CENTER FOR ANALYSIS & DESIGN OF INTELLIGENT AGENTS 2005-2008 REPORT

ARTIFICIAL INTELLIGENCE - A FIELD OF RESEARCH THAT EMERGED FROM ITS ORIGINS IN COMPUTER SCIENCE, PHILOSOPHY AND PSYCHOLOGY ONLY 50 YEARS AGO - IS RAPIDLY BECOMING ONE OF THE MOST EXCITING AND IMPORTANT FORCES IN MODERN TECHNOLOGICAL INNOVATION.

An uninterrupted exponential increase in the power of computing machines has increased the potential - and indeed the need - for ever-smarter machines and systems. Toys, movies and the popular press provide their share of speculation about the present and future of smart machines and robots; such machines are hitting the scene in all shapes and sizes, creating a positive feedback loop that is propelling general interest in the field to new heights every year.

The field of artificial intelligence (AI) spans a broad spectrum. It is increasingly being applied to solve complex problems, not only with a “serious” purpose, such as flexible and efficient manufacturing, content analysis and meaning extraction, cognitive robots and automatic traffic guidance, but also for entertainment and art, as evidenced by e.g. the increasing use of AI in computer games.

With an emphasis on agent-orientation, large-scale architectures, realtime intelligence, and virtual and augmented realities, CADIA's research focus is firmly placed in key parts of the AI spectrum. As evidenced in this booklet, our projects echo the breadth of AI in general while being focused enough to produce important synergies between research topics.

When we founded CADIA on April 22nd 2005 we had high hopes for the future. And the future has been kind: In the 3 short years since we founded the lab we have had the privilege of working with over 40 students and staff on more than 15 projects, secured over one million Euros from national and international competitive funds (met by a roughly equal amount from RU itself), expanded our network of collaborations to 8 countries, positively impacted the national high-tech industry through collaborative research projects, received one of the most prestigious national research grants, instigated two record-attendance national AI festivals, received a nomination for the President's Student Innovation Award, hosted the World Championship in Computer Chess, won the international General Games Playing Competition at AAAI - two years in a row, developed software for one of the most advanced humanoid robots in the world, and actively participated in a project that was nominated as one of the 10 most important scientific discoveries of the year (2007) by Science Magazine.

Great 3 years indeed.

In the coming years we will continue to work towards further expanding our national and international profile, continiously pushing the boundaries of the state of the art with cutting-edge research, driven by excellence, enthusiasm, and a passion to make the world a better - and more fun - place to live, work and play.

Reykjavik, April 22nd, 2008

Kristinn R. Thórisson

Yngvi Björnsson

- 20 graduate and undergraduate students
- 6 permanent staff
- Collaborations with leading research centers in North America and Europe
- Over 2 M Euros research budget to date
- 100 sq m office and lab space

Background Image: Students in the Virtual Environments course taught by Hannes H. Vilhjálmsson in the School of Computer Science created an interactive virtual version of CADIA for their final project in the course.

THE CENTER FOR ANALYSIS AND DESIGN OF INTELLIGENT AGENTS IS ICELAND´S FIRST ARTIFICIAL INTELLIGENCE LABORATORY. IT WAS FOUNDED ON APRIL 22ND 2005 BY DR. YNGVI BJÖRNSSON AND DR. KRISTINN R. THÓRISSON. THE LAB HAS GROWN TO BECOME ONE OF THE COUNTRY´S MOST PRESTIGIOUS RESEARCH LABORATORIES.

MAIN RESEARCH AREAS

A: Agent orientation. Our conception of an agent follows closely that of the first president of AAAI, Dr. Allen Newell, who in 1980 described an intelligent agent as consisting of cognitive faculties such as a perceptual system, memory system, processing system, motor system - the agent's sensory apparatus limits what it can directly observe; its memory restricts what it knows. Any challenge a dynamic environment may present needs to be addressed with the agent's own local intelligence.

B: Realtime in intelligent systems means readiness to respond to unforeseen events; the ability to handle deadlines and highly dynamic environments. To us an artificial system can only be intelligent if it uses time wisely for planning, decision making and execution.

C: Virtual and augmented worlds present new ways for us to experience information, to communicate with each other and to machines. They can bridge between the real and the digital. Virtual agents are often a good alternative to physical robots. Virtual environments provide AI researchers with interesting possibilities for both innovative experiments and innovative applications.

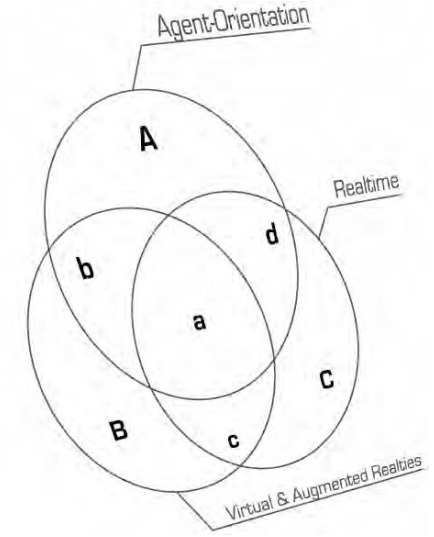
The three main areas of emphasis define four sub-areas where most of the Lab's projects fall:

a: Integrating architectures, tools, natural multimodal communication / Example projects: Constructionist Design Methdology (CDM), Game Tree Query Language (GTQL), Cognitive Map (with researchers at Honda Research Institute)

b: Virtual humanoids, simulation / Example projects: Velaldin - evolution of creativity, Agent-Based Modeling and Simulation (ABMS) with RU's Energy Lab

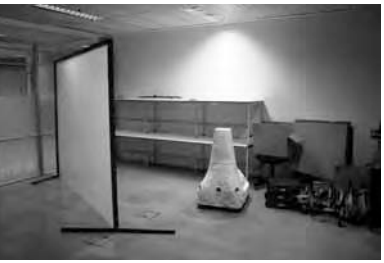
c: Interactive avatars, action coordination / Example projects: Behavior Markup Language (BML), CADIA Populus - social intelligence in virtual worlds (with CCP Games), Ambient Earth - realtime Web dialog visualization

d: Planning, perception / Example projects: Spatio-semantic representation for robot navigation, CADIA-Player - General Game Playing, Skundar the robot, Murphy humanoid robot, SuperRadioHost - interactive human-like dialogue, planning/search algorithms for food classification and sorting



SHORTLIST OF ACHIEVEMENTS

- Winners of the worldwide competition in General Game Playing, 2007 and 2008
- Collaborators on Science Magazine top-10 most important discoveries of 2007
- Project nominated for the President's Student Innovation Award
- Collaborated on developing software for ASIMO, one of the world's most advanced humanoid robots
- Collaborators on developing AI software for the largest unified online virtual world game in the world
- Received most prestigious national competitive research grant in science and technology 2008
- Over 40 scientific and technical papers published




FACILITIES

CADIA's research and office facilities include over 70 sq.m. of open office area and a 30 sq.m. media- and robot room, typically referred to as the “Botcave”. When working in CADIA every student gets high-quality office equipment and state of the art computing equipment. CADIA has access to significant computing resources, including Botcave computers specialized for audiovisual input and output processing, Gola, a 6-computer Linux cluster, Stormur, a 14-server rack of dual-processor machines, and most recently Blue Midget, a 16 quad-core-processor machine equipped with dual 2-Gb Ethernets and Infiniband. In realtime systems such as robotics and virtual worlds, timeliness and appropriateness of response is of utmost significance. Blue Midget services the lab's research on realtime processing including interactive autonomous agents in virtual worlds and agent-based modeling and simulation. In playing complex games like chess and Go, humans show a remarkable skill at identifying and exploring only relevant lines of play: The most skilled players can sometimes explore and see the consequences of very deep forced lines of play, which may prove difficult for even the fastest and most advanced game-playing programs. The lab's server racks provide batch-computing facilities for research on such topics.

In 2009 CADIA will move to a new location and building. The building will be one of the best outfitted research and educational facilities in Europe. Within the campus area one can find recreational outdoor opportunities including an oceanfront beach with artificial geothermal heating.

Left: Kristleifur Dadason boots up his software for an experimental musical performance by CADIA faculty & students, AI Festival 2006. Below: Winners in the annual AI Competition. From left: Hrafn Th. Thorisson in category Best software with instructions, Freyr Magnusson and Agust Karlsson in category Most useful AI technology, and Kristleifur "Krilli" Dadason, Jonheidur Isleifsdottir and Gudny R. Jonsdottir in category Final Project. Bottom left: Demonstration booth of Jónheidur Ísleifsdóttir (on left). Bottom right: Hannes H. Vilhjálmsson (far left) demonstrates interactive virtual agents that teach foreign languages.

CADIA's AI FESTIVAL

CADIA's AI Festival is an annual, public event where artificial intelligence is celebrated with interesting presentations on AI and robotics, an AI competition and project displays (and of course snacks and pastries!). Besides getting a lot of media attention since its inception in 2006 the festival has attracted hundreds of people of all ages and helped raise public interest in artificial intelligence.

Clockwise from top: CADIA founding party; TV interview about the artificial radio show host; Yngvi and Kris on April 22nd 2005; student research and study facilities in CADIA; Sverrir Sigmundarson built a LEGO-based computer vision robot for the Garage AI course. Right: Demonstration of research results in the early days of CADIA. Below: Vignir Hafsteinsson prepares a demo at a science fair in Reykjavík.

Hrafn Th. Thorisson, undergraduate researcher at CADIA, with the President of Iceland, Mr. Ólafur Ragnar Grímsson. President's Student Innovation Awards, Bessastaðir, 2007.

GARAGE AI

The Garage AI Movement is CADIA's effort to support the growing, Icelandic AI community. (The name is derived from the idea that modern AI systems can be tinkered with "in your garage", similar to the old HAM-radio movement.) Garage AI includes an annual lecture series where the public is invited to partake in hands-on workshops on robotics and artificial intelligence, accompanied by a growing collection of tutorials and code-examples available online. A Garage AI Competition and Awards is also held as part of the annual AI Festival, where AI enthusiasts can enter their home-grown robots and intelligences and compete in several categories such as Most Useful AI & Best Software With Documentation.

COMPUTER CHESS WORLD CHAMPIONSHIP

CADIA hosted the 13th World Computer-Chess Championship in 2005 under auspices of the International Computer Games Association (ICGA). The exciting computer-chess event consisted of a World Championship with 12 participants (from Israel, Germany, France, The Netherlands, Belgium and the USA), a World Speed-Chess Championship, a Fisher Random Chess Tournament, and (exclusively for the human participants) an excursion to some of the most beautiful places in Iceland. In terms of playing strength (Elo rating), and considering the selected group of twelve participating programs, we can assume that at the time it was possibly one of the strongest computer-chess tournaments ever held in history.

CHECKERS IS SOLVED

ACCORDING TO SCIENCE MAGAZINE ONE OF THE TOP SCIENTIFIC ACHIEVEMENTS OF THE YEAR 2007 WAS THAT A TEAM OF COMPUTER SCIENTISTS SOLVED THE GAME OF CHECKERS — A PERFECT PLAY LEADS TO A DRAW.

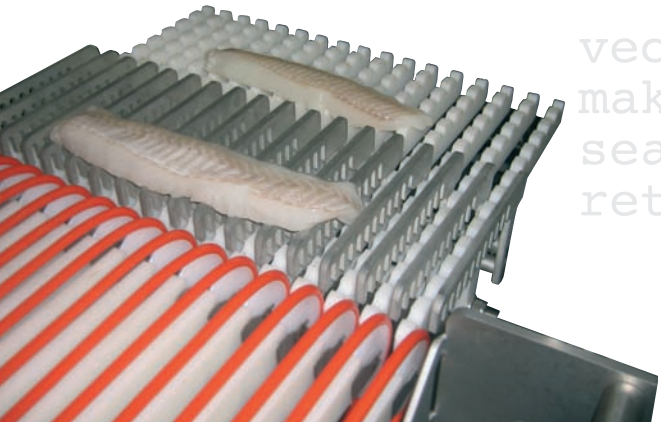
Dr. Yngvi Björnsson was one of the scientists on the team, which was headed by researchers at the Department of Computing Science at University of Alberta in Canada.

Solving the game constituted a great computational challenge as the state-space of checkers consists of over 500 billion-billion states, one million times larger than comparable problems previously solved. The solution was made possible by using state-of-the-art artificial intelligence search techniques, running continuously on several clusters of workstations over a number of years.

AUTOMATED FISH SORTING

CADIA WORKS WITH NUMEROUS PROGRESSIVE HIGH-TECH COMPANIES IN DEVELOPING SOLUTIONS WITH IMMEDIATE ECONOMIC IMPACT.

In collaboration with Valka ehf., an innovative solutions provider for the fish industry, CADIA developed control software for a revolutionary grading and packing production line. The system puts fresh fish products fully automatically into packs of fixed weight with absolute minimum give-away weight. The new processing line requires not only less manual labor than tradtitional grading equipment, it also improves product handling and yield. Dr. Yngvi Björnsson was principal developer of the optimization algorithms behind this advanced technology.



CADIA-PLAYER

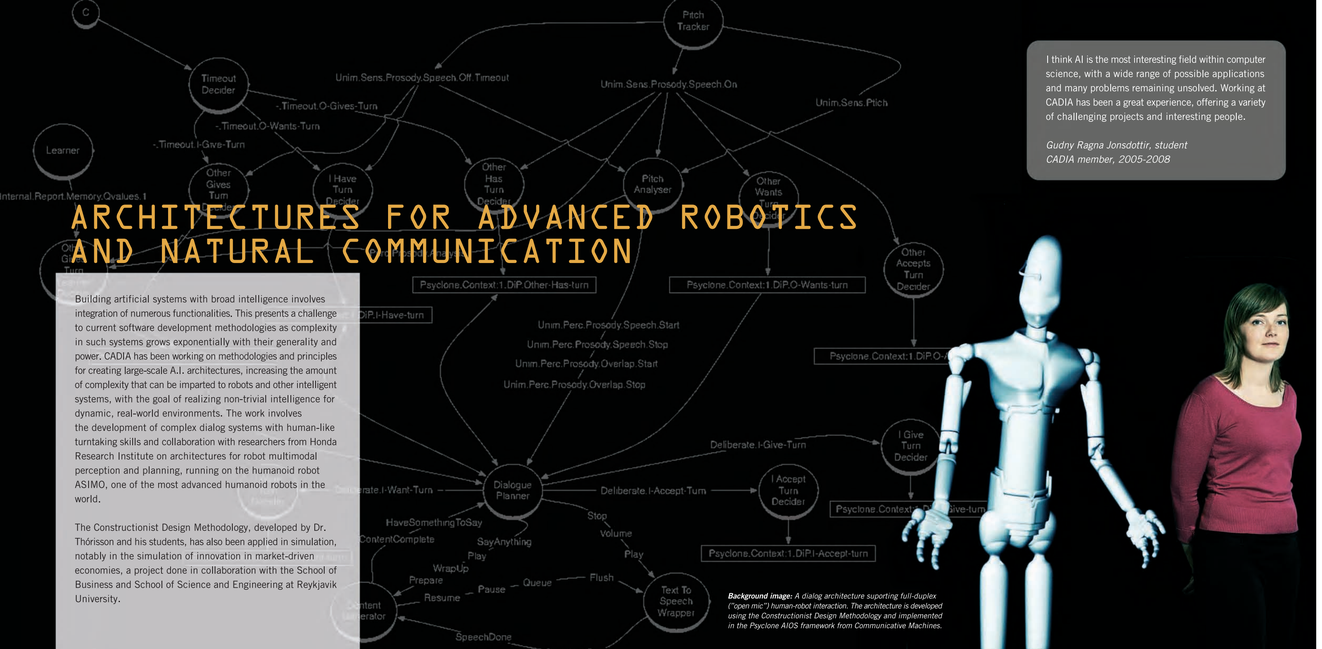
World Champion in General game play

CADIA-Player is a general game-playing agent developed at CADIA. The aim of General Game Playing (GGP) is to create intelligent agents that can automatically learn how to play many different games at an expert level without any human intervention, given only a description of the game rules. This requires that the agents learn diverse game-playing strategies without any game-specific knowledge being provided by their developers. A successful realization of this task poses interesting research challenges for artificial intelligence sub-disciplines such as knowledge representation, agent-based reasoning, heuristic search, and machine learning. Whereas the most successful GGP agents in the past have been based on the traditional approach of using game-tree search augmented with an automatically learned heuristic evaluation function for encapsulating the domain-specific knowledge, CADIA-Player is based on a radically different simulation-based approach. The agent has already proven its effectiveness by winning the 3rd International General Game Playing Competition two years in a row, thus being the reigning world-champion in general game playing.

ARCHITECTURES FOR ADVANCED ROBOTICS AND NATURAL COMMUNICATION

Building artificial systems with broad intelligence involves integration of numerous functionalities. This presents a challenge to current software development methodologies as complexity in such systems grows exponentially with their generality and power. CADIA has been working on methodologies and principles for creating large-scale A.I. architectures, increasing the amount of complexity that can be imparted to robots and other intelligent systems, with the goal of realizing non-trivial intelligence for dynamic, real-world environments. The work involves the development of complex dialog systems with human-like turntaking skills and collaboration with researchers from Honda Research Institute on architectures for robot multimodal perception and planning, running on the humanoid robot ASIMO, one of the most advanced humanoid robots in the world.

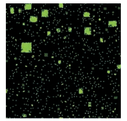
The Constructionist Design Methodology, developed by Dr. Thórisson and his students, has also been applied in simulation, notably in the simulation of innovation in market-driven economies, a project done in collaboration with the School of Business and School of Science and Engineering at Reykjavik University.

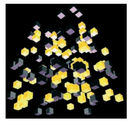


Background image: *A dialog architecture suporting full-duplex ("open mic") human-robot interaction. The architecture is developed using the Constructionist Design Methodology and implemented in the Psyclone AIOS framework from Communicative Machines.*

I think AI is the most interesting field within computer science, with a wide range of possible applications and many problems remaining unsolved. Working at CADIA has been a great experience, offering a variety of challenging projects and interesting people.

Gudny Ragna Jonsdottir, student
CADIA member, 2005-2008





EVOLUTION OF CREATIVITY

Creativity's entangled relationship between novelty, goals, intentionality and logic has proven difficult to explain. Hrafn Th. Thórisson has proposed new ways for studying the emergence and evolution of creativity. He has developed a software simulation platform called Véladin which allows for exploration of creative agents within emergent environments. The images above were generated by different configurations of cell grids, colors and interaction rules. By evolving intelligent agents within such worlds, Hrafn has shown how the environment directly and lawfully influences the planning and generative nature of the evolved agents' minds.

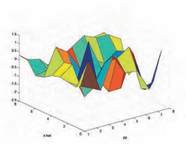
In 2007, Hrafn was nominated for the Icelandic Presidential Student Innovation Award for this research.

What interests you most about AI?
It's original thought and imagination: Working towards making machines capable of inventing new things on their own accord. Not only do creative computers help us solve problems but the research sheds light on how we, biological machines, function. Moreover, intelligence is applicable everywhere, which makes AI my portal to all the fields of science.

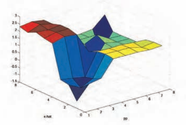
Hrafn Th. Thórisson, student
CADIA member 2005-2008

LEARNING MULTIMODAL SIGNALS

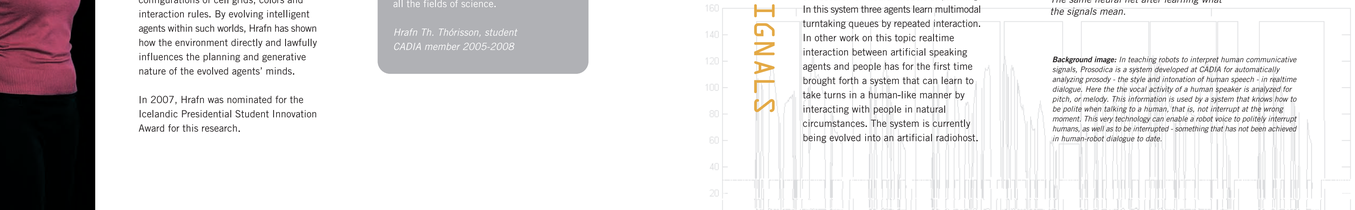
People communicate with each other using a combination of speech, gesture, facial expression, intonation and prosody. The timing and coordinated presentation of these complex signals, derives from years of training in social circumstances where tradition, social convention, emotions and comprehension all operate in parallel to mold and tune these skills. Collaboration with James Bonaiuto at USC has resulted in a model of turntaking that integrates Thorisson's Ymir Turntaking Model (YTTM) and the Augmented Competitive Queuing model developed at USC, which is based on research on neural models of planning. In this system three agents learn multimodal turntaking queues by repeated interaction. In other work on this topic realtime interaction between artificial speaking agents and people has for the first time brought forth a system that can learn to take turns in a human-like manner by interacting with people in natural circumstances. The system is currently being evolved into an artificial radiohost.



Initial random representation of a neural net that is being trained to respond to simulated multimodal dialog interaction. The net maps from simulated multimodal sensors to an Augmented Competitive Queueing system that plans what to do to achieve "polite" turntaking where the agents do not interrupt or talk on top of each other.

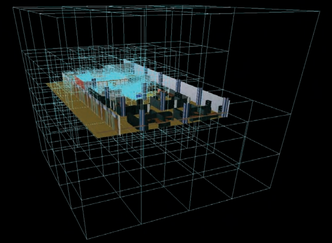


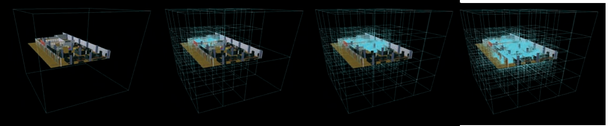
The same neural net after learning what the signals mean.



Background image: *In teaching robots to interpret human communicative signals, Prosodica is a system developed at CADIA for automatically analyzing prosody - the style and intonation of human speech - in realtime dialogue. Here the the vocal activity of a human speaker is analyzed for pitch, or melody. This information is used by a system that knows how to be polite when talking to a human, that is, not interrupt at the wrong moment. This very technology can enable a robot voice to politely interrupt humans, as well as to be interrupted - something that has not been achieved in human-robot dialogue to date.*

MULTIMODAL OCTREE



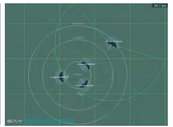


SPATIO-SEMANTIC

Building a spatio-semantic representation of the world allows robots to efficiently represent spatial information - for navigation and object recognition - with semantic information such as the names of objects, areas, people and places. This new representation, based on a nested octree hierarchy, was developed by Freyr Magnusson for Skundar the robot. Here, octree cubes are rendered on top of a virtual model of the CADIA labspace, showing how increased detail results in a tighter octree mesh.

I have an interest in automation, cognition and clever ways to solve problems. AI is the field that addresses these interests from a functional point of view, providing ideas and methods to work on these issues. At CADIA I got the opportunity to build a robot platform from scratch, working in close proximity with very clever students, teachers and advisors. There was an openness to the lab that promoted interesting discussions and debate.

Freyr Magnússon, student
CADIA member 2005-2008



CADIA POPULUS

CADIA Populus is a research tool that combines online multi-player capability with clear visual annotation of the dynamic social environment in terms of various theoretical models from psychology and sociology, such as theories of spatial organization (white lines) and proxemics (colored lines). The core of the tool, developed by student Claudio Pedica under guidance of Hannes H. Vilhjálmsson, is a flexible and powerful framework for experimenting with avatar automation, which allows steering behaviors to be activated and deactivated in the avatars based on their perception of the social environment. For example, a set of steering behaviors that automatically position and orient avatars into realistic conversation groups are activated when the start of a conversation is perceived. Since the steering behaviors are continuous, they can maintain group formations, even in the face of turbulence caused by new avatars joining, leaving or just pacing around.

What interests you most about AI?
AI is closer to people than most other topics in computer science. It can serve as an intriguing way for understanding yourself and others – or a good way to loose your sanity solving complicated problems. In both cases, AI is a way of reshaping your ignorance since, as we know, searching out the truth is a never-ending game.

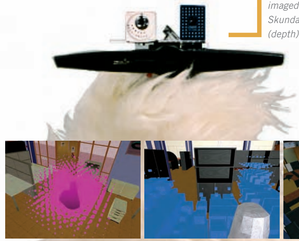
What makes your CADIA experience memorable?
CADIA=people + hi-tech atmosphere^{passion} *+salted liquorice+the flying monkey*

Claudio Pedica, student
CADIA member 2007-2008

A person holding a cup of coffee imaged with Skundar's 3D (depth) camera.

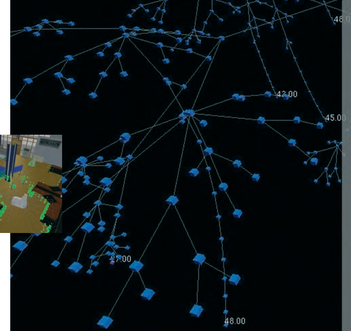
HOW TO UNDERSTAND IF YOU'RE A FUZZY THE WORLD ROBOT

Skundar is a robot platform created specifically to study human-robot interaction, designed and built by Freyr Magnusson under the direction of Kristinn R. Thórisson. Skundar is covered with Icelandic wool to make it more environment- and child-friendly. Here a simulation of Skundar the robot shows one way it can sense the world. The first frame shows Skundar at starting position; blue wireframe boxes show approximate area covered by its sonar sensors in the surroundings. As Skundar drives around it builds up a probability map, shown here as green boxes floating in the air – in reality these belong to Skundar's mind, shown here to illustrate what Skundar thinks of the world. The size of the green boxes shows how sure Skundar is that each point in space represents a real obstacle. The last frame shows what Skundar knows about the spatial layout of his surroundings after having driven 1.5 circles around the center pole in the CADIA labspace.



HIGH-PERFORMANCE GAME PLAYING

The search engines of high-performance game-playing programs are getting increasingly complicated as more and more enhancements get added. To maintain and further enhance such complex engines is a complex task and the risk of introducing bugs or other unwanted behavior during modifications is substantial. One of CADIA's ongoing projects is to develop techniques and tools to help software developers and researchers working on game-tree search. An important component of this is the Game Tree Query Language (GTQL), developed by Jónheidur Ísleifsdóttir, a language specifically designed for querying complex game-tree structures, including hierarchical relationships and aggregated attributes of subtrees. Jonheidur's Game Tree Query Tool (GTQT) allows efficient execution of GTQL, and thus helps users to gain added insight into the search process of their engines, as well as making regression testing easier.



The thing that interests me most (or what I love) about AI is that it enables us to learn more about ourselves. The brain of a human being is very complex, but simulations can be used to teach us about what makes us tick. AI is a broad field with great room for collaboration between people from different fields of study and work. AI is for everyone!

What makes your CADIA experience memorable?
The people. The staff is ambitious, motivating and very open to ideas and suggestions from students. The facilities are excellent and the graduate student association is very active, movie nights and parties are regular events that bring the group closer together. The environment at CADIA is always stimulating and inspiring and the crazier the idea the livelier the discussion. CADIA makes room for all kinds of AI. From complex algorithms in games to social and interactive AI. For me, CADIA was the obvious choice when deciding which lab to work in during my graduate studies.

Jónheidur Ísleifsdóttir, student
CADIA Member 2005-2008

Background image: *Visualization of the search tree generated by the Upper Confidence Bounds applied to Trees (UCT) algorithm as it plays the puzzle Peg in realtime.*

HUMANOID AGENTS IN SOCIAL

Background image: *An early-state realtime 3D rendering of an interior space station design for the EVE-Online universe, courtesy of CCP Games Inc. The goal is to fill these rooms with interacting people, both human-controlled and fully autonomous.*

GAME ENVIRONMENTS

Massively-multiplayer online role-playing games (MMORPGs) is mass-entertainment delivered over the Internet in the form of live game worlds that persist and evolve over time. Players connect to these worlds using client software that renders the world from their perspective as they move about pursuing their own goals, meeting fellow players and game controlled characters. CCP Games Inc. in Iceland has hosted its space-themed EVE-Online since May 2003 and has hundreds of thousands of subscribes worldwide.

Until now players of EVE have never had the chance to take their characters outside their space ships and meet each other in (virtual) person. It was only natural for CCP and CADIA to launch a collaborative effort to bring the state of the art in AI-controlled animated characters to the next level.

The goal of this collaborative project is to develop new methods to create believable human behavior in animated game characters. The focus is on natural motion and believable social interaction.

The characters are either fully controlled by the game AI or they are under the direction of human players. A particular emphasis is placed on the generation of natural nonverbal behavior that supports communication. The analysis and modeling of communicative behavior is drawn from an extensive scientific knowledge base. These models are used to derive computational structures that receive a description of characters, goals and environment and return a detailed description of appropriate nonverbal behavior in real-time. Finally an animation engine turns the description of behavior into a smooth continuous performance of articulated human figures in the interactive virtual environment. The project rests firmly on CADIA's research platform for cognitive robotics and is a part of an ongoing research collaboration with USC in the US and University of Paris 8 in France.

Frames: *The open-source BML Realizer is an easy-to-use toolkit for animating humanoids in virtual environments and was developed at CADIA to support the SAIBA framework.*

SAIBA CONSORTIUM

CADIA leads an effort to unify a multimodal behavior generation framework for communicative humanoids. The goal is to standardize important interfaces to facilitate collaboration. The current proposal describes a three stage behavior generation model called SAIBA where the stages represent intent planning, behavior planning and behavior realization. A Function Markup Language (FML), describing intent without referring to physical behavior, mediates between the first two stages and a Behavior Markup Language (BML) describing desired physical realization, mediates between the last two stages. Among those who lead in the effort with CADIA are the Institute for Creative Technologies at the University of Southern California, Paris 8 and Bielefeld University.

MINDMAKERS.ORG

CADIA is a leader in the MINDMAKERS.ORG effort, a non-profit effort to speed up the advancement of AI by fostering code and results sharing between AI researchers, groups and institutions. The consortium also focuses on the development of integration standards, the first one being the OpenAIR message and routing protocol. The collaboration includes people with a diverse set of backgrounds and spans several disciplines, from software development to psychological experimentation, from ethics to hardware engineering, including researchers in the U.S. and Europe.

Kristinn R. Thórisson is founding co-director of CADIA (with Yngvi Björnsson). Kris does research on holistic AI and artificial general intelligencece, A.I. architectures, interactive communicative characters, humanoid robots and multimodal realtime communication.

Before joining Reykjavik University Kristinn held a variety of positions, including consultant, research scientist, VP Engineering, CTO, and Wizard, at a wide range of companies including LEGO, NASA, Soliloquy, Radar Networks and British Telecom. He is co-founder of Radar Networks Inc. (funded by Vulcan Ventures and Draper Fisher Jurvetson). Radar Networks was named one of the year's top 10 most innovative startups by Reuter's Venture Capital (RVC) in 2002.

Kris holds a Ph.D. from the MIT Media Laboratory, an M.S. in engineering psychology from Florida Institute of Technology and a B.S. in psychology from the University of Iceland. Kris' work has been featured on numerous news and television programs including CNN Impact, BBC, New York Times online and Scientific American Frontiers.

Yngvi Björnsson is founding co-director of CADIA (with Kristinn R. Thórisson). His research focus is on informed search methods as a general problem solving mechanism and their application in domains such as game-playing, planning, and optimization problems in industrial applications. Yngvi developed the 2007 winner in general game playing agent; his collaboration with Alberta University on checkers was named among the 10 most important publications 2007 by Science Magazine.

Before joining Reykjavik University in 2004, Yngvi worked in the software industry for several years and held a position as a research associate with the GAMES research group at University of Alberta, Canada. He is a vice-president of the International Computer Games Association.

Yngvi holds a Ph.D. degree in Computer Science from the University of Alberta, Canada, and a B.Sc. degree in Computer Science from University of Iceland.

Hannes Vilhjálmsson joined CADIA as a principal investigator in 2006. His main focus is on modelling realistic social and linguistic nonverbal behavior in humanoid agents and avatars for online virtual worlds used in education and entertainment. Hannes has played a key role in CADIA's collaboration with CCP Games and in the international SAIBA initiative.

Before joining Reykjavik University, Hannes was the technical director on a $7M DARPA project at USC's Information Sciences Institute (ISI) in the Center for Advanced Technology for Education and Training. The project integrated a 3D game environment, various language technologies and agent-based tutoring to rapidly teach foreign language and culture, and won DARPA's Award for Significant Technical Achievement in 2005. Hannes co-founded Alelo Inc., a project spin-off specializing in game-based social training technologies, where he continue to be a board member and technical advisor.

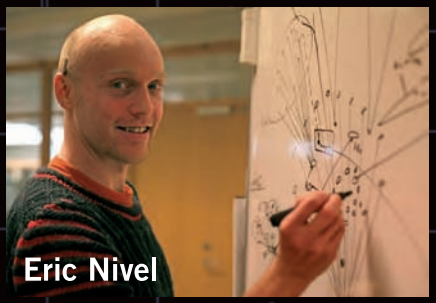
Hannes holds a Ph.D. and an M.Sc. from the MIT Media Laboratory and a B.Sc. in Computer Science from the University of Iceland.

Ari K. Jonsson

Ari K. Jonsson joined CADIA as principal investigator in summer of 2007. His areas of research include constraint reasoning, planning and scheduling, robust plan execution, mixed-initiative planning, autonomous operations, and validation of autonomous systems.

Before joining CADIA Ari was a senior scientist and project manager at NASA Ames Research Center in Silicon Valley, California. Over a 10 year period at NASA Ari's work included key planning technology research, contributions to unmanned and manned spaceflight missions, and management of multi-center research and development projects. Ari led the development of the EUROPA planning and scheduling framework. He lead development of the MAPGEN tool, one of the key tools used to determine science activities for the Mars Exploration Rovers. Ari was a project manager in a large multi-center collaboration to develop the next-generation infrastructure for spacecraft automation and in developing technologies for the International Space Station.

Ari holds a Ph.D. and an M.Sc. in Computer Science from Stanford University, as well as a B.Sc. in Computer Science and a B.Sc. in Mathematics from the University of Iceland.



Eric Nivel

Eric Nivel joined CADIA as an analyst in the spring of 2007. His areas of interest range from general autonomous systems to high-performance computing, with a special emphasis on real-world applications. Before joining Reykjavik University, Eric Nivel was the lead software engineer at Holografika, and designed the software for the real-time generation and transmission of dynamic holograms. He also developed an autonomous system to play as meta characters in experimental theatrical performances, along with an integrated show control platform. He consulted in the area of intelligent process control for aerospace, telecom and research institutions.

Eric Nivel holds an Engineering Diploma in Electronics from ISEN - Lille, France.

Hilmar Finnsson

Hilmar Finnsson joined CADIA in 2008 as an analyst. His work is in the area of General Game Playing. He is the co-author (with Yngvi Björnsson) of the game playing agent CADIA-Player, which won the Annual General Game Playing Competition in 2007 which was held at Stanford University and in Vancouver, and again in 2008 when the competition was held in Chicago. Hilmar's present work focuses of improving CADIA-Player through the use of advanced machine learning and heuristic search. His aim is to hold on to the title of World Champion in General Game Playing a third year in a row.

Before joining CADIA Hilmar worked on software development for Eimskip and TM Software. Hilmar holds an M.Sc. degree in computer science from Reykjavík University.

Background image: *In an experimental setup where three agents have learned to take turns speaking without interrupting each other, using multimodal cues, the image shows the output of a neural net that is being trained to respond to dialog interaction in the same manner as people do. The project is part of a collaboration with James Bonaiuto at the University of Southern California.*

Collaborators

CADIA collaboators include researchers at the following institutions:

- **Alelo Inc.**
- **CCP Games Inc.**
- **Communicative Machines**
- **Hexia.net**
- **Honda Research Institute USA**
- **U. Alberta, Canada**
- **U. Bielefeld**
- **U. Edinburgh**
- **U. Iceland**
- **U. Maastricht, The Netherlands**
- **U. Southern California**
- **U. Southern California ISI and ICT**
- **School of Business, RU**
- **School of Sci. & Eng., RU**
- **The SAIBA Consortium**
- **Valka ehf., Iceland**

People

Faculty

Ari K. Jónsson, Ph.D.
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Kristinn R. Thórisson, Ph.D.
Yngvi Björnsson, Ph.D.

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Eric Nivel
Hilmar Finnsson
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Eric Kasper
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Jónas Tryggvi Jóhannson
Jónheidur Ísleifsdóttir
Kári Halldórsson
María Arinbjarnar
Páll Rúnar Thráinsson
Shashank Singh
Steinthór Steingrímsson
Sverrir Sigmundarson

Grants

2008

Rannís Research Excellence Grant. *Humanoid Agents in Social Game Environments, 2008-2011.* ***430k Euros***
Rannís. *General Game Playing, 2008-2010.* ***100k Euros***
Rannís Equipment grant. *Cluster for Realtime and Agent-Based Computing.* ***16k Euros***
Reykjavik Energy. *Possibilities for a Regulatory Framework on Greenhouse Gas Emissions and Their Consequences.* ***40k Euros***

2007

Reykjavik Energy. *Possibilities for a Regulatory Framework on Greenhouse Gas Emissions and Their Consequences, 2007-2008.* ***14k Euros***
Rannís. *Humanoid Agents in Social Game Environments.* ***40k Euros***
NSN Student Innovation Fund. ***12k Euro***

2006

Marie Curie International Reintegration Grant. *Platform for Cognitive Robotics, 2006-2008.* ***80k Euros***
Marie Curie International Reintegration Grant. *Adaptive Real-Time Heuristic Search, 2006-2008.* ***80k Euros***
NSN Student Innovation Fund. ***12k Euro***

2005

Rannís. *Platform for Cognitive Robotics, 2005-2007.* ***95k Euros***
Rannís. *Automatic Learning of Search-Control in Heuristic Search, 2005-2007.* ***80k Euros***
Rannís Equpiment Grant. *Linux cluster and fast storage.* ***23k Euros***
NSN Student Innovation Fund. ***10k Euros***
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The first Icelandic A.I. Festival, 2006, saw the performance of a piece titled The Predictor: A Robot Opera, performed by the author Kristinn R. Thórisson, Kristleifur Dadason, Gudny R. Jonsdottir and a giant face controlled by artificially intelligent algorithms. The face told the sci-fi story of a prediction machine that realizes that the best way to predict the things is to manipulate them into happening, and its inevitable attempts to take over the world.

Intelligence is the foundation of all human activity.
The pursuit of intelligent machines
may be the most important endeavor
humanity can undertake.

REYKJAVÍK UNIVERSITY
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