



Ten Years of Elizabethtown Robotics and Machine Intelligence

J. Wunderlich Ph.D.

- ✦ *Lab Director*
- ✦ *Computer Engineering Program Coordinator (P&E and CS Departments)*



J. Wunderlich prior to 1999

- ★ Purdue Robotics
- ★ IBM Supercomputers
- ★ 1996 Ph.D. ECE, U.Delaware
 - robotic-arm design
 - factory automation
 - rehabilitation (A/ Dupont Hospital)
 - neural network chip design
- ★ 1992 M.Eng. PSU, Neural Net chip design
- ★ Professional Eng. (TX & CA)
- ★ 1984 BS Architectural Eng. UT(Austin)

PURDUE
UNIVERSITY

IBM®

University of Delaware
College of
Engineering

PENNSTATE
1855



THE UNIVERSITY OF TEXAS AT AUSTIN

Etown *Virtual* Lab founded in 1999

"Intelligent Machines to Benefit Humanity"

- ★ >150 students

- ★ >50 Senior Projects and Independent Studies

- CS/EGR 490/494 and 484

- ★ Many semester projects

- CS/EGR 230 Microcomputer Architecture

- CS 344 Simulation

- CS/EGR 332 Computer Org. and Design

- CS/EGR 333 Digital Design & Interfacing

- CS 375 Artificial Intelligence

- CS 434 AI and Robotics

- CS/EGR 433 Advanced Comp. Engineering

- ★ Leads to good jobs and grad-school

- ★ Phoenix-Contact, Lockheed-Martin, etc.

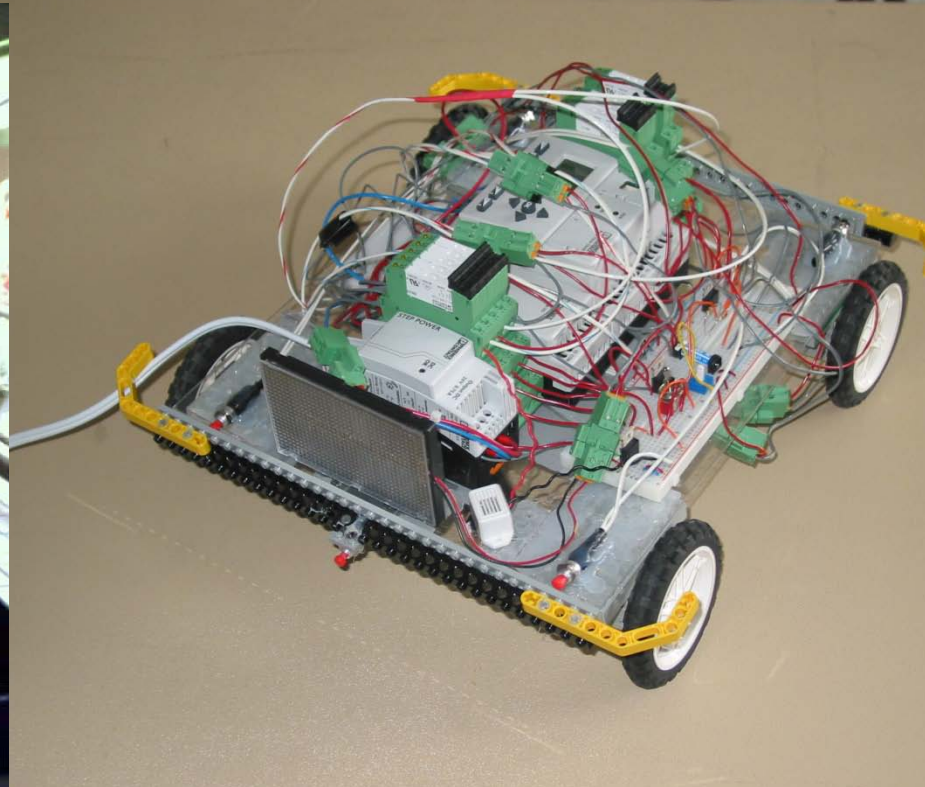
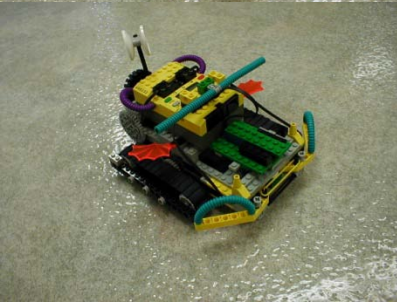
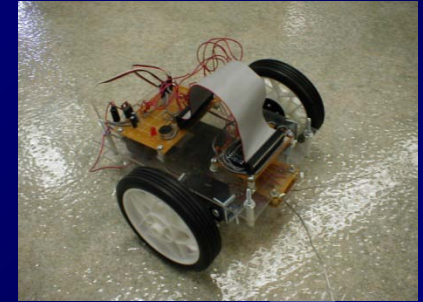
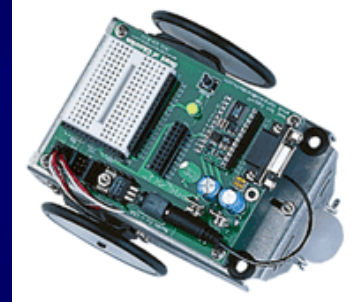
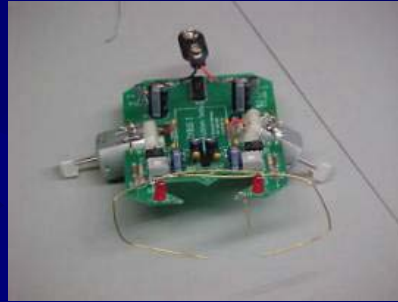
- ★ Stanford, Dartmouth, Notre Dame, U.Arkanasas, U.Mass, RPI, Drexel, etc.



Independent Student Research

- ✦ Many small projects by individuals
- ✦ Large projects by groups
 - ✦ But with individual accountability and glory

Some little Etown Robots



Some little Etown Robots



Some bigger ones



Many others

(no pictures taken)

- Neural Net Voice Recognizer (2000)
- Neural Net Character Recognizer (2002)
- “MultEbot I” (2002)
- Search and Rescue Robots (2002)
- Air Traffic Control Tester Robots (2002)
- Neural Net Chord Recognizer (2002)
- “Gollum” Mobile Robot (2002)
- Neural Net Vision System (2002)
- Neural Net Language Translator (2002)
- Full-scale Neural Net Simulator (2003)
- A.I. Psychological Analyzer (2003)
- Neural Net Music Harmonizer (2004)
- Autonomous Home Assistant (2005)

And some big ones

Ebot 1
"WunderBot 0"
(no picture available)

WunderBot I →



Wunderbot II



Wunderbot II News


- ** Nov. 6th - Invited to JLG industries for demonstration of Wunderbot and Tour
- ** Wunderbot II placed 12th in the Design Competition at the IGVC

Wunderbot II prototype demonstrated for Keck Foundation visitors



Wunderbot II visits JLG





Wunderbot II went to
National
Intelligent Ground Vehicle
Competition (IGVC)
in 2004

WunderBot III



Wunderbot III visits Phoenix Contact





WunderBot III at Intelligent Ground Vehicle Competition
(IGVC)

July 9-12, 2006
Selfridge air force base, MI

International Ground Vehicle Competition

TEAM



Dr. Wunderlich

David
Coleman

Juan
Rodreguez

Justin Shade

Brian Moran

Tom Yeager

James Painter

Shane
Rosencrance

PHOENIX
CONTACT



The Competition

- ★ Fourteenth year of competition
- ★ Autonomous! (so need path-planning !!)
- ★ Need Vision
- ★ Need GPS
- ★ “Ladar”
really helps!



- ★ 30 schools
- ★ Many >5000 students
- ★ Most have 100's of Engineering students
- ★ Some have thousands

- Virginia Tech
- Georgia Tech.
- U. Texas
- U. Wisconsin

★ International

- Japan
- India
- Canada



- ☀ Most have graduate programs
- ☀ Many have faculty dictating everything (not us !!)
 - (intent of competition is student work)



Arizona State University
Bluefield State College
Bob Jones University
Brigham Young University
California State University – Chico
California State University – Fullerton
California State University – Northridge
Case Western Reserve University
Cedarville University
College of New Jersey
Devry Calgary
Ecole de Technologie Superieure
Elizabethtown College
Georgia Tech
Hosei University
Kettering University
Lawrence Technological University
Oakland University
Rochester Institute of Technology
Trinity College
University of Alberta
University of Central Florida
University of Cincinnati
University of Colorado – Denver

University of Delhi
University of Detroit Mercy
University of Maryland – Baltimore County
University of Michigan – Dearborn
University of Minnesota – Duluth
University of Missouri – Rolla
University of Texas – Austin
University of Wisconsin – Madison
Virginia Tech



Four intense days



Four intense days



Working late into the nights



8:00 am Design Competition (talk and paper)



Judges



Ready to compete



Compete



Compete



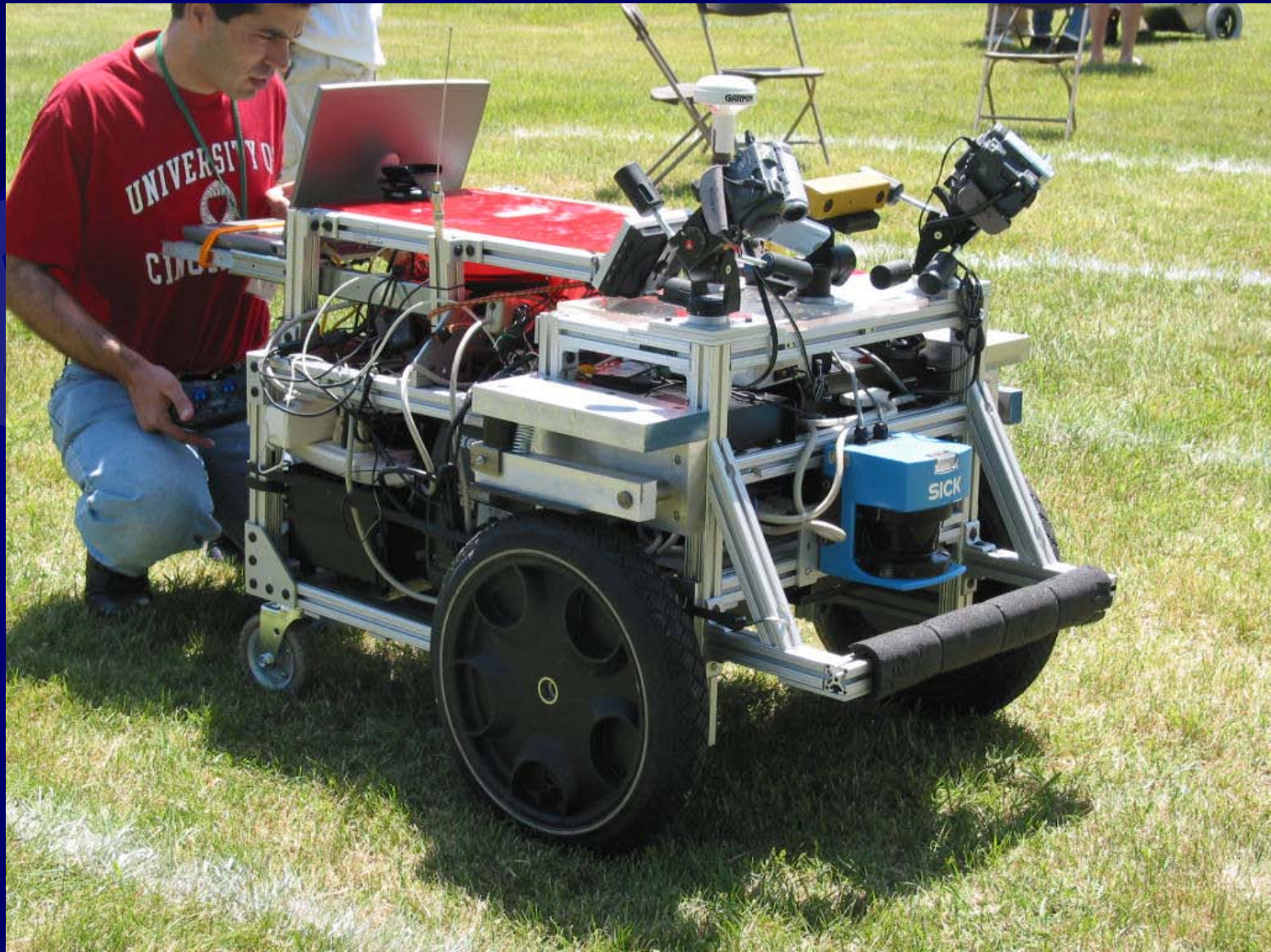
Compete



Competitors



University of Cincinnati



Georgia Tech



Kettering University



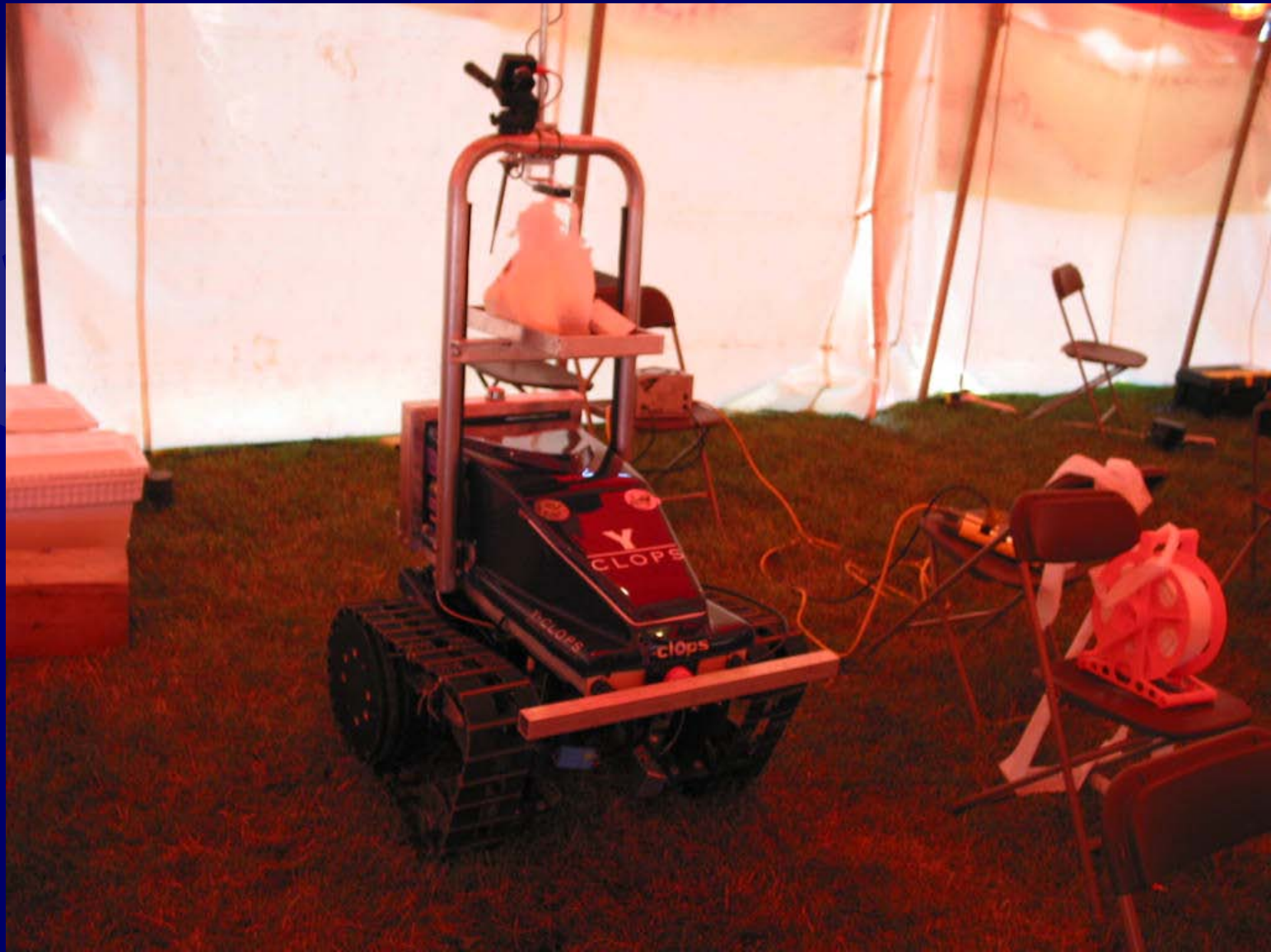
University of Texas



Bob Jones University



Brigham Young University



Case Western University



Oakland University



Honsei University (Japan)



University of Central Florida



Lawrence Technological University



University of Minnesota (Duluth)



Arizona State University



Bluefield State University



Trinity College



University of Wisconsin



University of Michigan, Dearborn





Rochester Institute of Technology



Ecole de Technologie Superieure (Canada)



University of Missouri, Rolla



Virginia Tech *(Robot #1)*



Virginia Tech *(Robot #2)*









Elizabethtown College











IGVC

IGVC

Retrosfour

PYLONS

Recent Happenings

- ★ 2007: AI and Robotics course officially in catalog
- ★ 2007: Sent student to Genoa, Italy for robotics research
- ★ 2008: New lab space opens
- ★ 2008: GREAT BS CENGR and BS ENGR Accreditation visit
- ★ 2008: Three new publications
- ★ 2008: Returned to Italy with student David Coleman
- ★ 2008: Florida Conference with NASA researchers
 - Put even more emphasis on space exploration into courses
- ★ 2008: Wunderbot IV 3rd time to national competition
- ★ 2008: Etown Robotics helps students into grad school
 - Stanford and U. Arkansas
- ★ 2009: Phoenix Contact nanoLC contest in CS/EGR 333
- ★ 2009: Robotic & AI for Space contest in CS/EGR 230
- ★ 2009: Return to Italy (3rd time) to teach Advanced Robotics course to U. Trento Ph.D. students

NEW OFFICIAL COURSE

CS/ENGR 434

“Artificial Intelligence and Robotics”
FALL 2007, Fall 2009

50% of course content previously taught in:

- CS 375 “Artificial Intelligence” (*Fall 2002, Fall 2004*)
- CS 344 “Simulation” (*Fall 2000, Fall 2001*)

Outstanding CS/EGR434 projects

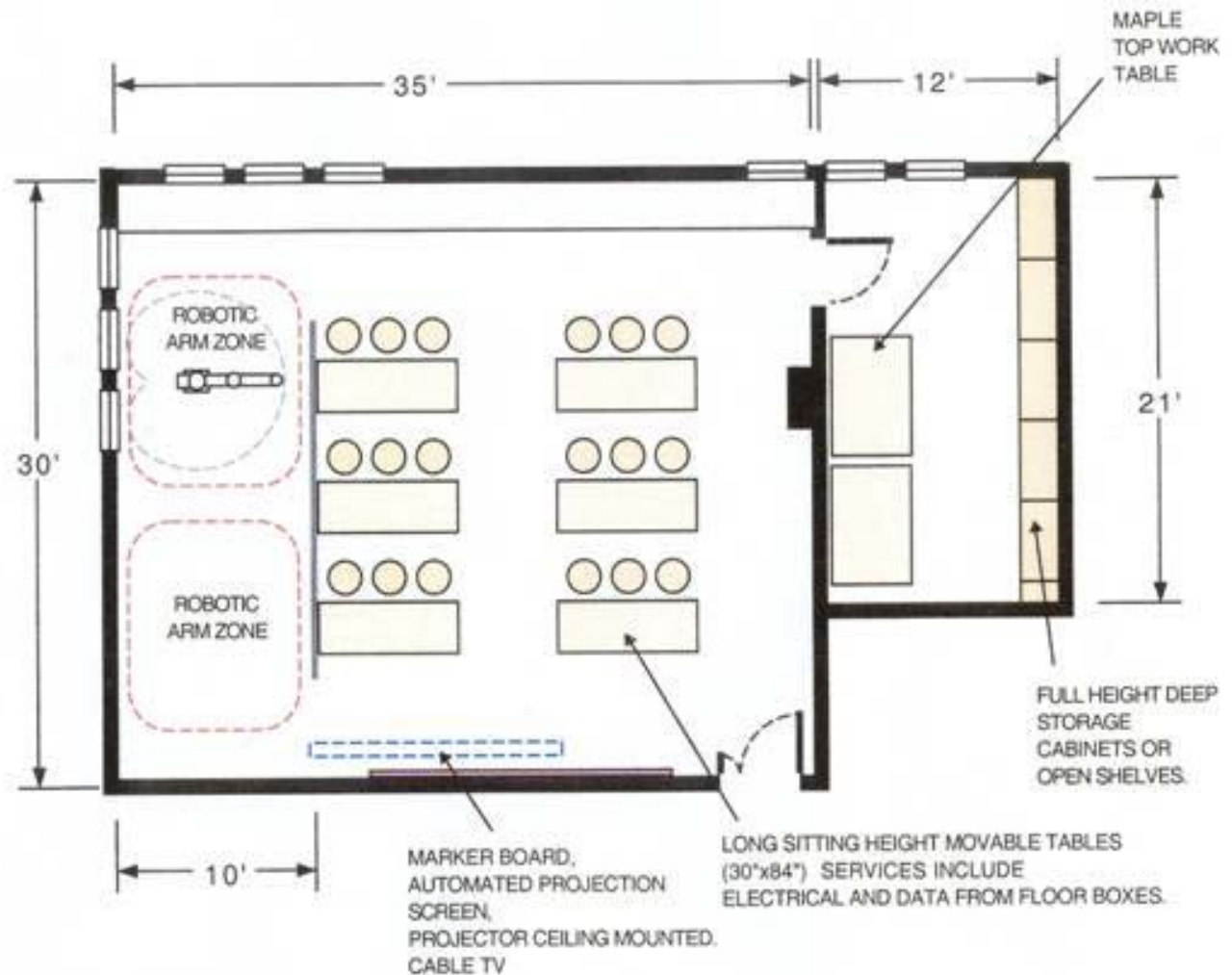


University of Genoa (Italy) and Italian Institute of Technology

- Dr. Wunderlich established relationship in 2004
- Juan Pablo Rodriguez (CENGR 07) sent for two weeks in 2006



New Robotics and Machine Intelligence Lab in new science building
(scheduled to open in 2008) 2003 preliminary design:



COMPUTER SCIENCE TEACHING LAB

ROBOTICS LAB & STORAGE - Rooms 3-100 & 3-101

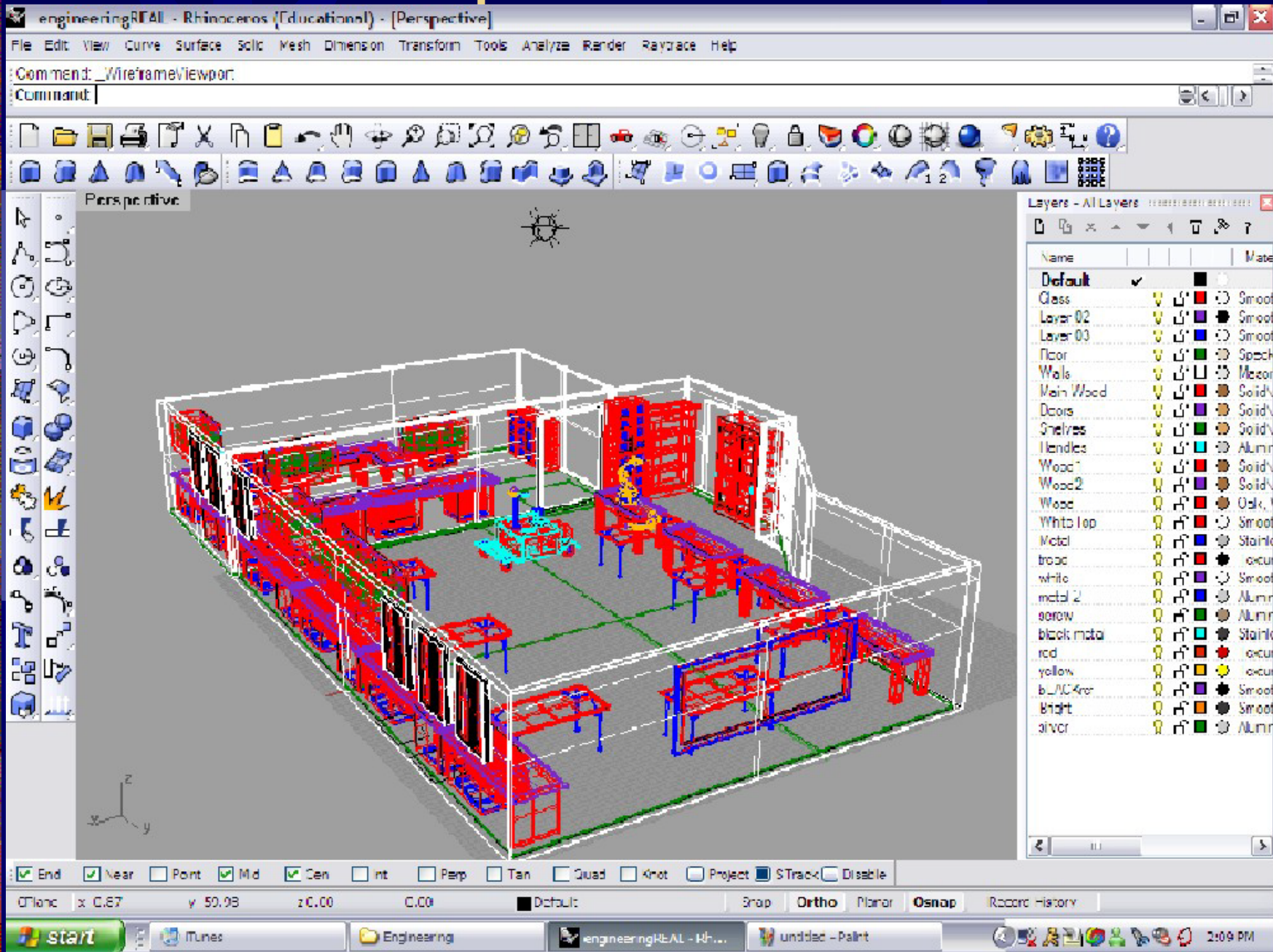
Elizabethtown College - Science, Mathematics, Engineering Center

SST PLANNERS
JANUARY 2003

New Lab Space



New Lab Space



New Lab Space



Excerpt from ABET Computer Engineering Self-Study (5/22/08)

Table 3-3. Table quantifying the contribution of each individual course to each ABET Program Outcome.

5 = Very strong support of ABET Program Outcome

4 = Strong support of ABET Program Outcome

3 = Moderate support of ABET Program Outcome

2 = Weak support of ABET Program Outcome

1 = Little or no support of ABET Program Outcome

YELLOW BOX = Course contributes significantly to this outcome AND examples are shown in A-K Outcome Binders.

Note: In addition to A-K Outcome Binders, every course also has a comprehensive Course Binder.

Courses	Program Outcomes										
	a	b	c	d	e	f	g	h	i	j	k
100 Introduction to Engineering I	2	3	3	5	3	3	4	3	3	2	3
110 Introduction to Engineering II	2	3	4	5	3	5	4	3	3	3	3
210 Circuit Analysis	5	4	3	2	4	2	3	2	2	2	4
220 Electronics ²	5	4	4	2	4	2	3	2	2	3	4
230 Microcomputer Architecture	3	1	3	1	4	4	5	5	5	4	3
310 Signals and Systems	5	1	1	1	5	2	4	1	2	2	5
332 Computer Organization & Architecture	5	1	5	1	5	4	4	3	3	1	5
333 Digital Circuits & Computer Interfacing	5	5	5	5	5	3	5	3	3	1	5
410 Control Systems	5	2	3	1	4	2	2	2	2	2	4
422 Operating Systems & Sys Programming	5	4	5	1	4	3	2	2	3	3	3
433 Advanced Computer Engineering	5	5	5	5	5	3	5	5	5	1	5
494 Senior Project in Computer Engineering	3	4	5	4	5	4	4	3	3	2	5
CS121 Computer Science I	5	5	5	3	4	4	2	3	5	5	5
CS122 Computer Science II	5	5	5	3	4	4	2	3	5	5	5
CS221 Algorithms and Data Structures	5	4	5	1	4	2	2	2	3	3	3
PHY200 College Physics I	5	5	1	2	4	2	4	1	2	1	3
PHY201 College Physics II	4	5	1	1	4	1	1	1	1	1	5
PHY202 College Physics	4	4	1	1	4	2	2	1	1	1	4
PHY302 Electromagnetism	4	1	1	1	4	1	1	1	1	1	5

Special Student/Faculty publications

Painter, J. and Wunderlich, J.T. (2008). **Wunderbot IV: autonomous robot for international competition.** In *Proceedings of the 12th World Multi-Conference on Systemics, Cybernetics and Informatics: WMSCI 2008, Orlando, FL*: (pp. xxx-xxx).

Coleman, D. and Wunderlich, J. T. (2008) Paper on Wunderbot IV Path-Planning and Environmental mapping (in peer review for international robotics conference in Italy)

Simione, D. and Wunderlich, J. T. (2003). “**Development of an object-oriented, scalable, back-propagating neural network simulation.**” In *Proceedings of IEEE SoutheastCon, Ocho Rios, Jamaica, [CD-ROM]*. IEEE Press.

Campos, D. and Wunderlich, J. T. (2002). “**Development of an interactive simulation with real-time robots for search and rescue.**” In *Proceedings of IEEE/ASME International conference on Flexible Automation, Hiroshima, Japan*: (session U-007). ASME Press.

Lister, M. and Wunderlich, J. T. (2002). “**Digital communications for a mobile robot.**” In *Proceedings of IEEE SoutheastCon, Columbia, SC. [CD-ROM]*. IEEE Press.

Other Related Research

Neural Network Hardware

★ Recent

Wunderlich, J.T. (2006). **“Two single-chip neurocomputer designs; one bottom-up, one top-down.”** [invited journal paper submitted for peer-review]

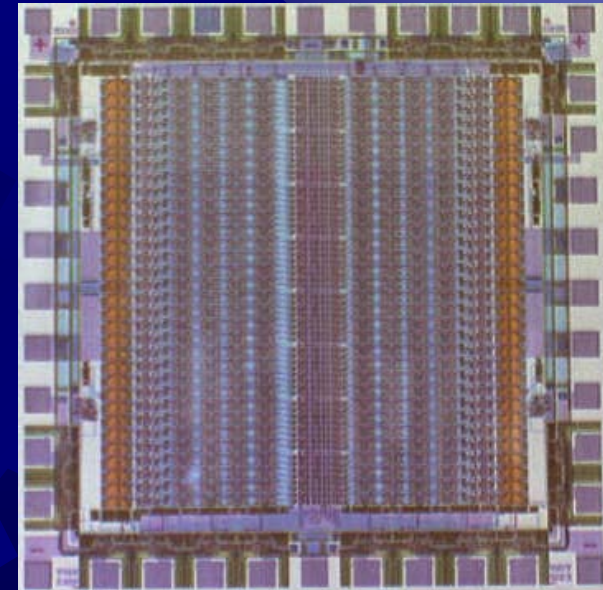
Wunderlich, J.T. (2004). **“Top-down vs. bottom-up neurocomputer design”**. In *Intelligent Engineering Systems through Artificial Neural Networks, Proceedings of ANNIE 2004 International Conference, St. Louis, MO*. H. Dagli (Ed.): Vol. 14. (pp. 855-866). New York, NY, ASME Press. ["Novel Smart Engineering System Design Award, 2nd runner-up best paper" from ~300 submissions]

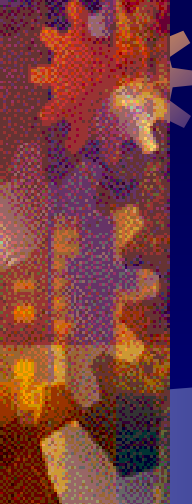
★ Past (1989-1993)

★ U. Del. →

★ PSU

★ patent disclosure





University of Trento (Italy)

David Coleman and Dr. Wunderlich 2008



University of Trento (Italy)

David Coleman and Dr. Wunderlich 2008



University of Trento (Italy)

David Coleman and Dr. Wunderlich 2008





Florida Conference with NASA researchers



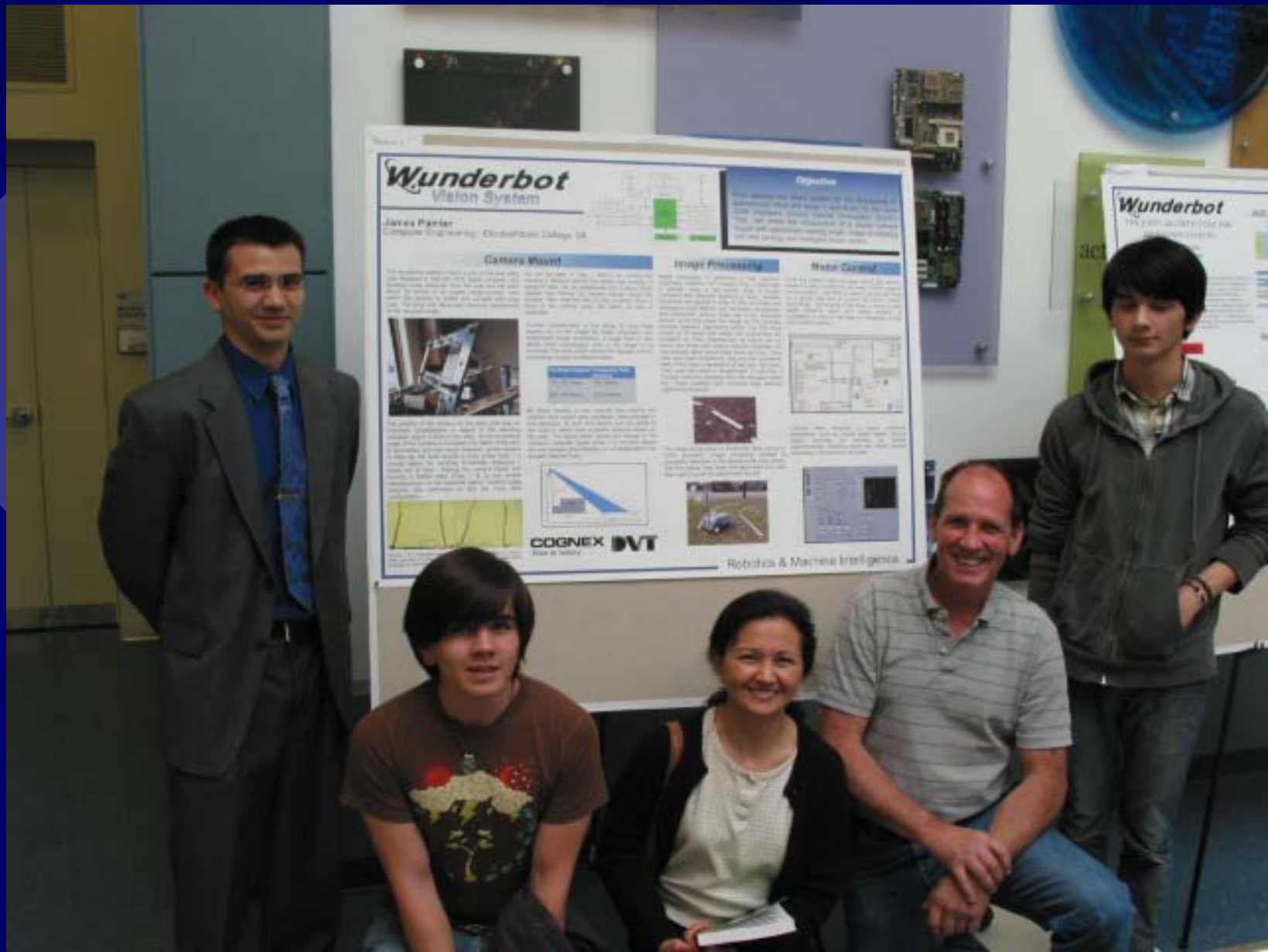
Wunderbot IV returned to National Competition (June 2008)

- ★ Design score ranked Wunderbot4 tied for 15th best score out of the 47 teams
- ★ Overall score ranked Wunderbot4 tied for 33rd place out of 47 teams (just above Princeton)
 - ★ Due to major power systems failure while implementing last minute systems integration
- ★ Only one of 8 teams to implement new wireless communication protocol (JAUS)
- ★ Pictures to come

Wunderbot IV



Wunderbot IV Vision (James Painter)



Wunderbot IV Path Planning (David Coleman)

OP
An Optimal and Opportunistic Path Planner
(with Obstacle Avoidance) using
Voronoi Polygons

David M. Coleman's, Computer Engineering
Research Advisor: Dr. Joseph Burchard

The OP Method

- 1. Define the Problem**
Generate an optimal path between a source
(Start) and a target (Goal) within a workspace.

- 2. Generate a Voronoi Diagram**
Apply the Voronoi diagram algorithm to the workspace.

- 3. Develop a Heuristic**
Reduce the search space of the diagram.

- 4. Prune the Search Space**
Eliminate search space through a heuristic.

- 5. Find the Optimal Path**
Apply the A* search algorithm to the search space.


Performance



The Wunderbot IV OP Method for the solution of a path planning problem (OP) is implemented in a software package that is available to the public. The software is available at www.wunderbot.com.

Robotics & Machine Intelligence

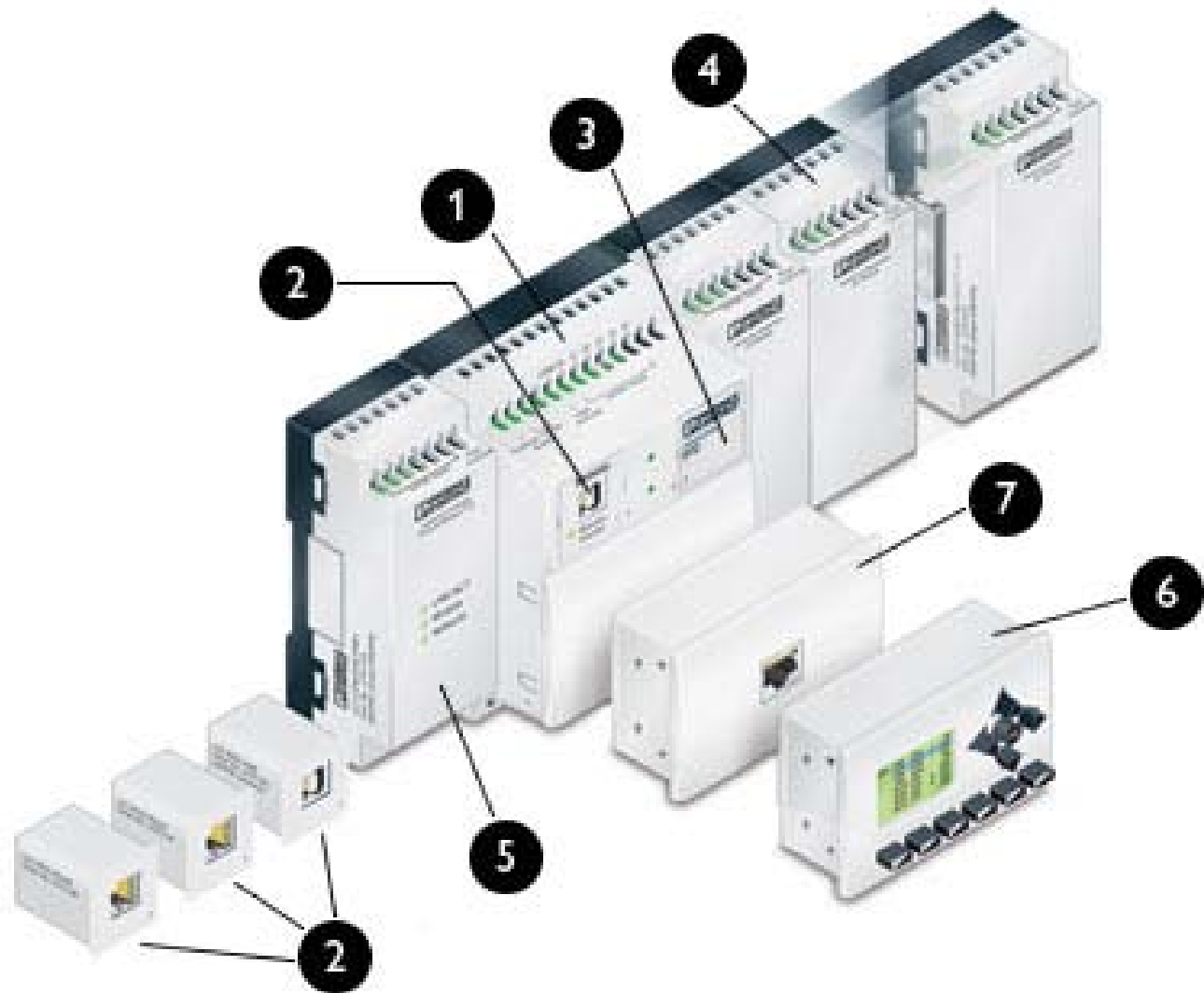
Wunderbot



Wunderbot IV Wireless Communication (Jeremy Crouse)



2009: Phoenix Contact nanoLC contest in CS/EGR 333



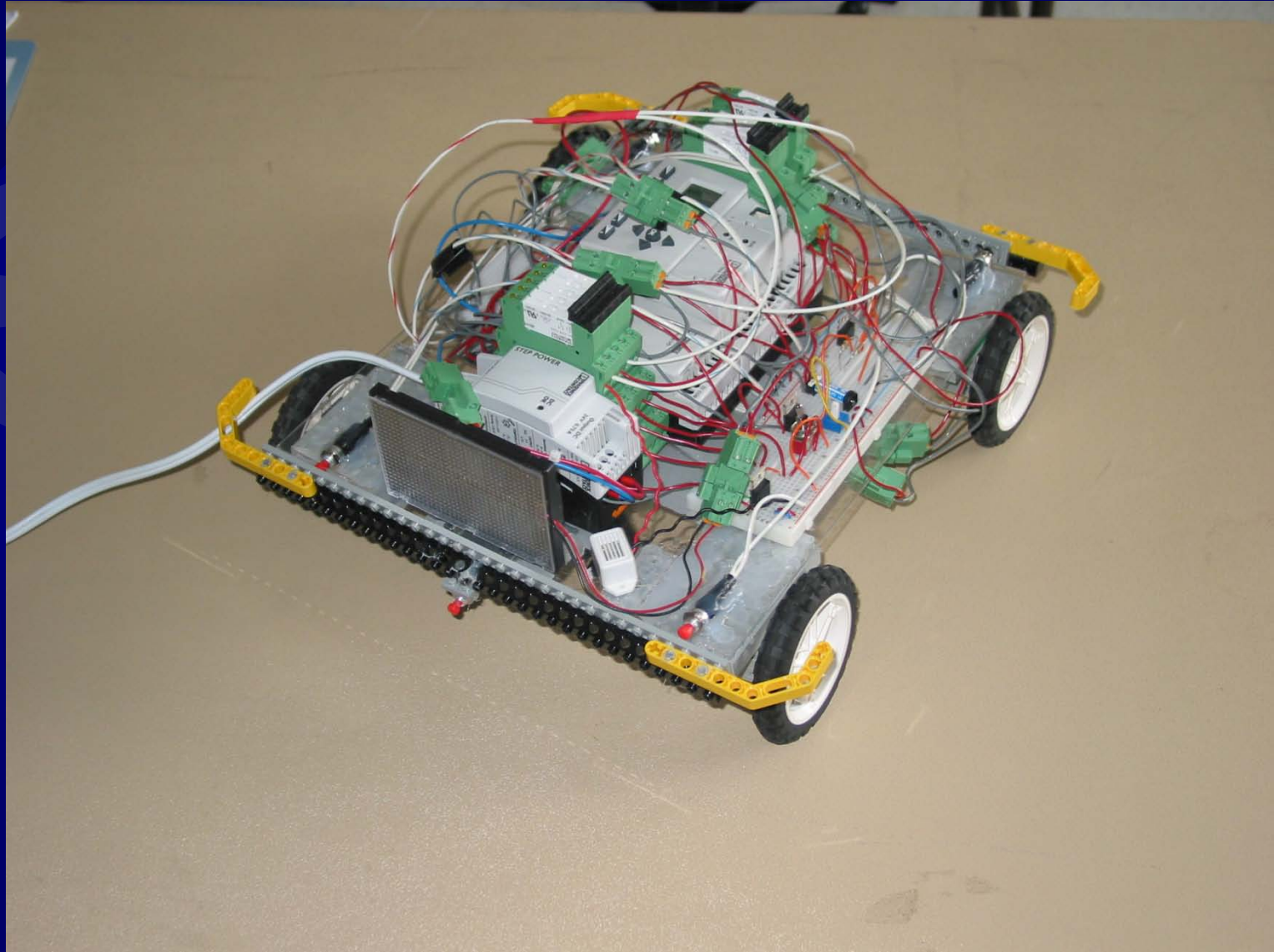
2009: Phoenix Contact nanoLC contest in CS/EGR 333



2009: Phoenix Contact nanoLC contest in CS/EGR 333



2009: Phoenix Contact nanoLC contest in CS/EGR 333



CS/EGR 230 Semester Projects

CONCEPTUAL DESIGN OF A SPACE-EXPLORATION RELATED ROBOT,
SPACE CRAFT, OR AI-CONTAINING COMPUTER SYSTEM

Educational Game for Exploring Space

by Kevin Christie

Exploring Space with AI

by Christine Miller

Mining Space

by Todd Lewellen and Kamron Malik

A Moon Station


by Michael Fleming

A Communications Probe

(Selected Talk for Today)

by Craig Rixham and David Tilesen





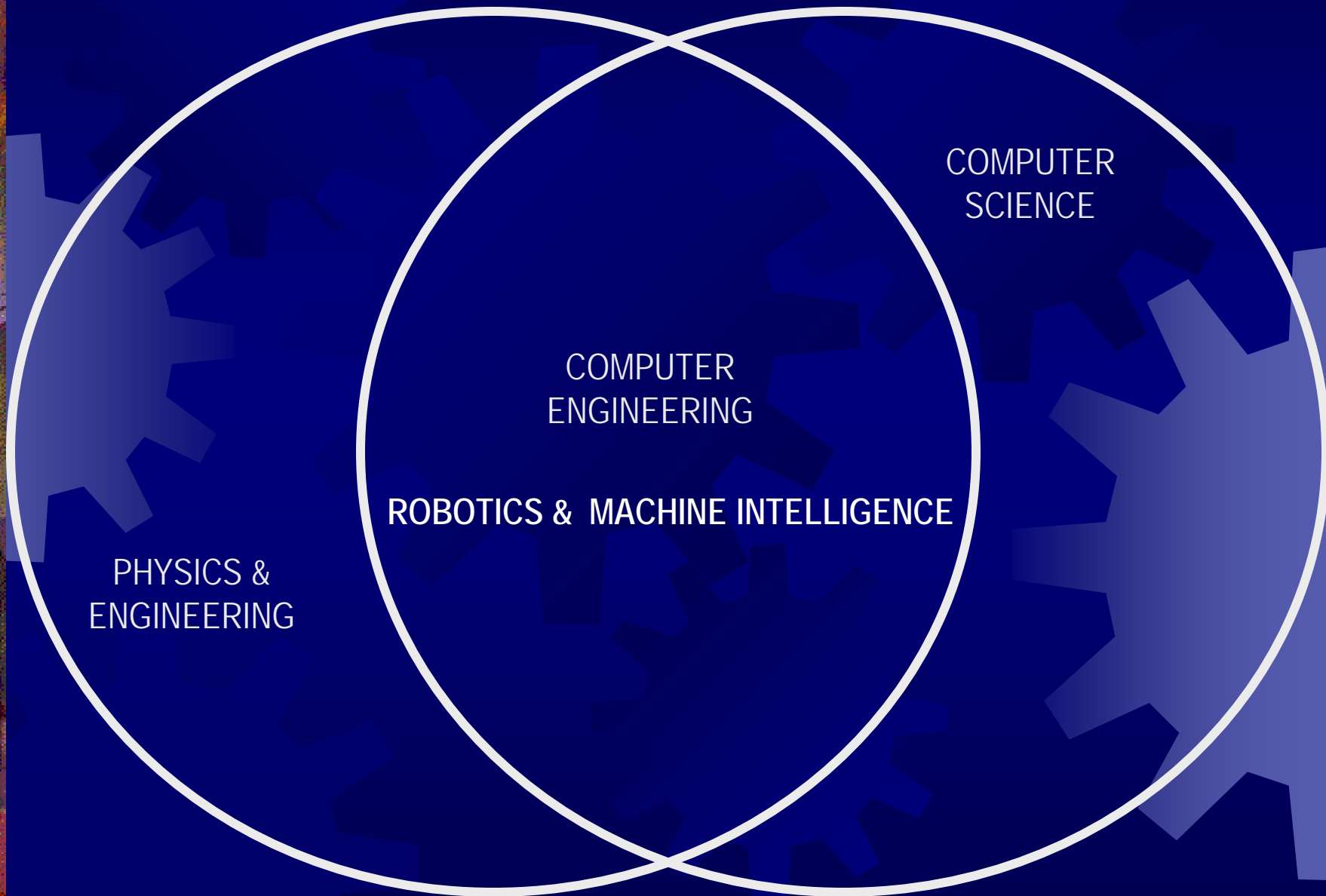
2009: Return to Italy (3rd time) to teach Advanced Robotics course to U. Trento Ph.D. students

- ★ <http://users.etown.edu/w/wunderjt/syllabi/EGRXXX%20Wunderlich,%20Joseph%20TRENTO.htm>

Future Summary

- ✦ Potentially new collaborations
- ✦ 2008/09 Grant proposals for robotic arms
- ✦ 2010 Wunderbot V returns to National Competition
- ✦ Also Rehabilitation robotics, Smart houses, Neural Network hardware, Psychology collaborations

HISTORY for all Projects (since 1999)



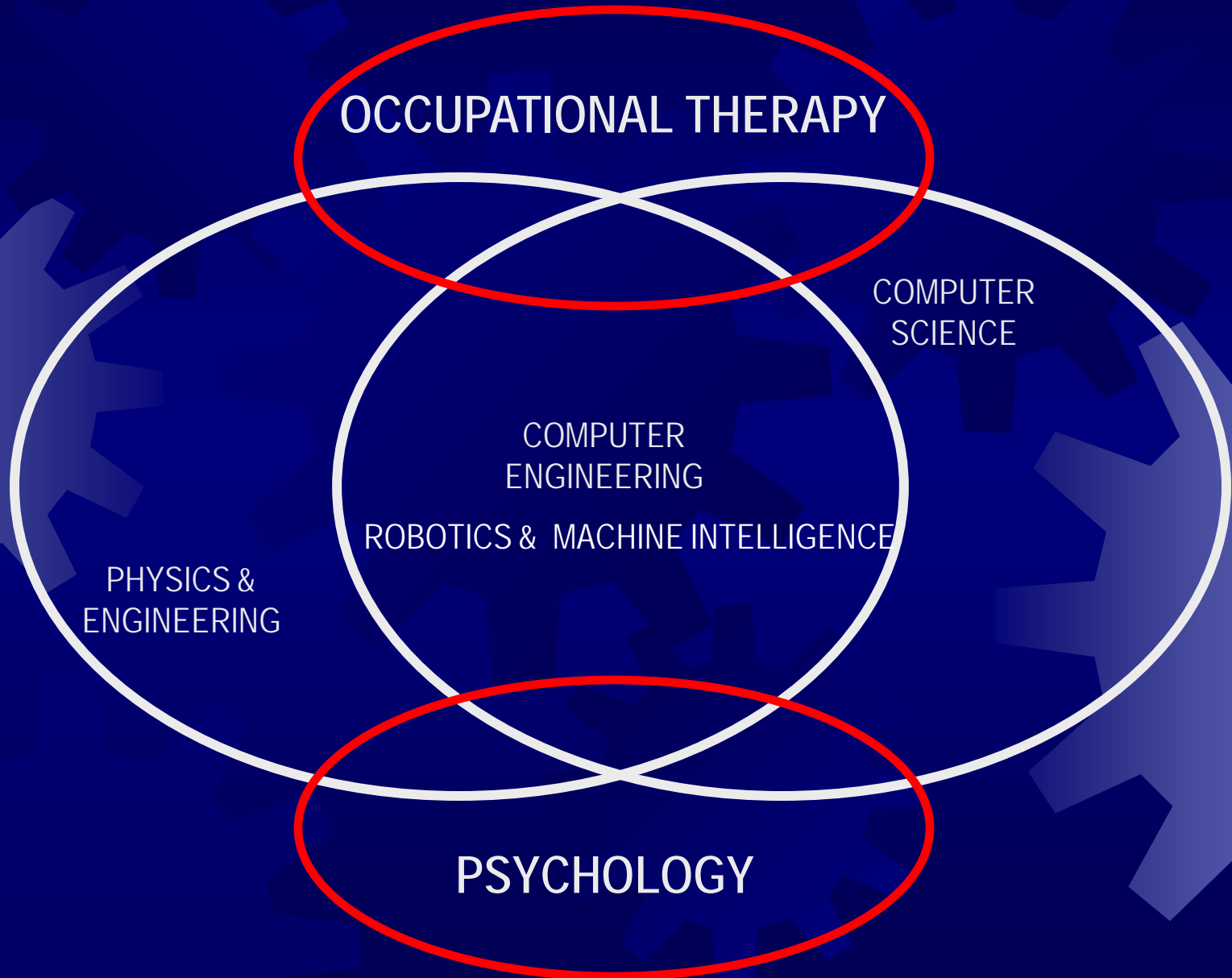
PHYSICS &
ENGINEERING

COMPUTER
SCIENCE

COMPUTER
ENGINEERING

ROBOTICS & MACHINE INTELLIGENCE

Potential New Collaborations



Old Robotic Arms



Recent Past Robotic Arms publications



Recent past

Wunderlich, J.T. (2004). **“Simulating a robotic arm in a box: redundant kinematics, path planning, and rapid-prototyping for enclosed spaces,”** In *Transactions of the Society for Modeling and Simulation International: Vol. 80.* (pp. 301-316). San Diego, CA: Sage Publications.

Wunderlich, J.T. (2004). **“Design of a welding arm for unibody automobile assembly,”** In *Proceedings of IMG04 Intelligent Manipulation and Grasping International Conference, Genova, Italy,* R. Molfino (Ed.): (pp. 117-122). Genova, Italy: Grafica KC s.n.c Press.

Past (1993-1996)

Wunderlich, J.T. and Boncelet, C.G. (1996). **“Local optimization of redundant manipulator kinematics within constrained workspaces,”** In *Proceedings of IEEE Int'l Conference on Robotics and Automation, Minneapolis, MN: Vol. (1).* (pp. 127-132). Piscataway, NJ: IEEE Press.

Wunderlich, J.T., S. Chen, D. Pino, and T. Rahman (1993). **“Software architecture for a kinematically dissimilar master-slave telerobot.”** In *Proceedings of SPIE Int'l Conference on Telem manipulator Technology and Space Telerobotics, Boston, MA: Vol. (2057).* (pp. 187-198). SPIE Press.



New Robotic Arms

- ★ Mike Patrick Research
 - (pictures to come)
- ★ New large Industrial Arms
 - Proposal in progress

Other Related Research

Future Smart-House Design

Recent and Future AI Theory and Philosophy / Psychology

Wunderlich, J.T. (2003). *“Defining the limits of machine intelligence.”* in *Proceedings of IEEE SoutheastCon Ocho Rios, Jamaica*, [CD-ROM]. IEEE Press.

Past and Future Rehabilitation Robotics

★ Past (1992-1994)

- Alfred I. Dupont Children’s Hospital
- Robotic-arms assist disabled

see robotic arm publications above



Return to Italy as Visiting Professor



Go to Japan to explore Robots (and other things)

