SRI International

PRACTICAL ROBOTICS

Perspectives in Assistive Technology Course
March 4, 2010

Rich Mahoney, PhD
Director of Robotics, Engineering & Systems Division

Professional Highlights

- Research Phase
  - 1988 B.S.M.E., Drexel University, Philadelphia
  - 1990 M.S.M.E., Drexel University, Philadelphia
  - 1994 Ph.D. Engineering, Cambridge University, Fulbright Student
- R&D Phase
  - 1994-1997 Principal Investigator, Co-Director of Robotics Lab, Applied Science and Engineering Labs, University of Delaware
- Commercialization Phase
  - 1997-2004 Director of Business Development, Rehab Technologies Division, Applied Resources Corp.
  - 2004-2008 General Manager, Motorika USA, Inc.
- R,D, & Commercialization
  - 2008 – Present Director of Robotics Engineering & Systems Division, SRI International

Market survey of visual inspection for manufacturing

Introduced wheelchair-mounted robotic aid in USA

Robotic Stroke Therapy Aid

Broad applications of advanced robotic technologies

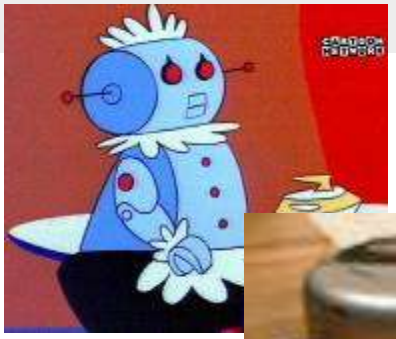
Take-aways for today

- Layperson's insight on the state of robotics
- My perspectives on how to bring a new robot product (or any innovation) to market

What is a robot?

A **reprogrammable, multi-functional** manipulator designed to interact physically with a person and the personal environment to [illegible]estore function.

A robot integrates **sensor information**, user input, and kno[illegible] and [illegible]ment t[illegible] to the [illegible] and t[illegible]

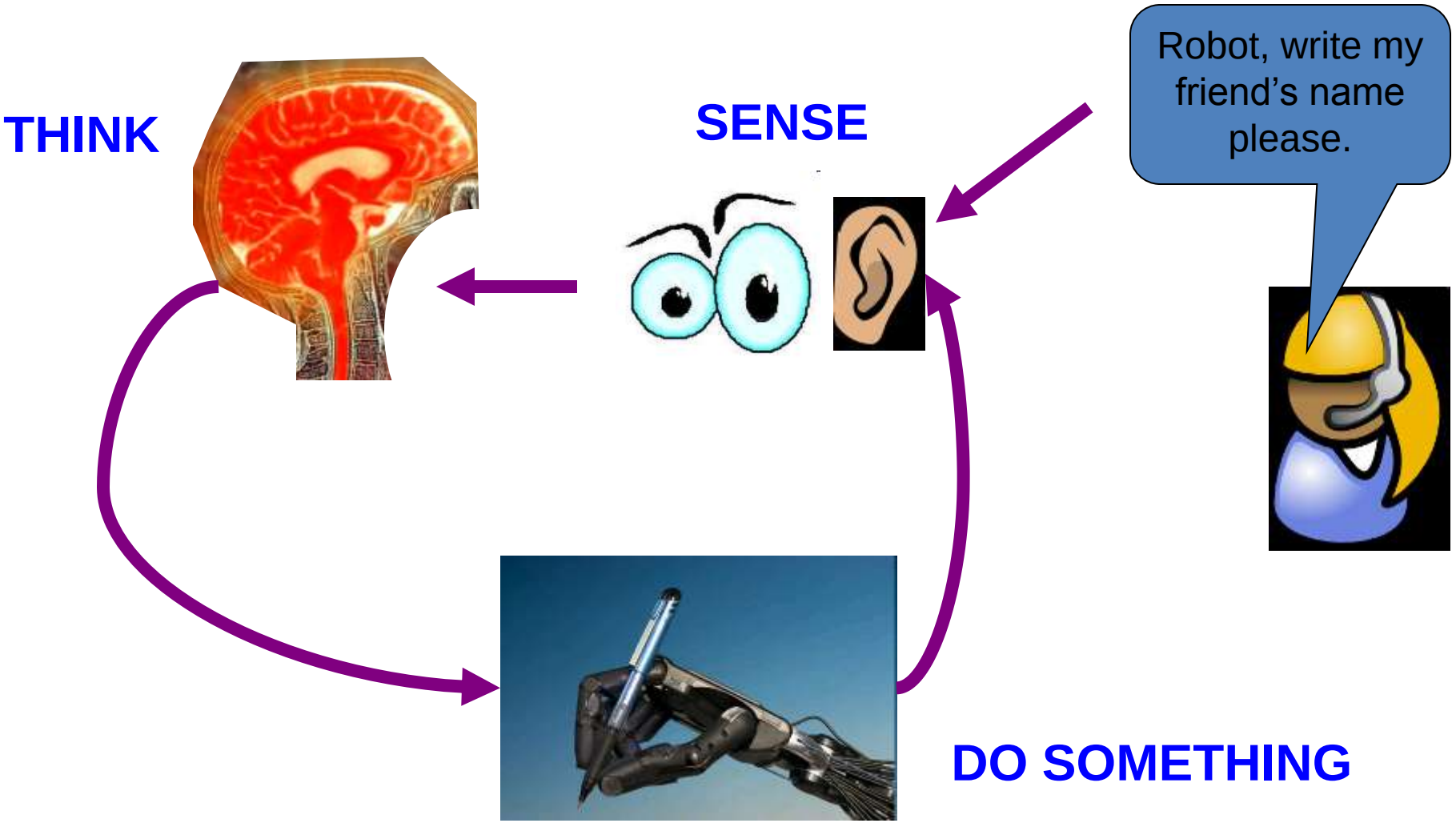


A robot is an automatic device that performs **functions normally ascribed to humans** or a machine in the form of a human.

WHY

We don't want to do it!
We don't have the time to do it!
A robot can do <u>some</u> things better.

Robots are Automatic



The Power of Robots (not just automation)

- Flexibility
  - Variability in task itself
  - Expanding to other tasks
- Data
  - Specification of task
  - Measurement of task
- Automation of labor intensive manual tasks (classic application for robotics)

- Biggest benefits to date
  - DO THINGS FASTER
  - DO BORING OR DANGEROUS TASKS

Advantage, Robot

Handy 1

self feeding

grooming

make-up

Robots are Everywhere

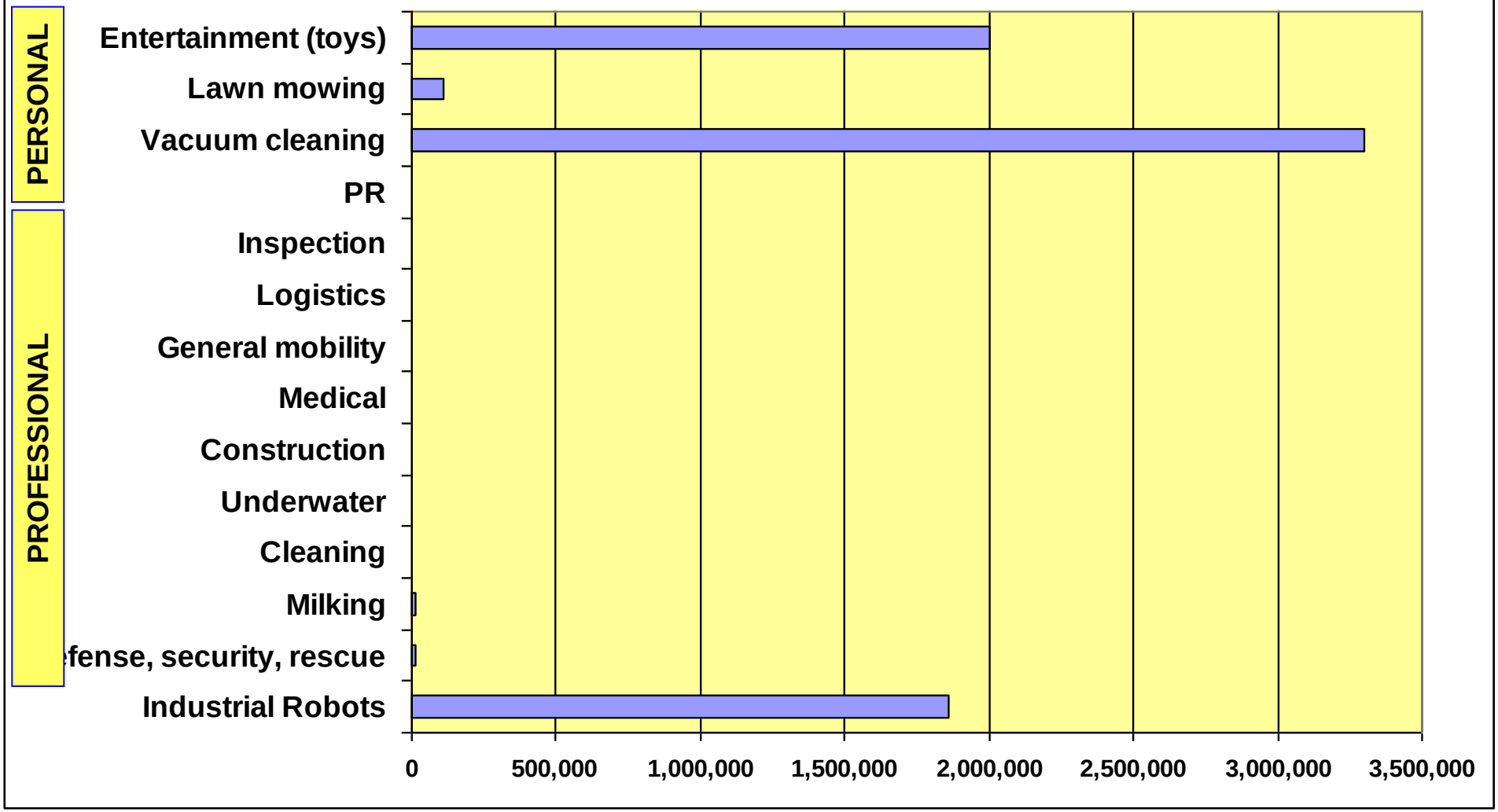
Intuitive Surgical Claims

- Intuitive Surgical
  - Taking surgery beyond the limits of the human hand.
- Enhancing Surgical Capability
  - da Vinci Surgical System
  - The breakthrough platform for minimally invasive surgery.
- Improving Clinical Outcomes
  - Bringing the benefits of minimally invasive surgery to the broadest possible base of patients.
- Driving Operational Efficiencies
  - Market share growth, clinical efficiency and overall system wide benefits.

Intuitive Lawncare Claims

- Intuitive Lawncare
  - Taking Lawncare beyond the limits of the human hand.
- Enhancing Lawn care Capability
  - Picasso Lawn Care System
  - The breakthrough platform for automated lawn care.
- Improving Lawn Services
  - Bringing the benefits of automated lawn care to the broadest possible base of clients.
- Driving Operational Efficiencies
  - Market share growth, work efficiency and overall system wide benefits

Robot Installations to Date (2007) by Category



The Future

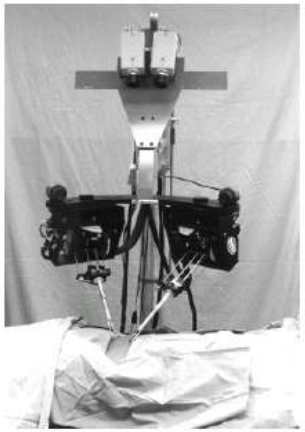
What's going on?

- Military is expanding interest to ALL aspects of operations
- Initial consumer robotics companies (toys and home services) have demonstrated commercial success and are growing
- Top universities have been training Roboticists - for decades
- Hobby and high school based robotics clubs are booming
- Governments around the world are investing in robotics to solve emerging elder care needs
- Several successful investments have investors willing to explore robotics as a technology (iRobot, Intuitive Surgical)
- STAY TUNED!
- BUT …
  The transition to successful commercial application is difficult

The M4 and Da Vinci

- Technologies:
  - The first minimally invasive robotic surgical system
  - The first telepresence system
- Market Value:
  - Surgical automation
  - Remote and dangerous locations
- Commercialization:
  - Patent portfolio licensed to Intuitive Surgical, an SRI spin-off company
  - Highly successful public company
    - $10b market cap
    - 200,000 procedures
    - 100's of units sold/year

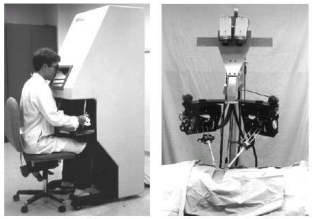
Workstation



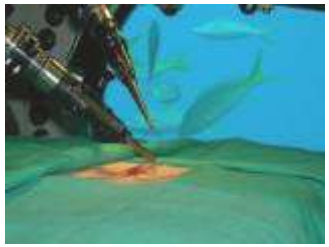
Remote Surgical Unit

Telepresence and Dexterous Manipulation

4-DOF Tele-operated Surgical Robot



Extreme Environment Tele-robotics

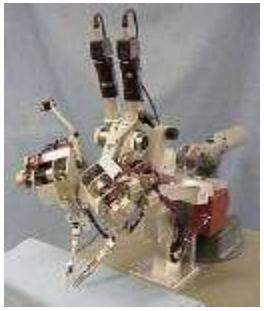


Surgical Telementoring System

7DOF Remote Open Surgery System

1992 — 2009

daVinci Laparoscopic Surgical Robot



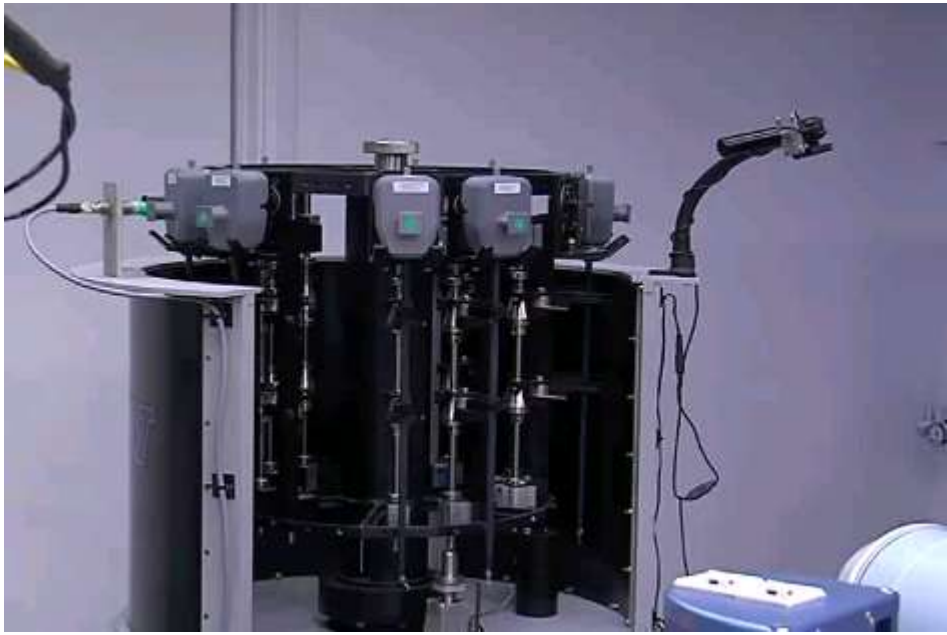
Microsurgery System

Robotic Laser Tissue Welding

Integrated Robotic Operating Room

Trauma Pod Prototype

- Technologies:
  - Proof of concept for battlefield surgical care
  - Fully automated surgical suite
  - Advanced human-robot communication
- Commercialization:
  - Subsystems under evaluation in medical device market



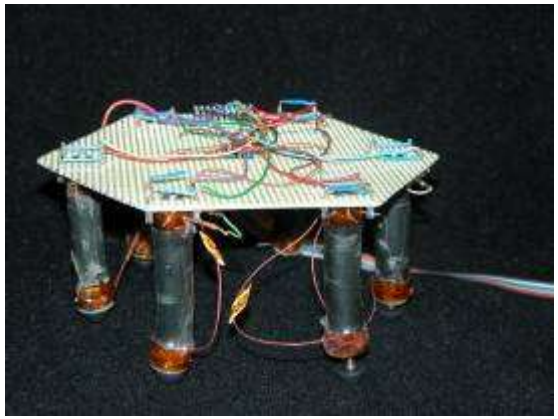
Trauma Pod tool-changing video

The M7 - Highly Dexterous Telepresence Platform

- Technologies:
  - Advanced platform for deployed, dexterous telemanipulation
- Market Value:
  - Remote expertise, safety, and security
- Commercialization:
  - Design for manufacturing under way
  - Development for bomb disposal, biohazard handling, and undersea recovery

Redefining the Design Space for Next-Gen Robotics

- Electro-active Polymers - EPAM
- Meta-materials
- Electro-adhesion
- State of the Art Artificial Intelligence and Data Analytics
- Video and Speech Content Extraction



HOW DO WE GET ROBOTICS INTO THE REAL WORLD?

Practical Success

- Follow the Task – Why robotics?
  - How can flexibility and data achieve the task?
  - How can flexibility and data lead to greater opportunities?
- Follow the money - Who will pay for the robotic product?
  - How much will they pay? What tangible business benefit can you articulate? How will you save money or make more money
- Define the minimum necessary product
  - Meet all of the requirements for that market (FDA, FCC, etc.)
- Find early adopters
  - Take care of them with caring people
- Evolve the product in the market
- Expand the uses as possible
- Use Data to establish standards

Robot facilitated neuro rehabilitation

- recovery of arm function for stroke patients.

- Automate labor intensive neurorehabilitation
  - High repetition
  - Functionally oriented
- Actively collect data
  - Document therapy activity
  - Direct assessment of patient outcomes
- Precise delivery and measurement of therapy

Reo™ Therapy

The Reo GO

Laptop PC

Travel Handle

Post for travel handle and laptop tray

Operation Panel

0/30 deg tilt button

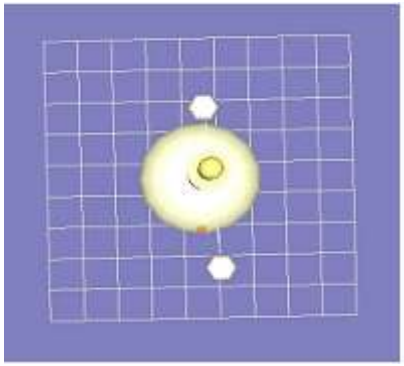
Travel Casters

'Quick disconnect' Handle feature.

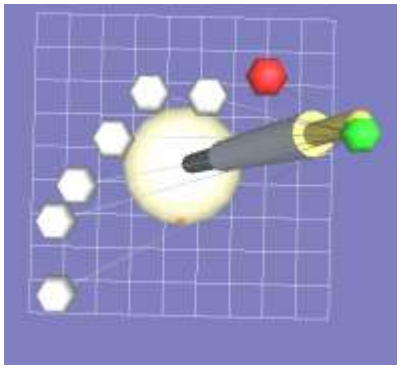
Moving Mast

0/30 deg tilted DMU

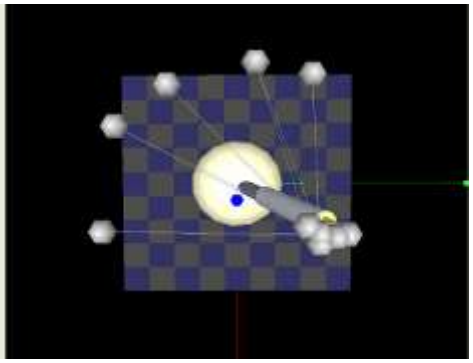
Exercise Patterns



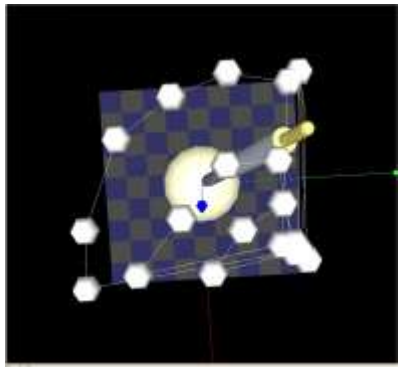
Thrust



Horizontal Reach



Forward Reach



Horizontal Abduction

3D Forward Reach

Reo video

Clinical Benefits

Start

After 3 Weeks

Market Progress – less than 3 years

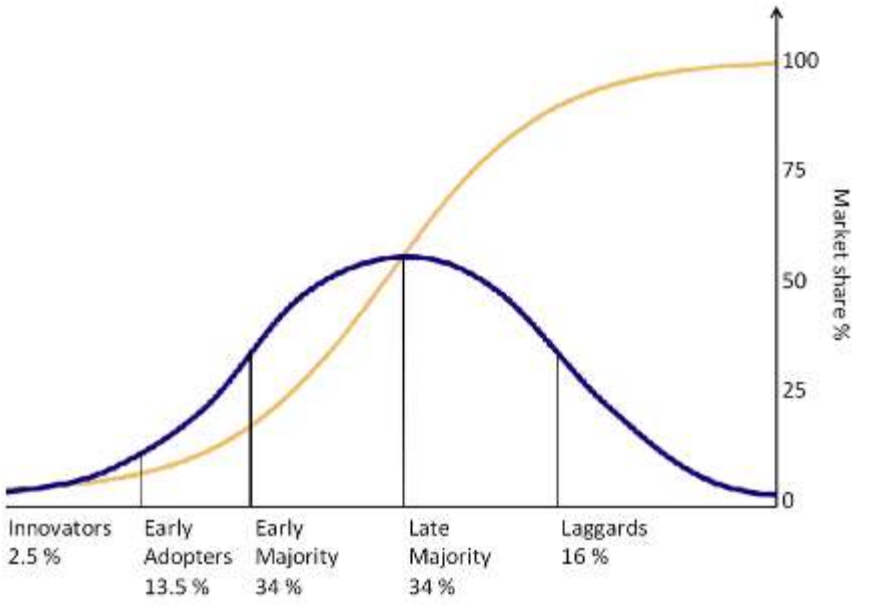
- Worldwide committed install base of robot-assisted therapy platforms
  - Reo Go: 50+ US installations
  - Reo Ambulator: 100 installations
- Active development of home product

Advisors and Opinion Leaders

- Know your strengths and look for the strongest possible advisors to augment your weaknesses
- Have multiple key advisors from the target market, from different levels of the market

Innovators and Early Adopters

- Get out into the market or application space
- Meet with key people across the organizations – at least one decision maker
- Create a single vision of what you are trying to accomplish
- Listen, Iterate, Listen, Iterate



Know the Business Model

- Start thinking about the business model from the very beginning – even when there is only a blank sheet of paper.
- How will the company make money?
- Know the difference between the user of the product and the approver of the product purchase?
- How does the product meet the need of the customer?
- Find a way to ask for compensation as soon as possible.

Minimum Usable Product

- Work with early adopters to define the absolutely necessary features of a product that they require.
- Discuss ‘what would you be willing to pay.’
- Accomplish all market requirements (regulatory, marketing, etc.) to be fully in the market.

The Right Team for the Right Stage

- Early stage team has to be able to adapt on the fly
- They have to have a customer focus
- They establish the reputation of the company

Evolve in the Market

- Leverage critical mass of early adopters to expand customer base
- Consider both the product feature set AND the business model
  - The best opportunity for innovation is often the BUSINESS PROCESS
- Keep asking the question, 'how can I make it better?' What else do you need from me?

Summary

- State of robotics
  - Robotics technology is now affecting our everyday life – beyond manufacturing (computers, elevators)
  - The first consumer successes have emerged (vacuum cleaners, toys)
  - There's a stew cooking right now
    - military interest and spending,
    - market needs like eldercare,
    - technology evolution,
    - public interest, and
    - educated roboticists
- Creating the market
  - Find the best field guides from the target market
  - Act like a business from the very beginning
  - Start small and important, and evolve from there

Thank you

- Questions and Discussion