

MAXIM LIKHACHEV

RESEARCH SCIENTIST
Computer and Information Science
University of Pennsylvania

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EDUCATION

09/01 – 09/05 **Carnegie Mellon University** **Pittsburgh, PA**

Ph.D., Computer Science, M.S., Computer Science

Thesis Title: “Search-based Planning for Large Dynamic Environments”

Advisors: Sebastian Thrun and Geoff Gordon

Thesis Committee: Geoff Gordon (co-chair), Sebastian Thrun (co-chair),
Manuel Blum, Sven Koenig

01/97 - 07/99 **Stevens Institute of Technology** **Hoboken, NJ**

M.E., Electrical Engineering/Digital Signal Processing

GPA: 4.0/4.0

05/94 – 12/96 **Stevens Institute of Technology** **Hoboken, NJ**

B.S., Major: Mathematics, Minor: Computer Science

Major GPA: 4.0/4.0 Minor GPA: 4.0/4.0 Cumulative GPA: 3.9/4.0

RESEARCH INTERESTS

Artificial Intelligence: graph search-based planning, real-time planning, planning under uncertainty, planning for multi-agent systems, robotics

PROFESSIONAL EXPERIENCE

09/07 – presently University of Pennsylvania Philadelphia, PA
Research Scientist

09/05 – 09/07 Carnegie Mellon University Pittsburgh, PA
Postdoctoral Fellow – worked under the supervision of Professor Tony Stentz and also was part of Tartanracing team that won the DARPA Urban Challenge in 2007 (the third DARPA Grand Challenge competition)

09/01 – 09/05 Carnegie Mellon University Pittsburgh, PA
Graduate Research Assistant – worked under the supervision of Professors Geoff Gordon and Sebastian Thrun.

09/99 – 09/01 Georgia Institute Of Technology Atlanta, GA

Graduate Research Assistant – worked under the supervision of Professors Sven Koenig and Ron Arkin

NON-ACADEMIC PROFESSIONAL EXPERIENCE

01/97 – 07/01 Intel Corporation, Parsippany, NJ
DSP Engineer II

Researched and implemented voice quality improvement algorithms for the use in telecommunication systems.

TEACHING EXPERIENCE

01/08 – 05/08 University of Pennsylvania Philadelphia, PA
Co-Instructor for graduate Advanced Robotics class (main instructor: Vijay Kumar, class: MEAM 620)

09/04 – 12/04 Carnegie Mellon University Pittsburgh, PA
Graduate Teaching Assistant for a Ph.D.-level graduate Machine Learning class (instructors: Andrew Moore and Ziv Bar-Joseph)

01/03 – 05/03 Carnegie Mellon University Pittsburgh, PA
Graduate Teaching Assistant for an undergraduate Artificial Intelligence class (instructor: Jaime Carbonell)

HONORS AND AWARDS

- ◆ Part of the Tartanracing team that won the 1st place in the Urban Challenge competition sponsored by DARPA in 2007
- ◆ Doctoral Fellowship (Carnegie Mellon University, 2001-2005)
- ◆ Stevens Cooperative Education Program Award for Academic Excellence (Stevens Institute of Technology, 1997)
- ◆ Charles I. Petschek Scholarship Award for a strong interest in mathematics (Stevens Institute of Technology, 1995)
- ◆ Distinguished Scholar Award (Brookdale Community College, 1995)
- ◆ National Dean's List (all semesters)
- ◆ Bachelor of Science with High Honor
- ◆ Member of Phi Theta Kappa Honor Society
- ◆ Member of Kappa Theta Epsilon Honor Society

FUNDING

- ◆ “Development of Standardized Library of Planning Algorithms and New Planning Algorithms for Manipulation Tasks,” granted by Willow Garage, PI: M. Likhachev, \$110K, 2008
- ◆ “Autonomous Landing Site Selection and Confirmation for Unmanned Helicopters,” granted by Dragonfly Pictures Inc., PI: M. Likhachev, \$75K, 2008
- ◆ “Path Planning for Unmanned Helicopters Navigating Urban Environments,” granted by Dragonfly Pictures Inc., PI: M. Likhachev, \$97K, 2008 (in the process of signing)
- ◆ “Path Planning in Dynamic Environments,” DARPA Phase I SBIR, PI for the project: Dragonfly Pictures Inc., PI at UPenn: M. Likhachev, \$100K total, 2008
- ◆ “Search and Rescue with Unmanned Helicopters,” Army Phase I SBIR, PI for the project: Dragonfly Pictures Inc., PI at UPenn: M. Likhachev, Co-PI at UPenn: V. Kumar, \$70K total, 2008

PUBLICATIONS

Journal and Magazine Articles, Book Chapters:

1. Maxim Likhachev and Anthony Stentz, "*Probabilistic Planning with Clear Preferences on Missing Information*," Artificial Intelligence Journal (AIJ), (to appear)
2. Dave Ferguson, Thomas Howard, and Maxim Likhachev, "*Motion Planning in Urban Environments*," Journal of Field Robotics (JFR), (to appear)
3. Chris Urmson et al., "*Autonomous Driving in Urban Environments: Boss and the Urban Challenge*," Journal of Field Robotics (JFR) Special Issue on the 2007 DARPA Urban Challenge, Part I, 25 (8), pp. 425-466, June 2008
4. Maxim Likhachev, Dave Ferguson, Geoff Gordon, Anthony Stentz, and Sebastian Thrun, "*Anytime Search in Dynamic Graphs*," Artificial Intelligence Journal (AIJ), 2008
5. Sven Koenig and Maxim Likhachev, "*Fast Replanning for Navigation in Unknown Terrain*," Transactions on Robotics (and Automation), Volume 21(3), pages 354-363, 2005
6. Sven Koenig, Maxim Likhachev, and David Furcy, "*Lifelong Planning A**," Artificial Intelligence Journal (AIJ), 155(1-2), pp. 93-146, 2004
7. Maxim Likhachev and Sven Koenig, "*Lifelong Planning for Mobile Robots*," Lecture Notes in Artificial Intelligence, Vol. 2466: Advances in Plan-Based Control of Robotic Agents, M. Beetz, J. Hertzberg, M. Ghallab, and M. Pollack (Eds.), Springer, pp. 140-156, 2002

Research Overview Publications:

- ◆ Sven Koenig, Maxim Likhachev, Yaxin Liu, and David Furcy, "*Incremental Heuristic Search in Artificial Intelligence*," Artificial Intelligence Magazine, 25(2), pp. 99-112, 2004.

Full-length Publications at Conferences:

1. Dave Ferguson, Thomas Howard, and Maxim Likhachev, "***Motion Planning in Urban Environments: Part I***," Proceedings of the IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS), 2008
2. Dave Ferguson, Thomas Howard, and Maxim Likhachev, "***Motion Planning in Urban Environments: Part II***," Proceedings of the IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS), 2008
3. Maxim Likhachev and Dave Ferguson, "***Planning Long Dynamically-Feasible Maneuvers for Autonomous Vehicles***," Proceedings of the Robotics: Science and Systems Conference (RSS), 2008
4. Maxim Likhachev and Anthony Stentz, "***Randomized A****," Proceedings of the National Conference on Artificial Intelligence (AAAI), 2008
5. Dave Ferguson, Chris Baker, Maxim Likhachev and John Dolan, "***A Reasoning Framework for Autonomous Urban Driving***," Proceedings of the IEEE Intelligent Vehicles Symposium (IV), oral presentation, 2008
6. Maxim Likhachev and Anthony Stentz, "***Information Value-Driven Approach to Path Clearance with Multiple Scout Robots***," Proceedings of the IEEE International Conference on Robotics and Automation (ICRA), 2008
7. Maxim Likhachev and Anthony Stentz, "***Goal Directed Navigation with Uncertainty in Adversary Locations***," Proceedings of the IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS), 2007
8. Sven Koenig, Maxim Likhachev and Xiaoxun Sun, "***Speeding up Moving-Target Search***," Proceedings of the International Joint Conference on Autonomous Agents and Multiagent Systems (AAMAS), 2007
9. Maxim Likhachev and Anthony Stentz, "***Path Clearance Using Multiple Scout Robots***," Proceedings of the Army Science Conference (ASC), 2006
10. Maxim Likhachev and Anthony Stentz, "***PPCP: Efficient Probabilistic Planning with Clear Preferences in Partially-Known Environments***," Proceedings of the National Conference on Artificial Intelligence (AAAI), 2006
11. Sven Koenig and Maxim Likhachev, "***Real-Time Adaptive A****," Proceedings of the International Joint Conference on Autonomous Agents and Multiagent Systems (AAMAS), 2006
12. H. Brendan McMahan, Maxim Likhachev, and Geoff Gordon, "***Bounded Real-Time Dynamic Programming: RTDP with monotone upper bounds and performance guarantees***," Proceedings of the International Conference on Machine Learning (ICML), 2005
13. Maxim Likhachev, Dave Ferguson, Geoff Gordon, Anthony Stentz, and Sebastian Thrun, "***Anytime Dynamic A*: An Anytime, Replanning Algorithm***," Proceedings of the International Conference on Automated Planning and Scheduling (ICAPS), 2005

14. Maxim Likhachev, and Sven Koenig, "***A Generalized Framework for Lifelong Planning A****," Proceedings of the International Conference on Automated Planning and Scheduling (ICAPS), 2005
15. Maxim Likhachev, Geoff Gordon and Sebastian Thrun, "***Planning for Markov Decision Processes with Sparse Stochasticity***," Advances in Neural Information Processing Systems 17 (NIPS), MIT Press, Cambridge, MA, 2005
16. Maxim Likhachev, Geoff Gordon and Sebastian Thrun, "***ARA*: Anytime A* with Provable Bounds on Sub-Optimality***," Advances in Neural Information Processing Systems 16 (NIPS), MIT Press, Cambridge, MA, 2004
17. Maxim Likhachev and Sven Koenig, "***Speeding up the Parti-Game Algorithm***," Advances in Neural Information Processing Systems 15 (NIPS), MIT Press, Cambridge, MA, 2003
18. Maxim Likhachev and Sven Koenig, "***Incremental Replanning for Mapping***," Proceedings of the IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS), Vol. 1, pp. 667-672, 2002
19. Sven Koenig and Maxim Likhachev, "***D* Lite***," Proceedings of the National Conference on Artificial Intelligence (AAAI), pp. 476-483, 2002
20. Maxim Likhachev, Michael Kaess, and Ronald C. Arkin, "***Learning Behavioral Parameterization Using Spatio-Temporal Case-Based Reasoning***," Proceedings of the IEEE International Conference on Robotics and Automation (ICRA), Vol. 2, pp. 1282-1289, 2002
21. J. Brian Lee, Maxim Likhachev, and Ronald C. Arkin, "***Selection of Behavioral Parameters: Integration of Discontinuous Switching via Case-Based Reasoning with Continuous Adaptation via Learning Momentum***," Proceedings of the IEEE International Conference on Robotics and Automation (ICRA), Vol. 2, pp. 1275-1281, 2002
22. Sven Koenig and Maxim Likhachev, "***Incremental A****," Advances in Neural Information Processing Systems 14 (NIPS), MIT Press, Cambridge, MA, 2002
23. Maxim Likhachev and Ronald C. Arkin, "***Spatio-Temporal Case-Based Reasoning for Behavioral Selection***," Proceedings of the IEEE International Conference on Robotics and Automation (ICRA), Vol. 2, pp. 1627-1634, 2001
24. Maxim Likhachev and Ronald C. Arkin, "***Robotic Comfort Zones***," Proceedings of SPIE: Sensor Fusion and Decentralized Control in Robotic Systems III Conference, Vol. 4196, pp. 27-41, 2000

Short-length Publications at Conferences:

- ◆ Dave Ferguson and Maxim Likhachev, "***Efficiently Using Cost Maps For Planning Complex Maneuvers***," Proceedings of ICRA Workshop on Planning with Cost Maps, 2008.
- ◆ Maxim Likhachev and Sven Koenig, "***Incremental Heuristic Search in Games: The Quest for Speed***," Proceedings of the Artificial Intelligence and Interactive Digital Entertainment Conference (AIIDE), Poster Abstract, 2006

- ◆ Dave Ferguson, Maxim Likhachev and Anthony Stentz, "*A Guide to Heuristic-based Path Planning*," Proceedings of ICAPS Workshop on Planning under Uncertainty for Autonomous Systems, 2005
- ◆ Sven Koenig and Maxim Likhachev, "*A New Principle for Incremental Heuristic Search: Theoretical Results*," Proceedings of the International Conference on Automated Planning and Scheduling (ICAPS), Poster Abstract, 2005
- ◆ Sven Koenig and Maxim Likhachev, "*Adaptive A**," Proceedings of the International Joint Conference on Autonomous Agents and Multiagent Systems (AAMAS), Poster Abstract, 2005

PATENTS

- ◆ Patent 7,136,813 (issued 11/14/2006, filed 09/25/2005), "**Probabilistic networks for detecting signal content**," (Intel Corporation).

INVITED TALKS AND TUTORIALS

- ◆ Internal talk "Solving Hard Planning Problems in Robotics with Simple Graph Searches" at GRASP seminar at University of Pennsylvania, 2008
- ◆ Invited talk "Solving Hard Planning Problems in Robotics with Simple A*-like searches" at the First International Symposium on Search Techniques in Artificial Intelligence and Robotics (at AAAI conference), 2008
- ◆ Invited talk "Planning Long Dynamically-Feasible Complex Maneuvers for Autonomous Vehicles" at NREC, CMU, 2008
- ◆ Invited talk "Challenges of Planning in Dynamic Cluttered Environments" at DARPA sponsored workshop on Cognitive Mobile Robotics, 2008
- ◆ Invited talk "Pushing the Limits of Search-based Planning" at Intel Research, Pittsburgh, 2007
- ◆ Invited talk "Search-based Planning under Time Constraints and under Uncertainty" at NREC, CMU, 2007
- ◆ Invited talk "Search-based Planning under Time Constraints and under Uncertainty" at State University of New York, Stony Brook, 2007
- ◆ Invited talk "Fast Replanning" at ICAPS Summer School on Artificial Intelligence Planning 2006 (together with Sven Koenig)
- ◆ Invited talk "Search-based Planning for Large Dynamic Environments" at Palo Alto Research Center (PARC) 2005
- ◆ Part of the tutorial "Greedy On-Line Planning" given by Sven Koenig and Anthony Stentz at AAAI 2005
- ◆ Part of the tutorial "Greedy On-Line Planning" given by Sven Koenig and Anthony Stentz at ICRA 2005

PROFESSIONAL SERVICES

- ◆ **Member of Program Committee for:** International Joint Conferences on Artificial Intelligence (IJCAI) 2009, National Conference on Artificial Intelligence (AAAI)

2008 (PC member at both the main track and Physically-grounded AI track), Workshop “Search in Artificial Intelligence and Robotics” at AAAI’08, Workshop “Path Planning on Costmaps” at ICRA’08, International Conference on Machine Learning (ICML) 2007

- ◆ **Session Chair for** National Conference on Artificial Intelligence (AAAI) 2008, IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS), 2007.
- ◆ **Reviewer for the following journals:** Journal of Artificial Intelligence Research (JAIR) 2008, Artificial Intelligence Journal (AIJ) 2008, Journal of Intelligent and Robotic Systems (JINT) 2008, Artificial Intelligence Journal (AIJ) 2007, Artificial Intelligence Journal (AIJ) 2006, Journal of Artificial Intelligence Research (JAIR) 2006 (2 papers), IEEE Transactions on Robotics (TRO) 2006, Journal of Machine Learning Research (JMLR) 2005, Journal of Artificial Intelligence Research (JAIR) 2005, IEEE Transactions on Robotics (TRO) 2005, IEEE Transactions on Robotics and Automation (TRA) 2003, IEEE Transactions on Robotics and Automation (TRA) 2002.
- ◆ **Reviewer for the following conferences:** IEEE International Conference on Robotics and Automation (ICRA) 2009, American Control Conference (ASC) 2009, IEEE International Conference on Robotics and Automation (ICRA) 2008, IEEE Multi-conference on Systems and Control (MSC) 2008, IEEE International Conference on Robotics and Automation (ICRA) 2007, International Joint Conference on Artificial Intelligence (IJCAI) 2007 (5 papers), Robotics: Science and Systems (RoSS) 2006, International Joint Conference on Artificial Intelligence (IJCAI) 2005, International Conference on Intelligent Autonomous Systems (IAS) 2005 (2 papers), IEEE International Conference on Robotics and Automation (ICRA) 2005, International Joint Conference on Artificial Intelligence (IJCAI) 2003, Advances in Neural Information Processing Systems (NIPS) 2002 (6 papers).

TECHNICAL SKILLS

- ◆ Programming Languages: C/C++, Fortran 77, Lisp, Scheme, Matlab, Intel Assembly, Motorola DSP Assembly, FoxPro.
- ◆ Platforms: UNIX, Windows, Macintosh OS.

LANGUAGES

Fluent in English & Russian. Some knowledge of Latvian language.

INTERESTS AND ACTIVITIES

Fishing, downhill skiing, the history of old silver

REFERENCES

Professor Geoff Gordon
School of Computer Science
Carnegie Mellon University,
ggordon+@cs.cmu.edu

Professor Sebastian Thrun
Computer Science Department
Stanford University,
thrun@stanford.edu

Professor Anthony Stentz

Professor Sven Koenig

Robotics Institute
Carnegie Mellon University,
tony+@cmu.edu

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University of Southern California,
skoenig@usc.edu

CITIZENSHIP STATUS

Citizenship of USA