Linguistics (NAACL) Workshop on Adaptation in Dialogue Systems, Pittsburgh, USA*, pages 12–19, 2001.
- [21] K Scheffler and SJ Young. Automatic learning of dialogue strategy using dialogue simulation and reinforcement learning. In *Proc Human Language Technologies (HLT), San Diego, USA*, pages 12–18, 2002.

- [22] S Singh, DJ Litman, M Kearns, and MA Walker. Optimizing dialogue management with reinforcement learning: experiments with the NJFun system. *Journal of Artificial Intelligence*, 16:105–133, 2002.
- [23] JR Tetreault and DJ Litman. Comparing the utility of state features in spoken dialogue using reinforcement learning. In *Proc Human Language Technologies: The Annual Conference of the North American Chapter of the Association for Computational Linguistics (NAACL-HLT), New York, New York, USA, 2006*.
- [24] JR Tetreault and DJ Litman. Using reinforcement learning to build a better model of dialogue state. In *Proc European Association for Computational Linguistics (EACL), Trento, Italy, 2006*.
- [25] MA Walker. An application of reinforcement learning to dialogue strategy selection in a spoken dialogue system for email. *Journal of Artificial Intelligence Research*, 12:387–416, 2000.
- [26] MA Walker, JC Fromer, and S Narayanan. Learning optimal dialogue strategies: a case study of a spoken dialogue agent for email. In *Proc Association for Computational Linguistics and Intl Conf on Computational Linguistics (ACL/COLING), Montreal*, pages 1345–1351, 1998.

## 3.2 POMDP-based methods

### References

- [1] TH Bui. *Toward Affective Dialogue Management using Partially Observable Markov Decision Processes*. PhD thesis, University of Twente, 2008.
- [2] TH Bui, M Poel, A Nijholt, and J Zwiers. A POMDP approach to affective dialogue modeling. In *Proceedings workshop on The Fundamentals of Verbal and Non-verbal Communication and the Biometrical Issue, Amsterdam*, pages 349–355, 2007.
- [3] TH Bui, M Poel, A Nijholt, and J Zwiers. A tractable DDN-POMDP approach to affective dialogue modeling for general probabilistic frame-based dialogue systems. In *Proc Workshop on Knowledge and Reasoning in Practical Dialogue Systems, Intl Joint Conf on Artificial Intelligence (IJCAI), Hyderabad, India*, pages 34–37, 2007.
- [4] TH Bui, M Poel, A Nijholt, and J Zwiers. A tractable hybrid DDN-POMDP approach to affective dialogue modeling for probabilistic frame-based dialogue systems. In *Proceedings of the 20th Belgian-Netherlands Conference on Artificial Intelligence, Enschede, The Netherlands*, October 2008.
- [5] TH Bui, M Poel, A Nijholt, and J Zwiers. A tractable hybrid ddn-pomdp approach to affective dialogue modeling for probabilistic frame-based dialogue systems. *Natural Language Engineering*, 15(2):273–307, 2009.

- [6] TH Bui, BW van Schooten, and DHW Hofs. Practical dialogue manager development using pomdps. In *Proc SIGdial Workshop on Discourse and Dialogue, Antwerp, Belgium*, pages 215–218, 2007.
- [7] TH Bui, J Zwiers, M Poel, and A Nijholt. Toward affective dialogue modeling using partially observable markov decision processes. In *Proceedings of the 1st workshop on Emotion and Computing Current Research and Future Impact, Bremen*, pages 47–50, 2006.
- [8] F. Doshi and N. Roy. Spoken language interaction with model uncertainty: an adaptive humanrobot interaction system. *Connection Science*, 20(4):299318, 2008.
- [9] Finale Doshi and Nicholas Roy. Efficient model learning for dialog management. In *Proc of Human-Robot Interaction (HRI), Washington, DC, USA, March 2007*.
- [10] N Roy, J Pineau, and S Thrun. Spoken dialog management for robots. In *Proc Association for Computational Linguistics (ACL), Hong Kong*, pages 93–100, 2000.
- [11] Sebastian Varges, Silvia Quarteroni, Giuseppe Riccardi, Alexei V. Ivanov, and Pierluigi Roberti. Combining POMDPs trained with user simulations and rule-based dialogue management in a spoken dialogue system. In *ACL-IJCNLP Demonstrations, 2009*.
- [12] Jason D Williams. Demonstration of a POMDP voice dialer. In *Proc Demonstration Session of Association for Computational Linguistics Human Language Technologies (ACL-HLT), Columbus, Ohio, 2008*.
- [13] Jason D Williams and Steve Young. Partially observable Markov decision processes for spoken dialog systems. *Computer Speech and Language*, 21(2):393–422, 2007.
- [14] JD Williams. Applying POMDPs to dialog systems in the troubleshooting domain. In *NAACL-HLT Workshop on Bridging the Gap: Academic and Industrial Research in Dialog Technologies, Rochester, New York, USA*, pages 1–8, 2007.
- [15] JD Williams, P Poupart, and SJ Young. Factored partially observable Markov decision processes for dialogue management. In *Proc Workshop on Knowledge and Reasoning in Practical Dialogue Systems, Intl Joint Conf on Artificial Intelligence (IJCAI), Edinburgh, 2005*.
- [16] JD Williams, P Poupart, and SJ Young. Partially observable Markov decision processes with continuous observations for dialogue management. In *Proc SIGdial Workshop on Discourse and Dialogue, Lisbon, Portugal, 2005*.

- [17] JD Williams and SJ Young. Scaling up POMDPs for dialog management: The “summary POMDP” method. In *Proc IEEE Workshop on Automatic Speech Recognition and Understanding (ASRU), San Juan, Puerto Rico, USA*, pages 177–182, 2005.
- [18] B Zhang, Q Cai, J Mao, E Chang, and B Guo. Spoken dialogue management as planning and acting under uncertainty. In *Proc Eurospeech, Aalborg, Denmark*, pages 2169–2172, 2001.
- [19] B Zhang, Q Cai, J Mao, and B Guo. Planning and acting under uncertainty: A new model for spoken dialogue system. In *Proc Conf on Uncertainty in Artificial Intelligence (UAI), Seattle, Washington*, pages 572–579, 2001.

### 3.3 Feature-based reinforcement learning

#### References

- [1] J Henderson and O Lemon. Mixture model POMDPs for efficient handling of uncertainty in dialogue management. In *Proc Association for Computational Linguistics Human Language Technologies (ACL-HLT), Columbus, Ohio*, 2008.
- [2] J Henderson, O Lemon, and K Georgila. Hybrid reinforcement/supervised learning for dialogue policies from Communicator data. In *Proc Workshop on Knowledge and Reasoning in Practical Dialogue Systems, Intl Joint Conf on Artificial Intelligence (IJCAI), Edinburgh*, pages 68–75, 2005.
- [3] Fabrice Lefevre, Milica Gasic, Filip Jurcicek, Simon Keizer, Francois Mairesse, Blaise Thomson, Kai Yu, and Steve Young. k-Nearest neighbor Monte-Carlo control algorithm for POMDP-based dialogue systems. In *SIGDIAL*, London, UK, 2009.
- [4] Lihong Li, Jason Williams, and Suhrid Balakrishnan. Reinforcement learning for dialog management using least-squares policy iteration and fast feature selection. In *Proc INTERSPEECH, Brighton, UK*, 2009.
- [5] B Thomson, J Schatzmann, K Welhammer, H Ye, and SJ Young. Training a real-world POMDP-based dialog system. In *Proc Human Language Technologies: The Annual Conference of the North American Chapter of the Association for Computational Linguistics (NAACL-HLT) Workshop on Bridging the Gap: Academic and Industrial Research in Dialog Technologies, Rochester, New York, USA*, pages 9–17, 2007.
- [6] Jason D Williams. The best of both worlds: Unifying conventional dialog systems and POMDPs. In *Proc Intl Conf on Spoken Language Processing (ICSLP), Brisbane, Australia*, 2008.
- [7] Jason D Williams. Integrating expert knowledge into POMDP optimization for spoken dialog systems. In *Proc AAAI Workshop on Advancements in POMDP Solvers, Chicago*, 2008.

- [8] JD Williams. *Partially Observable Markov Decision Processes for Spoken Dialogue Management*. PhD thesis, Cambridge University, 2006.
- [9] JD Williams and SJ Young. Scaling POMDPs for dialog management with composite summary point-based value iteration (CSPBVI). In *Proc American Association for Artificial Intelligence (AAAI) Workshop on Statistical and Empirical Approaches for Spoken Dialogue Systems, Boston*, 2006.
- [10] JD Williams and SJ Young. Scaling POMDPs for spoken dialog management. *IEEE Trans. on Audio, Speech, and Language Processing*, 15(7):2116–2129, 2007.
- [11] SJ Young. Probabilistic methods in spoken dialogue systems. *Philosophical Trans of the Royal Society (Series A)*, 1769(358):1389–1402, 2000.
- [12] Steve Young, Milica Gašić, Simon Keizer, François Mairesse, Jost Schatzmann, Blaise Thomson, and Kai Yu. The hidden information state model: a practical framework for POMDP-based spoken dialogue management. *Computer Speech and Language*, 2009. To appear.
- [13] Steve Young, Jost Schatzmann, Blaise Thomson, Karl Weilhammer, and Hui Ye. The hidden information state dialogue manager: A real-world POMDP-based system. In *Proc Demonstration Session of Human Language Technologies: The Annual Conference of the North American Chapter of the Association for Computational Linguistics (NAACL-HLT), Rochester, New York, USA*, 2007.

### 3.4 Utility maximization

#### References

- [1] D Bohus and AI Rudnicky. Modeling the cost of misunderstandings in the CMU Communicator dialogue system. In *Proc IEEE Workshop on Automatic Speech Recognition and Understanding (ASRU), Madonna di Campiglio, Italy*, 2001.
- [2] D Bohus and AI Rudnicky. A principled approach for rejection threshold optimization in spoken dialog systems. In *Proc Eurospeech, Lisbon, Portugal*, 2005.
- [3] E Horvitz and T Paek. A computational architecture for conversation. In *Proc 7th International Conference on User Modeling (UM), Banff, Canada*, pages 201–210, 1999.
- [4] E Horvitz and T Paek. DeepListener: Harnessing expected utility to guide clarification dialog in spoken language systems. In *Proc Intl Conf on Spoken Language Processing (ICSLP), Beijing*, pages 226–229, 2000.

- [5] Cheongjae Lee and Gary Geunbae Lee. Robust dialog management with n-best hypotheses using dialog example and agenda. In *Proc Association for Computational Linguistics Human Language Technologies (ACL-HLT)*, Columbus, Ohio, 2008.
- [6] E Levin and R Pieraccini. Value-based optimal decision for dialog systems. In *Proc Workshop on Spoken Language Technologies (SLT)*, Aruba, pages 198–201, 2006.
- [7] T Paek and E Horvitz. Uncertainty, utility, and misunderstanding: A decision-theoretic perspective on grounding in conversational systems. In *AAAI Fall Symposium on Psychological Models of Communication*, North Falmouth, MA, USA, pages 85–92, 1999.
- [8] T Paek and E Horvitz. Uncertainty, utility, and misunderstanding: A decision-theoretic perspective on grounding in conversational systems. In *Proc AAAI Fall Symposium on Psychological Models of Communication in Collaborative Systems*, North Falmouth, Massachusetts, USA, 1999.
- [9] T Paek and E Horvitz. Conversation as action under uncertainty. In *Proc Conf on Uncertainty in Artificial Intelligence (UAI)*, Stanford, California, pages 455–464, 2000.
- [10] T Paek and E Horvitz. Grounding criterion: Toward a formal theory of grounding. Technical Report MSR-TR-2000-40, Microsoft Research, 2000.
- [11] T Paek, E Horvitz, and E Ringger. Continuous listening for unconstrained spoken dialog. In *Proc Intl Conf on Spoken Language Processing (ICSLP)*, Beijing, 2000.
- [12] SJ Young, J Schatzmann, K Weilhammer, and H Ye. The hidden information state approach to dialog management. In *Proc Intl Conf on Acoustics, Speech, and Signal Processing (ICASSP)*, Honolulu, Hawaii, USA, pages IV149–IV152, 2007.

### 3.5 Supervised learning based approaches

#### References

- [1] David Griol, Lluís F. Hurtado, Encarna Segarra, and Emilio Sanchis. Managing unseen situations in a stochastic dialog model. In *Proc. of AAAI Workshop Statistical and Empirical Approaches for Spoken Dialogue Systems*, Boston (USA), pages 25–30, 2006.
- [2] David Griol, Lluís F. Hurtado, Encarna Segarra, and Emilio Sanchis. A statistical approach to spoken dialog systems design and evaluation. *Speech Communication*, 50(8-9):666–682, 2008.

- [3] LF Hurtado, D Griol, E Sanchis, and E Segarra. A stochastic approach to dialog management. In *Proc IEEE Workshop on Automatic Speech Recognition and Understanding (ASRU), San Juan, Puerto Rico, USA*, pages 226–231, 2005.
- [4] Cheongjae Lee, Sangkeun Jung, Jihyun Eun, Minwoo Jeong, and Gary Geunbae Lee. A situation-based dialogue management using dialogue examples. In *Proc Intl Conf on Acoustics, Speech, and Signal Processing (ICASSP), Toulouse, France*, 2006.
- [5] Cheongjae Lee, Sangkeun Jung, Kyungduk Kim, and Gary Geunbae Lee. Hybrid approach to robust dialog management using agenda and dialog examples. *Computer speech and language*, Accepted for publication, 2009.
- [6] Cheongjae Lee, Sangkeun Jung, Seokhwan Kim, and Gary Geunbae Lee. Example-based dialog modeling for practical multi-domain dialog system. *Speech Communication*, 51(5):466–484, May 2009.
- [7] V Rieser and O Lemon. Learning effective multimodal dialogue strategies from wizard-of-oz data: Bootstrapping and evaluation. In *Proc Association for Computational Linguistics Human Language Technologies (ACL-HLT), Columbus, Ohio*, 2008.
- [8] Verena Rieser. *Bootstrapping Reinforcement Learning-based Dialogue Strategies from Wizard-of-Oz data*. PhD thesis, Saarland University, 2008.
- [9] Verena Rieser and Oliver Lemon. Using logistic regression to initialise reinforcement-learning-based dialogue systems. In *Proc Workshop on Spoken Language Technologies (SLT), Aruba*, 2006.
- [10] Jason D. Williams and Steve Young. Using wizard-of-oz simulations to bootstrap reinforcement-learning-based dialog management systems. In *Proc SIGdial Workshop on Discourse and Dialogue, Sapporo, Japan*, 2003.

## 4 Underlying models (User, ASR, and others)

### References

- [1] Hua Ai and Diane J Litman. Knowledge consistent user simulations for dialog systems. In *Proc Eurospeech, Antwerp, Belgium*, 2007.
- [2] D. Bohus and A. Rudnicky. *Integrating multiple knowledge sources for utterance-level confidence annotation in the CMU Communicator spoken dialog system*. CARNEGIE-MELLON UNIV PITTSBURGH PA SCHOOL OF COMPUTER SCIENCE, 2002.
- [3] P. Carpenter, C. Jin, D. Wilson, R. Zhang, D. Bohus, and A. Rudnicky. Is this conversation on track? In *Eurospeech-2001, Aalborg, Denmark*, 2001.

- [4] Heriberto Cuayáhuitl, Steve Renals, Oliver Lemon, and Hiroshi Shimodaira. Human-computer dialogue simulation using hidden markov models. In *Proc IEEE Workshop on Automatic Speech Recognition and Understanding (ASRU), San Juan, Puerto Rico, USA*, pages 290–295, 2005.
- [5] E Filisko and S Seneff. Developing city name acquisition strategies in spoken dialogue systems via user simulation. In *Proc SIGdial Workshop on Discourse and Dialogue, Lisbon, Portugal*, 2005.
- [6] Fernando García, Lluís F. Hurtado, David Griol, María José Castro, Encarna Segarra, and Emilio Sanchis. Recognition and understanding simulation for a spoken dialog corpus acquisition. In Václav Matousek and Pavel Mautner, editors, *TSD*, volume 4629 of *Lecture Notes in Computer Science*, pages 574–581. Springer, 2007.
- [7] M. Gasic, S. Keizer, F. Mairesse, J. Schatzmann, B. Thomson, K. Yu, and S. Young. Training and evaluation of the his pomdp dialogue system in noise. In *Proceedings of the 9th SIGDIAL Workshop on Discourse and Dialogue*, 2008.
- [8] Kallirroi Georgila, James Henderson, and Oliver Lemon. Learning user simulations for information state update dialogue systems. In *Proc Eurospeech, Lisbon, Portugal*, pages 893–896, 2005.
- [9] Kallirroi Georgila, James Henderson, and Oliver Lemon. User simulation for spoken dialogue systems: Learning and evaluation. In *Proc Intl Conf on Spoken Language Processing (ICSLP), Pittsburgh, Pennsylvania, USA*, 2006.
- [10] David Griol, Lluís F. Hurtado, Encarna Segarra, and Emilio Sanchis. A statistical approach to spoken dialog systems design and evaluation. *Speech Communication*, 50(8-9):666–682, 2008.
- [11] DJ Litman H Ai, JR Tetreault. Comparing user simulation models for dialog strategy learning. In *Proc Human Language Technologies: The Annual Conference of the North American Chapter of the Association for Computational Linguistics (NAACL-HLT), Rochester, New York, USA*, 2007.
- [12] T. J Hazen, T. Burianek, J. Polifroni, and S. Seneff. Integrating recognition confidence scoring with language understanding and dialogue modeling. In *Sixth International Conference on Spoken Language Processing*, 2000.
- [13] R. Higashinaka, N. Miyazaki, M. Nakano, and K. Aikawa. Evaluating discourse understanding in spoken dialogue systems. *ACM Transactions on Speech and Language Processing (TSLP)*, 1:120, 2004.
- [14] Lluís F. Hurtado, David Griol, Encarna Segarra, and Emilio Sanchis. A statistical user simulation technique for the improvement of a spoken dialog system. *Lecture Notes in Computer Science LNCS. Progress in Pattern Recognition, Image Analysis and Applications*, 4756:743–752, 2007.

- [15] Sangkeun Jung, Cheongjae Lee, Kyungduk Kim, Minwoo Jeong, and Gary Geunbae Lee. Data-driven user simulation for automated evaluation of spoken dialog systems. *Computer Speech and Language*, 23(4):479–509, Oct 2009.
- [16] S. Keizer, M. Gasic, F. Mairesse, B. Thomson, K. Yu, and S. Young. Modelling user behaviour in the HIS-POMDP dialogue manager. In *IEEE Spoken Language Technology Workshop, 2008. SLT 2008*, page 121124, 2008.
- [17] IR Lane, S Ueno, and T Kawahara. Cooperative dialogue planning with user and situation models via example-based training. In *Proc Workshop on Man-Machine Symbiotic Systems, Kyoto, Japan*, pages 2837–2840, 2004.
- [18] O Lemon and X Liu. Dialogue policy learning for combinations of noise and user simulation: transfer results. In *Proc SIGdial Workshop on Discourse and Dialogue, Antwerp, Belgium*, 2007.
- [19] Olivier Pietquin. Consistent goal-directed user model for realistic man-machine task-oriented spoken dialogue simulation. In *IEEE International Conference on Multimedia and Expo, Toronto, Canada*, 2006.
- [20] Olivier Pietquin and Richard Beaufort. Comparing asr modeling methods for spoken dialogue simulation and optimal strategy learning. In *Proc Eurospeech, Lisbon, Portugal*, 2005.
- [21] Olivier Pietquin and Thierry Dutoit. Dynamic bayesian networks for nlu simulation with application to dialog optimal strategy learning. In *Proc Intl Conf on Acoustics, Speech, and Signal Processing (ICASSP), Toulouse, France*, 2006.
- [22] Verena Rieser and Oliver Lemon. Cluster-based user simulations for learning dialogue strategies. In *Proc Intl Conf on Spoken Language Processing (ICSLP), Pittsburgh, Pennsylvania, USA*, 2006.
- [23] Verena Rieser and Oliver Lemon. Automatic learning and evaluation of user-centered objective functions for dialogue system optimisation. In *Proc 6th International Conference on Language Resources and Evaluation (LREC), Marrakech*, 2008.
- [24] J Schatzmann, K Georgila, and SJ Young. Quantitative evaluation of user simulation techniques for spoken dialogue systems. In *Proc SIGdial Workshop on Discourse and Dialogue, Lisbon, Portugal*, pages 178–181, 2005.
- [25] J Schatzmann, MN Stuttle, K Weillhammer, and SJ Young. Effects of the user model on simulation-based learning of dialogue strategies. In *Proc IEEE Workshop on Automatic Speech Recognition and Understanding (ASRU), San Juan, Puerto Rico, USA*, 2005.

- [26] J. Schatzmann, B. Thomson, K. Weilhammer, H. Ye, and S. Young. Agenda-based user simulation for bootstrapping a POMDP dialogue system. In *Proceedings of Human Language Technologies / North American Chapter of the Association for Computational Linguistics (HLT/NAACL)*, 2007.
- [27] J Schatzmann, B Thomson, and SJ Young. Error simulation for training statistical dialogue systems. In *Proc IEEE Workshop on Automatic Speech Recognition and Understanding (ASRU), Kyoto, Japan*, pages 526–531, 2007.
- [28] J Schatzmann, B Thomson, and SJ Young. Statistical user simulation with a hidden agenda. In *Proc SIGdial Workshop on Discourse and Dialogue, Antwerp, Belgium*, pages 273–282, 2007.
- [29] J Schatzmann, K Weilhammer, MN Stuttle, and SJ Young. A survey of statistical user simulation techniques for reinforcement-learning of dialogue management strategies. *Knowledge Engineering Review*, 21(2):97–126, June 2007.
- [30] MN Stuttle, JD Williams, and SJ Young. A framework for Wizard-of-Oz experiments with a simulated ASR channel. In *Proc Intl Conf on Spoken Language Processing (ICSLP), Jeju, Korea*, pages 241–244, 2004.
- [31] Umar Syed and Jason D Williams. Using automatically transcribed dialogs to learn user models in a spoken dialog system. In *Proc Association for Computational Linguistics Human Language Technologies (ACL-HLT), Columbus, Ohio*, 2008.
- [32] B Thomson, K Yu, M Gasic, S Keizer, F Mairesse, J Schatzmann, and S Young. Evaluating semantic-level confidence scores with multiple hypotheses. In *Proc Intl Conf on Spoken Language Processing (ICSLP), Brisbane, Australia*, 2008.
- [33] Francisco Torres, Emilio Sanchisa, and Encarna Segarra. User simulation in a stochastic dialog system. *Computer Speech and Language*, 22(3):230–255, July 2008.
- [34] Jason Williams and Suhrid Balakrishnan. Estimating probability of correctness for asr n-best lists. In *Proc SIGdial Workshop on Discourse and Dialogue, London, United Kingdom*, 2009.
- [35] Jason D Williams. A method for evaluating and comparing user simulations: The Cramer-von Mises divergence. In *Proc IEEE Workshop on Automatic Speech Recognition and Understanding (ASRU), Kyoto, Japan*, 2007.
- [36] Jason D Williams. Exploiting the ASR N-best by tracking multiple dialog state hypotheses. In *Proc Intl Conf on Spoken Language Processing (ICSLP), Brisbane, Australia*, 2008.

## 5 Commentary and evaluations

### References

- [1] Oliver Lemon, Kallirroi Georgila, and James Henderson. Evaluating effectiveness and portability of reinforcement learned dialogue strategies with real users: the TALK TownInfo evaluation. In *Proc Workshop on Spoken Language Technologies (SLT), Aruba*, pages 178–181, 2006.
- [2] T Paek and E Horvitz. On the utility of decision-theoretic hidden subdialog. In *Proc ISCA Workshop on Error Handling in Spoken Dialogue Systems, Chateau-d’Oex-Vaud, Switzerland*, pages 95–100, 2003.
- [3] Tim Paek. Reinforcement learning for spoken dialogue systems: Comparing strengths and weaknesses for practical deployment. In *Interspeech Workshop on Dialogue on Dialogues – Multidisciplinary Evaluation of Advanced Speech-based Interactive Systems*, 2006.
- [4] Tim Paek and David Maxwell Chickering. The Markov assumption in spoken dialogue management. In *Proc SIGdial Workshop on Discourse and Dialogue, Lisbon, Portugal*, pages 25–44, 2005.
- [5] B. Thomson, M. Gasic, S. Keizer, F. Mairesse, J. Schatzmann, K. Yu, and S. Young. User study of the bayesian update of dialogue state approach to dialogue management. In *Proceedings of Interspeech*, 2008.