1. Introduction of lecturer

Please visit my WEB-site:
http://www.dynamics.mep.titech.ac.jp/english/index.html

or
Search by Google with a keyword ‘Iwatsuki-Okada lab’
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Several artistic works:
My policy for research and education:
(1) Confront everything actively!
   - Think after trying!
   - Make it by yourself if you can purchase it!

(2) Believe your infinite possibility!
   - The merit exists just near the demerit.
   - Always think about the conversion of conception.

(3) Develop gentle machinery to mankind
   - Not only for industrial application
     but also for human daily life
   - Flexible and intelligent mechanical system

Research Themes:
(A) Synthesis and Control of Robotic Mechanisms
   Especially focused on ‘Mechanism Design and Motion Control of Hyper Redundant Robots’
(B) Silent Engineering
   Especially focused on ‘Estimation of Sound Power Radiating from Vibrating Structure and Structural Optimization to Reduce the Sound Power’
(C) Intelligent Laser Measurement
   Especially focused on 'Development of a Laser Speckle Interferometer to Measure Multi-dimensional Displacement with High Accuracy and Speed'
Several Examples of My Research Works:
(1) Biped Walking Machine
   – While undergraduate/Ph.D student (-1987)

A Biped Walking Machine with only 1 DOF
(Mechanical synthesis for simple control)

Walking speed : 120 steps/min (World record)

Dynamics is important not only to stabilize
Biped machine but also to drive actuators!
(2) Dexterous Motion of Hyper Redundant Robot
- Optimum learning control of snake-like robot with 10DOF to avoid obstacles

Dexterity is set as an objective function to generate optimum trajectory.

(3) Module-based Control of Redundant Multi-loop Mechanism

Module: Minimum unit to synthesize and control of whole mechanism

Photograph of a prototype (12DOF-12Actuators)
(1) Straight line trajectory  
(2) Ellipsoidal trajectory

Experimental results of CP control

Large scale mechanism can be controlled by using 'kinematic modules'.

(4) Control of Structural Flexibility and Its application

Motion control of a flexible link (coil spring) taking account of its reaction force
(5) Estimation of Sound Radiation from Thin Plate subjected to Acoustic Excitation

Thin rectangular plate

Transmitted sound power should be estimated to design silent structure.
Transmitted sound power can be estimated with an adequate accuracy.

(6) Estimation of Sound Radiation from Frog-type Guiro

The calculated acceleration and Expanded
Laser speckle interferometer with the quad aperture method

The interference image like a distorted lattice moves two-dimensionally as a target moves.

2D light intensity can be measured and its movement should be detected.

Phase detector by real-time Fourier transform composed of analogue electronic circuit
Two-dimensional displacement can be measured with the proposed laser speckle interferometer.

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if you are interested in other research works.

Thank you!
2. Outline of lecture

Objectives of lecture
Redundant robots which have redundant degrees-of-freedom can generate intelligent, flexible and complicated motions. These motions are important especially for human daily life. The design and motion control methods based on kinematics dynamics analyses will be explained with several examples.

Schedule of lecture
3/18 Mon  12:00-13:00  Introduction, 
            Advantages and issues to be solved for redundant robots
       16:30-18:30  Optimum motion control of serial redundant manipulator
3/19 Tue  10:00-12:00  Synthesis of redundant closed-loop mechanisms
        15:30-16:30  Control of redundant closed-loop mechanisms
3/20 Wed  9:00-11:00  Design of overactuator mechanisms
         15:30-16:30  Control of overactuator mechanisms with elastic elements
3/21 Thu  10:00-12:00  Motion control of redundant robot based on reflex motion of each link
                Examination
3. Advantages and Issues to be solved for redundant robots

A robot in industry

A robot in human daily life

High performance robot which can generate intelligent and flexible motion should be required in the future.

Aiming to develop high performance robots which will work in human daily life, the methods to synthesize and control new robotic mechanisms with hyper redundancy (HR) should be established.

Objectives:

- Remarkable advances in computer techniques (Hardware & Software)
- Microprocessor
- Neural computing
- Development of microactuators
- With microfabrication
- Functional materials

“The robot may not be required in industries but must be required in human daily life.”

There will be a possibility to build a robot which has hundreds of actuators and can achieve intelligent motions with adequate flexibility.
3.1 Merits of hyper redundant robots

(1) Flexibility
- *Kinematical flexibility*  
  "To achieve complicated motion"
- *Structural flexibility*  
  "Soft touch for a human"

(2) Cooperative motion
- Small size
- Low power
- Simply controlled (can cooperatively generate high power).

(3) Reliability
"No problem if a few actuators will be broken down."

(4) Ambiguosity
"Accuracy won’t be required."

3.2 Issues to be solved

(1) How to develop practical and useful small/micro actuators
  → Development of new materials should be expected.

(2) How to synthesize HR mechanisms
  → Not only serial mechanism should be synthesized.

(3) How to manufacture HR mechanisms
  → Rigid links and joints won’t be available.
  → Flexible structure and new manufacturing method should be expected.

(4) How to control so many DOF
  → Optimum control of redundant DOF will be necessary.
  → Autonomous dispersion control should be adopted instead of conventional integrated control.
  → Over-constrained mechanism problem should be solved.

ex. Piezoelectric micro cilium actuators in group fabricated with the Hydrothermal method.
3.2 Issues to be solved

(1) How to develop practical and useful small/micro actuators
→ Development of new materials should be expected.

(2) How to synthesize HR mechanisms
→ Not only serial mechanism but also multi-loop mechanism should be systematically synthesized.

(3) How to manufacture HR mechanisms
→ Rigid links and joints won’t be available.
   • Flexible structural material and new manufacturing method should be expected.

(4) How to control so many Degree Of Freedom
→ Optimum control of redundant DOF will be necessary
   • Autonomous dispersion control should be adopted in stead of conventional integrated control.
   • Over-constraint and over actuator problem should be solved.

Not MEMS but Rapid Prototyping!
Ex. Elastic hinge
3.2 Issues to be solved

(1) How to develop practical and useful small/micro actuators
   → • Development of new materials should be expected.

(2) How to synthesize HR mechanisms
   → • Not only serial mechanism but also multi-loop mechanism should be systematically synthesized.

(3) How to manufacture HR mechanisms
   → • Rigid links and joints won’t be available.
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(4) How to control so many Degree of Freedom
   → • Optimum control of redundant DOF will be necessary
   • Autonomous dispersion control should be adopted in stead of conventional integrated control.
   • Over-constraint and over actuator problem should be solved.

3.3 Concluding remarks on advantages and Issues to be solved for redundant robots

On hyper redundant robots in future
(1) Structural/motion flexibility is important for human daily life.

(2) Group of small and simple actuators can generate large power.

(3) Development of functional materials and method to manufacture hyper redundant robots is necessary.

(4) Kinematic design and control methods should be developed soon.
You can download this lecture note from the following WEB-site:

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