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Industrial Technology
Research Institute

ITRI Mechanical and Systems Research in Robotics and Automation

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Vice President & General Director

Industrial Technology Research Institute

Outline

- Briefing of ITRI
- Mechanical and Systems Research
- Global Collaboration
- Summary

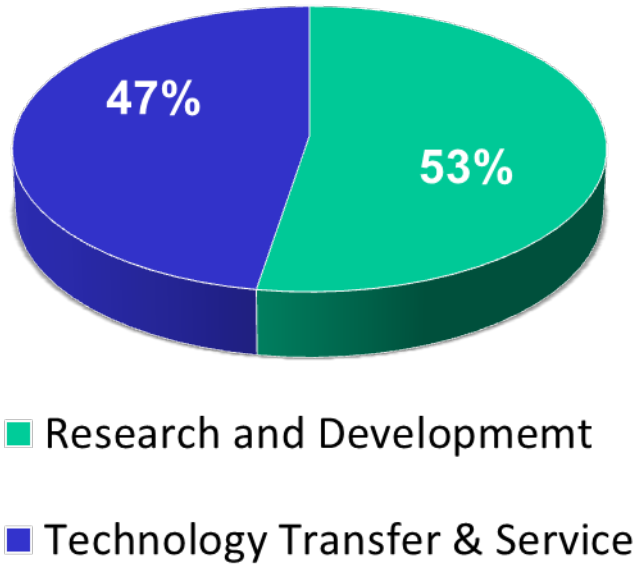
Briefing of ITRI

A non-profit R&D institution founded in 1973

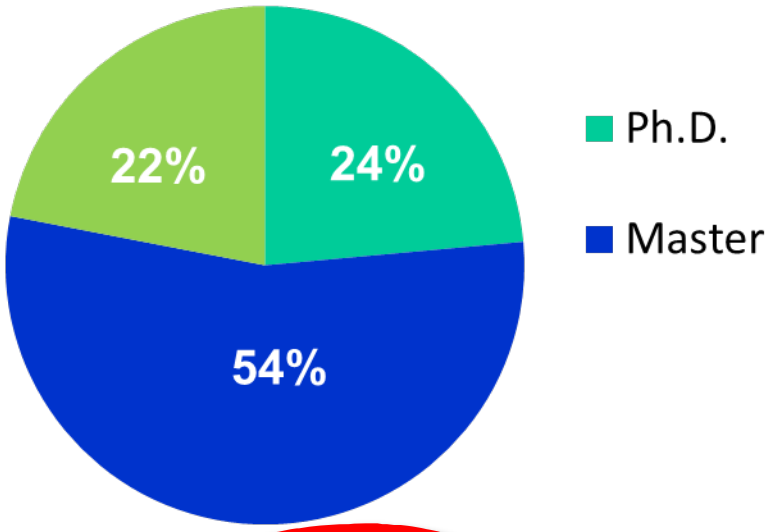
- To spearhead the development of emerging high-tech industries
- To enhance the competitiveness of industries in the global market
- To create economic value through technology R&D

Revenue and Headcount

Operating Revenue: USD 618M (2014)



Staffs ~ 5,600



Alumni ~ 23,500

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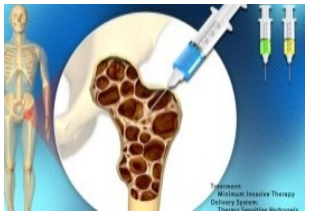
Core Laboratories of ITRI

- IoT & Wearable Electronics
- Wireless Communications
- Big data and cloud computing

Information and Communications



Medical Device and Biomedical

- Medical Electronics & Imaging
- Biomarker & In Vitro Diagnostics
- Orthopedic Device & Tissue Regeneration

- Flexible Display
- Lighting
- Semiconductor Technologies
- Human Machine Interface

Electronics and Optoelectronics

Mechanical and Systems

- Robotic Automation
- Electric Vehicle
- Machine Tools
- Additive Manufacturing

- Bio-based Chemicals
- High-value Petro Chemical
- Materials for Next Generation ICT
- Plant Factory

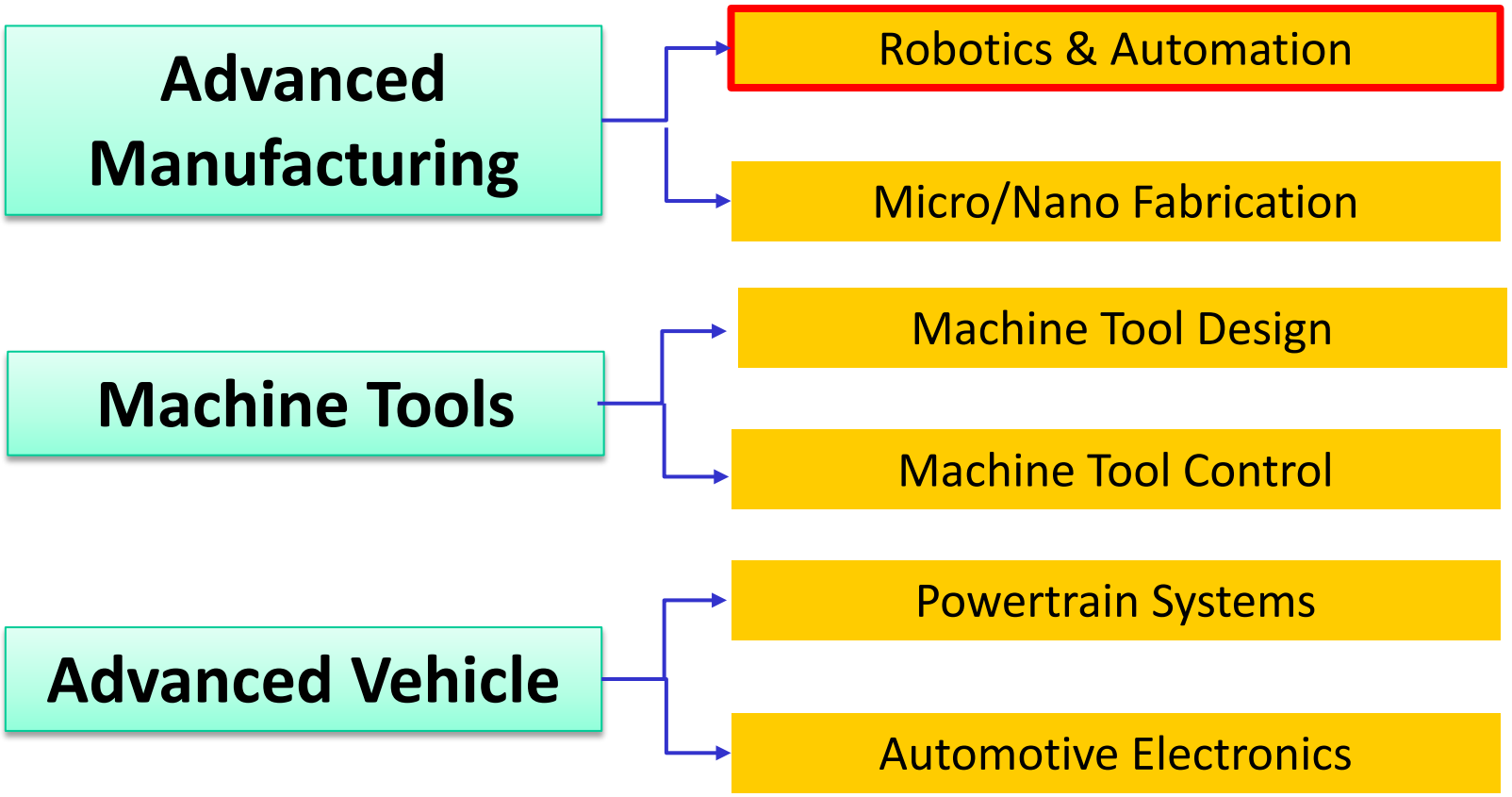
Materials, Chemicals and Nanotechnology

Green Energy and Environment

- Renewable Energy
- Energy Management
- Environment Protection
- ICT for Energy

Mechanical & Systems Research

R&D of ITRI
Mechanical and Systems Technology



Robotics & Automation

- Cyber-physical systems –
- Human Robot Collaboration –
- Exoskeleton for SCI -

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ITRI Robotics Lab

Robotics Enabled Industrial Automation

Design and Analysis Software

Hand-eye-force coordination controller

- System Analysis
- Structure/Mechanism Design & Analysis
- Optimization
- Controller Design & Prototyping

System Reliability Test & Planning

- Design for Reliability (Parts & Assembly)
- Robot Reliability Test
- Accuracy Enhancement Platform
- System Level Reliability Test

- **Production Line Design Lab**
- **Robot System Lab**
- **Machine vision Lab**

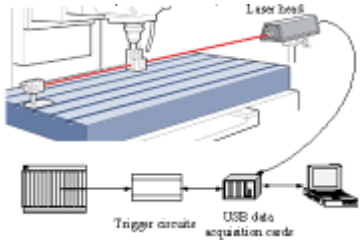
Integrated System Analysis

System Integration & Reliability Test

Mechanism Design & Analysis

Autodesk Inventor

Robot manipulator Reliability



Robot Accuracy Enhancement

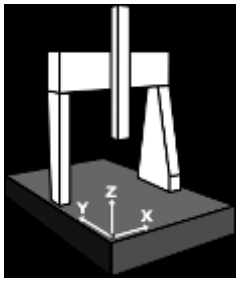
Software Design

Adams
Structure Dynamics

Component/Assembly Reliability

Control Hardware

Equipment/System Level Design



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智慧自動化應用整合平台
Robot Application System

Industrial Robot Manipulators

Controllability

- Hybrid control (position/velocity/compliance)
- Visual servo
- 6 DOF force feedback

Usability

- Multi-modal user interface
- Teaching by demonstration
- Automatic/efficient path planning
- Intelligent grasping

Accuracy

- Absolute accuracy
- Repeatability
- Path tracking error

Reliability

- Long term MTBF test
- Component life & load variation test
- EMI/EMC

Speed

- Vibration control
- Flexibility compensation

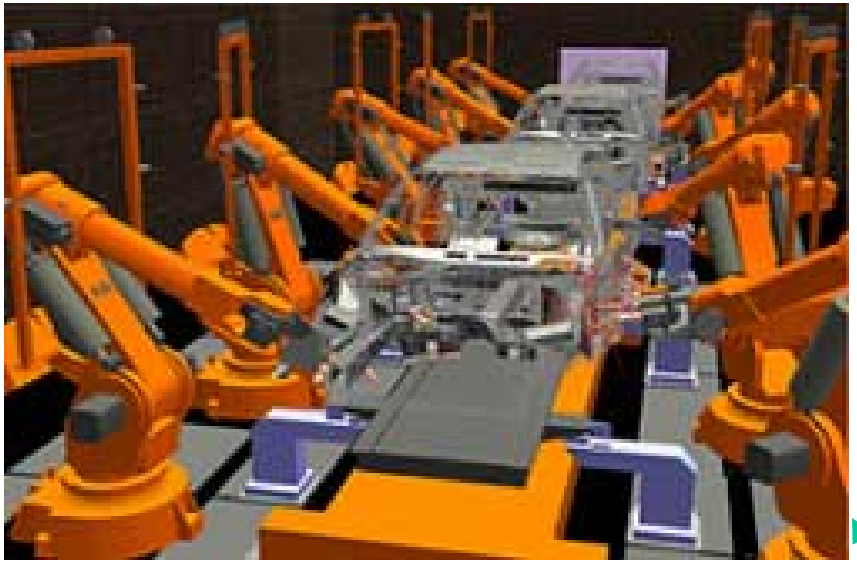
Safety

- Collision detection and avoidance
- Situation awareness technology (vision)
- Intrinsically compliant joints

Plan & Control Real Systems Virtually

- To have a high-fidelity process dynamics and planning in virtual space
- To be able to update the virtual model when there are changes

Virtual work space and virtual robots



Real work space and real robots

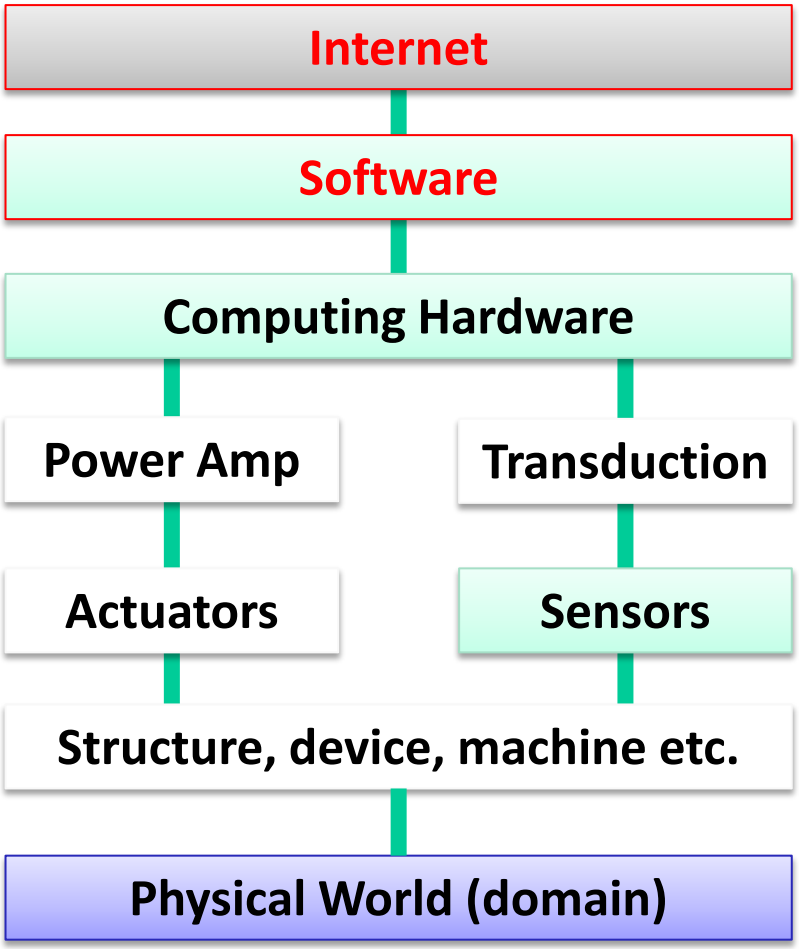
- Risk reduction
- Faster start-up
- Shorter change-over
- Increased productivity

Accuracy in

- **Dimensional correspondence**
- **Dynamic behavior**
- **Mapping of control commands & sensor signals**

Cyber Physical Systems

- **It is a holistic view of "computer controlled system" under the internet era.**



Driving force for CPS technology

- To take advantage of internet and massive computing resources to enhance and constantly improve system performance
- Potential disruptive innovation for individual product/technology within the system

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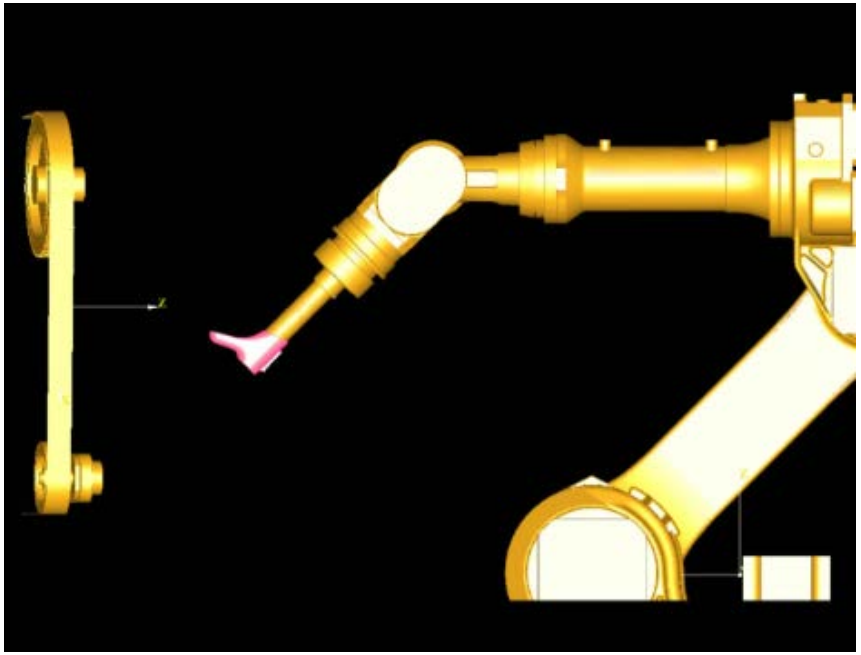
A CPS Example

CAD model based programming in grinding

- Interactive task description via feature assignment
- Automatic path planning under robot dynamics constraints
- Simulation of grinding force and surface finish quality

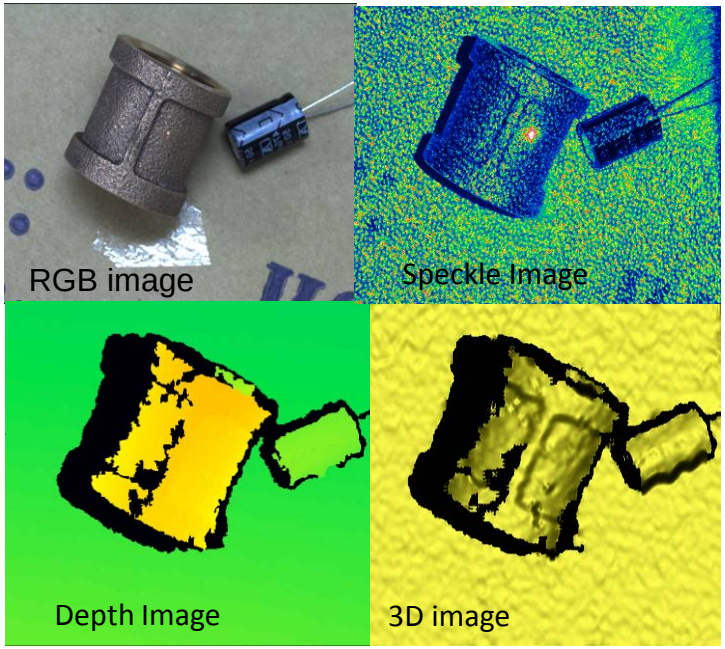
Virtual



Real

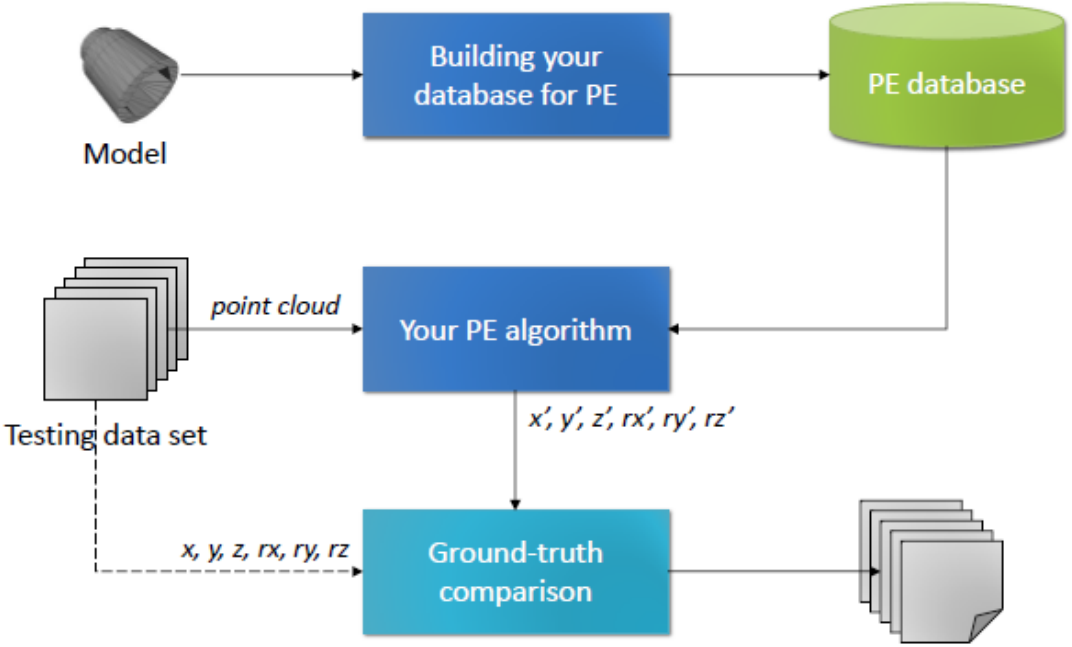
Randomness

- Model-based
  - Object 3D model
  - Grasping point & path planning
- There are no models for
  - Object pose and occlusion in random stacking
  - Cluttered background
  - Generic description of shadow and highlight
  - Fragmentation and sensor noise



Learning Pose Estimation and Grasping

- **Learning from Simulation Data**
  - Photo-realistic simulation for sensors (optics, lighting, noise)
  - Force and contact simulation
  - Deformation and multi-body simulation
  - Algorithms
  - Database construction and update



Database for algorithm development

Database

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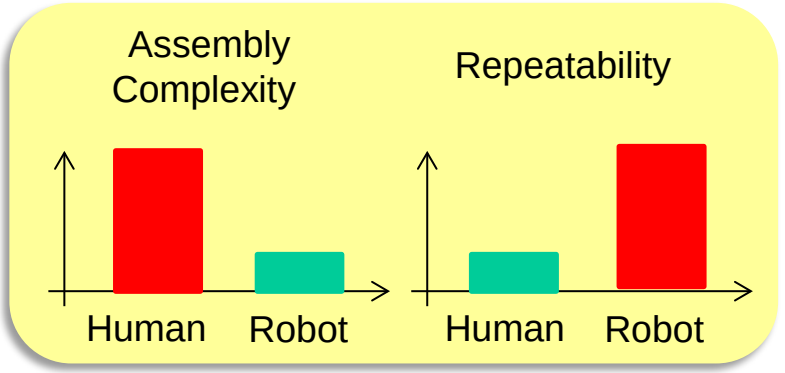
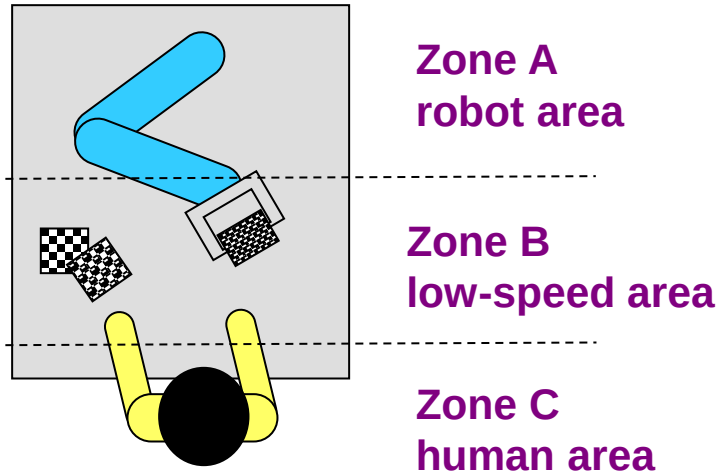
Human-Robot Collaboration

Hybrid Assembly Cell

- Assembly process recognition based on human gesture
- Intuitive robot teaching
- Human intension understanding
- Safety zone interlock
- Collision Safe





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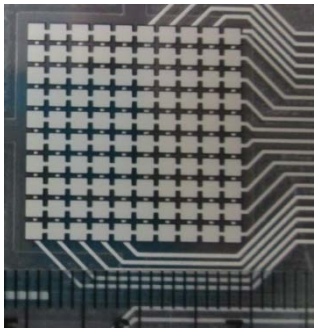
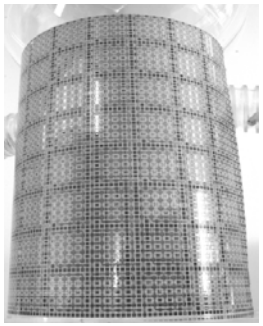
ITRI Flexible Tactile Sensor Array for robot safety

- Satisfy safety requirements of collaborative robot
  - ISO/TS 15066 (Standard in development)
- Collision sensing
- ***Tactile sensing signal as a communication interface***



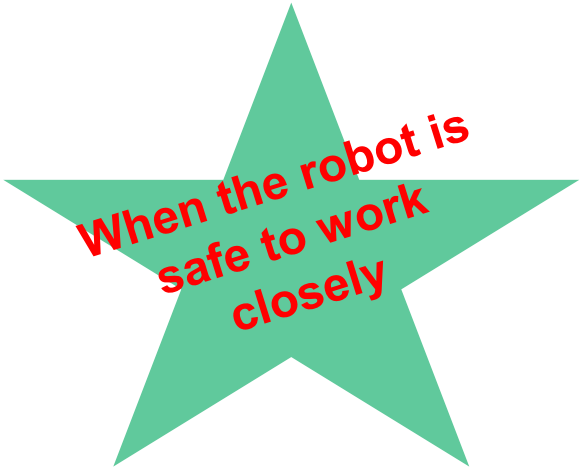


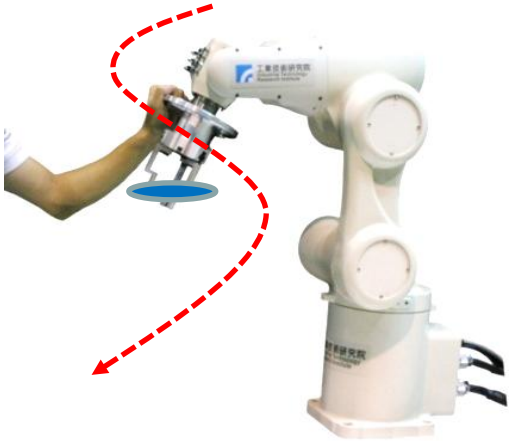
Flexible Tactile Sensor Array

Customization to the surface of the robot manipulator

Task Learning from Human Demonstration

- Motion teaching by compliance
  - Lead through programming
  - Simple task such as pick and place
- From motion to complex task
  - Task description and environment modeling
  - Multi-modal: vision and tactile





Teaching a trajectory following task on a surface

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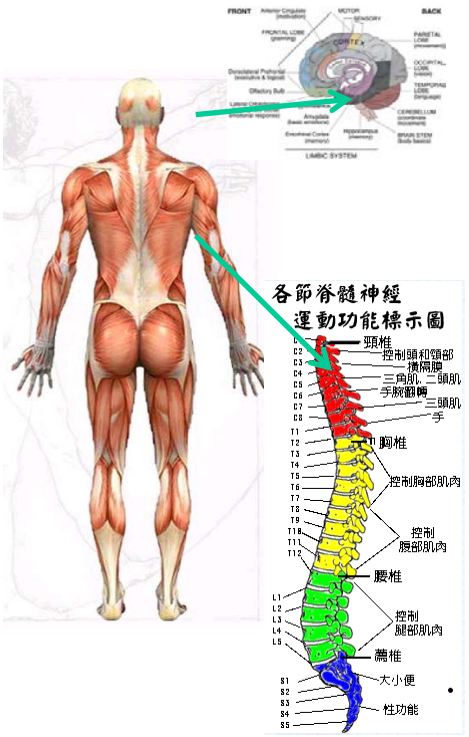
Powered Exoskeleton

- Mobility Impairment Groups
  - ➢ Joint and muscle degeneration
    - – Degeneration due to aging affects directly the mobility which could lead to chronic and cardiovascular diseases. (In 2012, Taiwan 65+ age group is 11.2% and will increase to 39.4% in 2060)
  - ➢ Central nerve system damage
    - – Partial loss of mobility such as Stroke (~30K cases/year in Taiwan) 、Brain Tumor (1,800~2,000 cases/year)、Cerebral Palsy (2.1 per 1,000 live births)、Parkinson's Disease (1% for 60+ ages) etc.
  - ➢ Spinal Cord Injury
    - – Completely loss of mobility (23 K cases in Taiwan with 1K~1.2K new ones per year)
- Active devices (exoskeleton robots) to assist or regain mobility were proved to be effective in clinical studies.



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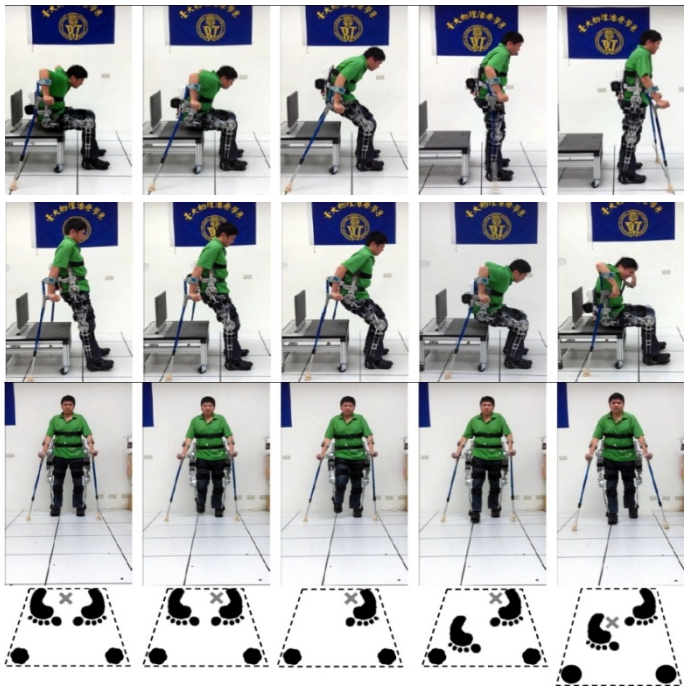
ITRI Exoskeleton Robot

-Walking aids for spinal cord injuries-

- Features
  - Light weight: 20kg
  - Maximum walking speed: 70 cm/sec
  - Battery operating time: 3.5 hrs
  - Patient could regain capability of stand up, sit down, walk along flat floors, upstairs, downstairs, and ramps



2nd Generation Exoskeleton

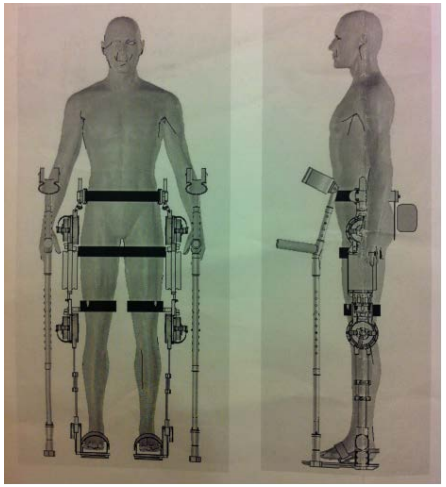
1st Generation Exoskeleton

Exoskeleton robot verification @ ITRI lab

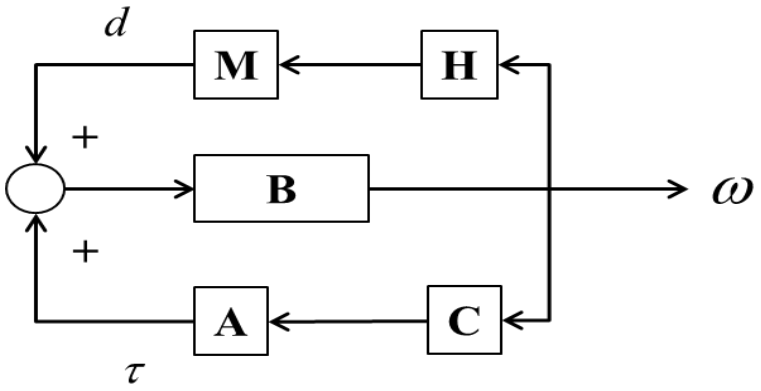
Gait Pattern, Balance and Intention

Human-in-the-loop

- Dual loop feedback control with multi-objective optimization
  - Gait pattern generation to keep COG flat, minimize upper limb effort and power consumption
  - Ability to adapt to different SCI cases
- Balance
  - Ground surface conditions and slope
- Intention
  - Command the robot's gait speed



w: Body Swing，
M: Crutch，**B**: Inertia，
A: Exoskeleton，**C**: Controller，
H: Human Decision



Global Collaboration

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Global Connection

-Speeding, Deepen -

More than 20 projects are executed cross board every year

- Explorative Research
  - Academic Institutions
    - North America: UCB, UM, VirginiaTech, UBC(Canada)
    - Europe: Cambridge, Sheffield, Bath U, MSU
    - Japan: Tokyo, Waseda, Keio, Nagoya, Osaka
  - Research Institutes
    - North America: UL, NIST
    - Europe: Fraunhofer, TUV
    - Japan: AIST, NIMS, Riken
- Business cooperation
  - North America: Corning, VisualSize, ICA, Airproduct
  - Europe: R+P, FIDIA, Linde, Ricardo,
  - Japan: Nidec, ULVAC, Taiyo Yuden, Nissan, Disco, Mitsubishi Electric, Kikuchi Seisakusyo, TMSUK

ITRI's Open Innovation Platform (OIP)

- Cross-field fusion, autonomic creation and strong TBB
- Unite major users and partners to develop future applications

Simulation
Scientific Discovery
Modeling

Science Based Innovation

Technology Building Block

- **Functionality**
- **Manufacturability**
- **Reliability/Availability/Serviceability**

Technology Enabled Solutions

IBM
PHILIPS sense and simplicity
SONY
DUPONT
MERCK Be well
BASF The Chemical Company
MEDIATEK
DELTA
AUO
ASUS
acer
htc quietly brilliant

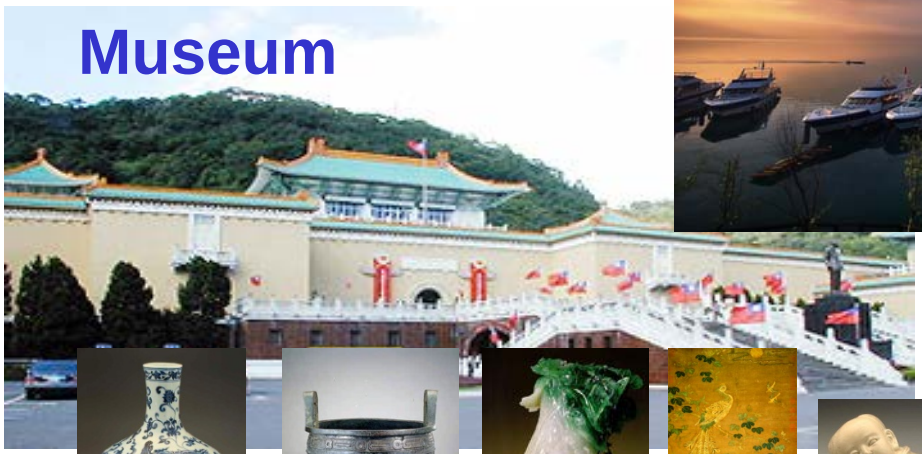
Discovery | New Technology | Applications

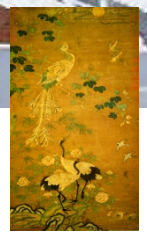
Summary

- Research activities at Mechanical and System Lab, ITRI
  - Advanced Manufacturing
  - Machine Tools
  - Advanced Vehicles
- Robotics and Automation Research in MSL
- Approach from system viewpoint is the key to bridge the gap between technology R&D to products
- ITRI MSL has established several platforms for research in various technology fields and welcome international collaboration.

Spotlight of Taiwan

National Palace Museum





Thank you for your attention!