NTT-MIT Research Collaboration
http://www.ai.mit.edu/projects/ntt
Outline of Talk

- MIT - research partnerships
- MIT - structure, LCS/AI
- LCS/AI as labs
- Why we think it is a good idea for MIT
- Why we think it is a good idea for NTT
- Seventeen NTT-MIT projects
- Web site
- Some highlights
- Oxygen
- Summary
MIT-- Constant but Changing
MIT Research Collaborations

Amgen       Bio-tech
Ford        Automobiles
Merck       Pharmaceuticals
Merrill-Lynch Finance
Microsoft   Software
NTT         Telecommunications

All are five year projects with multiple faculty involved
MIT--Organized in Five Schools

- School of Engineering is about 2/3 of MIT students
  - has eight departments and two divisions

- Department of Electrical Engineering and Computer Science (EECS) has about 1/3 of all MIT students

- CS now has more than half of the EECS students
The Research Happens In Labs

All CS faculty at MIT belong to one of these two labs

Each has faculty from other departments (and other schools)
LCS and AI

- AI Lab founded in 1959, LCS in 1963 (as project MAC)
- AI Lab: 225 people, LCS: 500 people

AI occupies top 3 floors

LCS occupies bottom 6 floors
# The Top 20 U.S. Research Laboratories

<table>
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<th>Rank</th>
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**Stanford University**
Where many researchers want to work

**Carnegie Mellon University (CMU)**
Computer Science
Creating new centers to pursue key technologies

**MIT Laboratory for Computer Science**
Long a hotbed for new startups

**AT&T Labs**
Tied with Bell Labs, though only one-tenth as big

**Bell Labs**
(Lucent Technologies)
King-sized lab is awarded an average of three patents a day

**University of California-Berkeley**
Closing the gap with traditional leaders

**IBM Research**
Big Blue remains a research bulwark

**Xerox PARC**
Now generating startups, too

**MIT Artificial Intelligence Lab**
Has spun off 20 startup companies

**MIT Media Lab**
Keeps on making news—and waves

**Microsoft Research**
A five-year-old newcomer leaps ahead

**CMU Robotics Institute**
Its robots aren't just for factories

**Santa Fe Institute**
Very strong in complexity research

**University of Illinois-Urbana**
Mosaic and Netscape started here

**University of Southern California**
Its Information Sciences Institute is a star

**University of Michigan**
Good marks in artificial intelligence

**University of Washington**
Rapid rise in standing since 1970s

**Georgia Institute of Technology**
Has new Advanced Telecommunications Center

**California Institute of Technology**
Leader of a new program in quantum computing

**Cornell University**
An Ivy League computer pioneer
Some LCS Innovators

Ward
Workstation/
NuBus

Clark
Internet

Metcalf
Ethernet

Dertouzos
Information
Marketplace

Berners-Lee
WWW

Rivest
RSA
Encryption

Zue
Speech
Interfaces

Corbato
Time Sharing

Frankston
SpreadSheet

Zue
Speech
Interfaces

Szołovits
Guardian
Angel

Musashino, January 13, 2000
Rodney A. Brooks
Some AI Lab Innovations

- 1959 LISP -- first computer language with
  - conditional expressions
  - storage management
- 1965 MacHack -- first tournament level chess program
  - all major features found today in Deep Blue
  - first real implementation of alpha-beta search
- 1967 First megabyte memory
- 1968 Macsymma -- first widely available computer algebra system
- 1972 First RAM-based bit-mapped display
- 1972 VICARM -- prototype of first commercial electric robot arm
- 1972 SHRDLU -- first natural language interface to a computer
- 1973 Actors -- precursor to object oriented programming
- 1975 Chess machine -- special purpose computer
- 1976 Chaosnet -- concurrent with first ethernet
- 1976 Lisp machine -- first personal workstations
- 1979 First special purpose vision chip
- 1982 Digital Orrerey -- first supercomputer in a box
- 1982 Connection Machine
- 1988 Small mobile robots -- direct precursor to 1997 Mars mission
- 1993 White House publication system
- 1993 PHANTOM -- first commercial haptic interface system
- 1997 Daily image guided brain surgery
Distribution of People - 1999

Musashino, January 13, 2000

Rodney A. Brooks
Research Sponsorship - 1999

Funding

- 61% DARPA
- 33% Government (Other)
- 6% Industry

Funding

- 65% DARPA
- 21% Government (Other)
- 14% Industry
Why MIT Likes Working with NTT

- MIT Computer Science has been driven since the 1960’s by the needs of US defense
- The world situation has changed over the last few years
- We believe that it is important for us to be driven by a more commercial set of fundamental issues

- NTT is a large scale player in telecommunications and multimedia
- It has a culture of understanding the importance of basic research
Why We Think it’s Beneficial to NTT

• In the US the model of innovation into large companies has been augmented
  – large companies still have good internal research labs (Microsoft, Compaq, IBM, AT&T, Lucent, Xerox, etc.)
  – but, they also buy many small companies

• Small companies are a major source of innovation
  – there is a much stronger tradition of entrepreneurial small companies in the US than in Japan or Europe
  – but, it may be hard for foreign companies to absorb small US companies into their main stream

• But where does the innovation come from?
  – largely it is from research students coming out of the major research universities: MIT, CMU, Stanford & Berkeley

• NTT gets direct access to these students and their ideas at the pre-competitive stage
The Collaboration

• Began July 1st, 1998
  – first year had seven projects
  – MIT faculty and NTT researchers
    • many visits to NTT from MIT faculty
    • many visits to MIT from NTT researchers (for varying lengths of time)
  – all projects were renewed for a second year

• Second year began July 1st, 1999
  – ten new projects
  – each project has NTT collaborators
First Year Projects; 1998-2000

- **WIND: Wireless Networks of Devices**
  - Hari Balakrishnan and John V. Guttag; Minoru Katayama

- **Multilingual Conversational Speech Research**
  - James Glass and Stephanie Seneff; Kiyoaki Aikawa

- **Research in Cryptography, Info Security and Algorithm Dev.**
  - Shafi Goldwasser, Ronald L. Rivest, and Mike Sipser; Tatsuaki Okamoto

- **Self-updating Software**
  - Barbara Liskov and Daniel Jackson; Minoru Kubota

- **Variable Viewpoint Reality**
  - Paul Viola and Eric Grimson; Ken’ichiro Ishii

- **Image Database Retrieval**
  - Paul Viola; Tsutomu Horikoshi

- **Interactive Sculpting of Virtual 3D Materials**
  - Julie Dorsey and Leonard McMillian; Tsutomu Horikoshi
Second Year Projects(1); 1999-2000

- **Malleable Architectures for Adaptive Computing**
  - Arvind, Larry Rudolph, and Srinivas Devadas; Hiroshi Sawada

- **A Framework for Automation Using Networked Information Appliances**
  - Srinivas Devadas and Larry Rudolph; Satoshi Ono

- **Haystack: Per-User Information Environments**
  - David Karger and Lynn Andrea Stein; Kazuhiro Kuwabara

- **Learning Rich, Tractable Models of the Real World**
  - Leslie Pack Kaelbling; Shigeru Katagiri

- **Digital Control and Communication in Living Cells**
  - Tom Knight and Gerry Sussman; Hitoshi Hemmi
Second Year Projects(2); 1999-2000

- Building Blocks for High-Performance, Fault-Tolerant Distributed Systems
  - Nancy Lynch and Idit Keidar; Kiyoshi Kogure

- A Synthetic-Aperture Camera Array
  - Leonard McMillian and Julie Dorsey; Hiroshi Murase

- Adaptive Man-Machine Interfaces
  - Tomaso Poggio; Norihiro Hagita

- High Resolution Mapping and Modeling of Multi-Floor Architectural Interiors
  - Seth Teller; Tsutomu Horikoshi

- Human-Robot Dynamic Social Interaction
  - Rodney Brooks; Katsunori Shimohara
Current Status

• 17 projects

• 28 MIT faculty members
17 Projects in 5 Broad Areas

- Man-Machine Interface: 4 projects
- Networks: 5 projects
- Content: 3 projects
- Information Management: 3 projects
- Architectures: 2 projects
Areas of Research (1)

• **Man-machine interface**
  - Multilingual Conversational Speech Research
  - Adaptive Man-Machine Interfaces
    - Interactive Sculpting of Virtual 3D Materials
  - Human-Robot Dynamic Social Interaction

• **Networks**
  - WIND: Wireless Networks of Devices
    - Self-updating Software
    - Cryptography, Info Security and Algorithm Development
    - Automation Using Networked Information Appliances
    - High-Performance, Fault-Tolerant Distributed Systems
Areas of Research (2)

- **Content**
  - Mapping and Modeling of Architectural Interiors
  - A Synthetic-Aperture Camera Array
  - Variable Viewpoint Reality

- **Architectures**
  - Malleable Architectures for Adaptive Computing
    - Digital Control and Communication in Living Cells

- **Information Management**
  - Image Database Retrieval
    - Haystack: Per-User Information Environments
    - Learning Rich, Tractable Models of the Real World
Collaboration Web Site

- **http://www.ai.mit.edu/projects/ntt**
  - *username:* NTTMIT
  - *password:* collaboration

- **information on all the current projects**
  - project overviews
  - recent updates and breaking news
  - presentations, online papers
  - progress reports
  - links to related research
  - scripts for NTT and MIT researchers to add
    - comments
    - content
A Page for Each Project

Variable Viewpoint Reality

9807-28
Start date: 07/86

Project summary

This work synthesizes information from many different cameras to produce arbitrary viewpoints of sporting or entertainment events.

Project description

In the foreseeable future, sporting events will be recorded in super high fidelity from hundreds or even thousands of cameras. Currently, the nature of television broadcasting demands that only a single viewpoint be shown, at any particular time. This viewpoint is necessarily a compromise and is typically designed to displease the largest number of viewers.

In this project we are creating a new viewing paradigm which will take advantage of recent and emerging methods in computer vision, virtual reality and computer graphics technology, together with the computational capabilities likely to be available on next generation machines and networks. This new paradigm will allow each viewer the ability to view the field from any arbitrary viewpoint — from the point of view of the ball being played towards the soccer goal, or from that of the goalie defending the goal, or as the quarterback dropping back to pass, or as a hitter waiting for a pitch.

In this way, the viewer can observe exactly those portions of the game which most interest him, and from the viewpoint that most interests him (e.g., some fans may want to have the best view of Michael Jordan as he sails toward the basket, others may want to see the world from his point of view).

Demos, movies and other examples

Our current system consists of a set of cameras, distributed around an open working area. These cameras can automatically self-calibrate, so that their input can be coordinated.
The OXYGEN Project

• A new project started in AI and LCS in mid-1999

• We expect it to grow to cover approximately one third of our two laboratories

• We view our new building as a target of opportunity for building the Oxygen project on a very large scale
Oxygen: Goals and Vision

• Goal: Help people “do more by doing less”
  – bring information technology to people
  – increase ease of use
  – increase human productivity, 300% possible

• Vision: To bring an abundance of computation and communication within easy reach of humans
  – through natural perceptual interfaces of speech and vision
  – so computation blends into peoples’ lives
  – enabling them to easily do tasks they want to do -
    • collaborate, access knowledge, automate, and customize
Translating the vision...Oxygen System

1. Speech and vision
2. Automation & customization
3. Individualized knowledge access
4. Collaboration

Physical systems
Software Env
User technologies

Musashino, January 13, 2000
Rodney A. Brooks
Whose World?

• **That was then:**
  – people enter the computational world, they go to a computer
    • more recently they lug it around
    • it doesn’t care, nor is aware, whether they are even there
  – virtual reality makes this even worse…

• **This is now:**
  – Computation to enter the human world, and understand the goals, intentions, and desires of people
  – To be freely available everywhere, like batteries and power sockets
Oxygen Funding

- US Government
- Negotiating with European Union

- Setting up an industrial consortium
  - speaking actively to many companies
  - these companies will come from a spectrum of different interests (e.g., chip manufacturers, computers, software, etc.)
  - companies will contribute research funds
  - companies benefit by being part of the research

- Of course, NTT is already such a close collaborator, that NTT is a member by virtue of our existing arrangement
Summary

- We are 18.5 months into a five year collaboration
- The collaboration has established many relationships between NTT and MIT researchers
- Visits between the groups are commonplace
- MIT is very interested in finding new research challenges that are driven by NTT’s strategic needs
- MIT is very grateful for close intellectual interactions
- LCS and AI are strong advocates for NTT and feel very fortunate to be working with such a strong group