

# 446.612 Robot Mechanics & Control

## 로봇역학 및 제어

### - lecture 1 -

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## Course Information

- Robot Mechanics & Control  
Graduate-level introductory course on robotics, with emphasis on analytical treatments of kinematics, dynamics, and control of robotic manipulators
- Instructor: Dongjun Lee (djlee@snu.ac.kr, 301-1517, 880-1724)
- Teaching Assistants:
  - Sangyul Park (Lead: sangyul@snu.ac.kr, 301-211, 880-1690)
  - Yonghan Lee (Grading: ldragonfly@snu.ac.kr, same as above)
- Prerequisites
  - Undergraduate-level dynamics, linear algebra, system dynamics or their equivalent; or by the consent of instructor
- Grading
  1. HW 20% (score 0/0.5/1: before lecture; 50% same day; 0% if not)
  2. Mid-term exam 40% 11/3/2017 F 7-9:30pm (one A4 cheat sheet)
  3. Final project 40% 12/15/2017 11:59pm (industrial manipulators: TBA)

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## Course Information

- Course Topics

1. Rigid body motion description in  $SE(3)$
2. Forward and inverse kinematics
3. Differential kinematics and Jacobians
4. Kinematic null-space-based control
5. Dynamics: Lagrangian and Newton-Euler approaches
6. Nonlinear motion control
7. Interaction control
8. Dynamics and control of constrained systems

## Course Information

- Textbooks

- Murray, Li, Sastry, A Mathematical Introduction to Robotic Manipulation, CRC Press, 1994
- Spong, Hutchinson, Vidyasagar, Robot Modeling & Control, John Wiley & Sons, 2005

- References

- Lynch, Park, Modern Robotics: Mechanics, Planning, and Control, Cambridge University Press, 2017
- Choset, Burgart, Kavraki, Kantor, Hutchinson, Lynch, Principles of Robot Motion, MIT Press, 2005
- Slotine and Li, Applied Nonlinear Control, Prentice-Hall, 1991

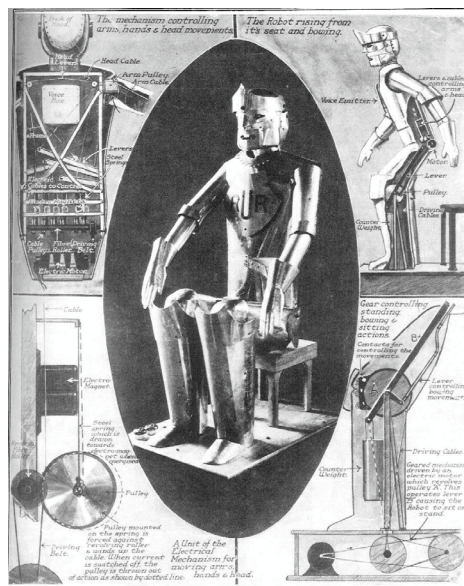
## Course Information

- The SG (Special Grade) Group
  - Grade guaranteed at least B-, yet, upper-bounded by B+.
  - As long as you submit all the HWs, and sincerely take all the exams.
  - Can lower though if not submit HWs ( $\geq$  Co); not do exams ( $\leq$  Co)
  - For those who just want to apply robotics, not work on it.
  - To allow "non-robotics" students to take course w/o worrying grade.
  - Yet, need to establish fairness with other "robotics" students.
  - Grade first all students, then, saturate SG-group students grade.
  - You should elect this SG-group option before the midterm exam.
  - UG students not need to elect: will receive whichever better.
- No lectures on 9/25, 9/27 (IROS)
- Other important information → Course Syllabus

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## Karel Capek 1921



- R.U.R (Rossum's Universal Robot)

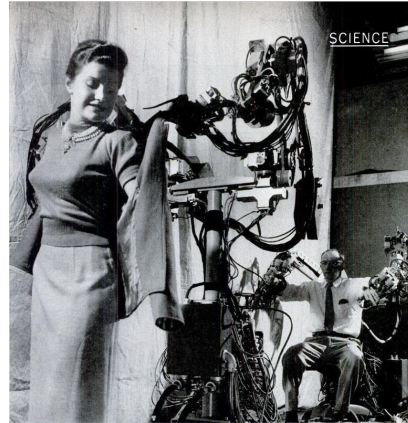
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## Teleoperators: 1940-50



- Mechanical Teleoperator (1952, ANL)

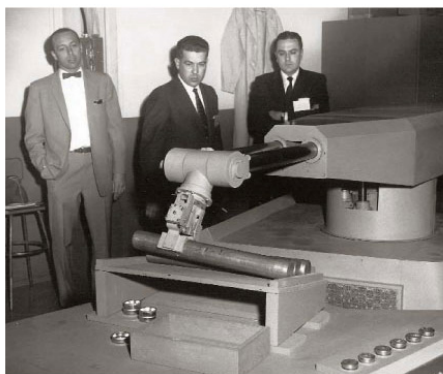


- Yes-Man Hydraulic Teleoperator w/ Force Feedback (1956, GE)

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## First Industrial Robot "Unimate" 1961



- Unimations Unimate #001 in GM (1961, Joel Engelberger & George Devol, Ewing, NJ)



- Unimate at Johnny Carson Tonight Show (1966)

*Johnny Carson marvels that this robot can "replace someone's job."*

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## 1970



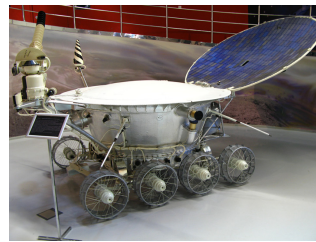
- Stanford arm (first computer-controlled w/ closed-form IK 1969: V. Scheinman)



- SCARA (Selective Compliant Articulated Robot for Assembly: Sankyo Seiki, Pentel & NEC 1981)



- PUMA (Programmable Universal Machine for Assembly: Unimation 1977)

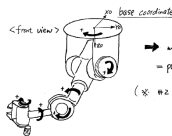


- Lunokhod1 (Soviet Union, first remote-controlled lunar rover 1970)

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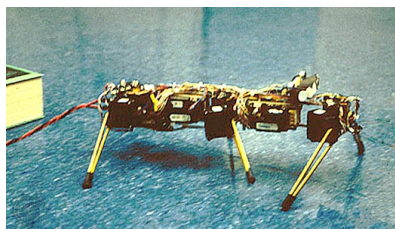
## 1980



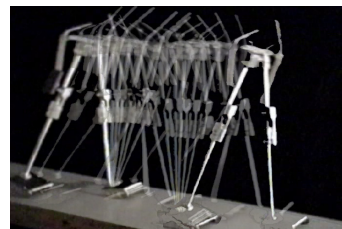
- Direct-driven arm with no gear (H. Asada & T. Kanade, CMU 1981)

### Dynamics-Based Robot Control:

- Impedance control
- Dynamics computation
- Computed torque control
- Feedback linearization
- Passivity-based control
- Adaptive/robust control



- Genghis (Rodney Brooks, MIT, 1989: A Robot That Walks; Emergent Behaviors from a Carefully Evolved Network)

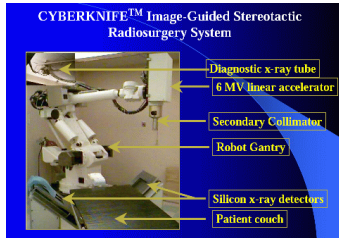


- Passive walking (Tad McGeer, MIT 1990)

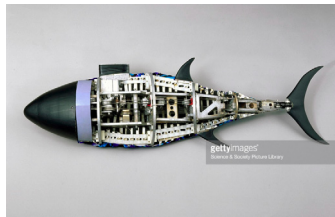
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## 1990



- CyberKnife (J. R. Adler, Stanford 1992)



- Robotuna (D. Barrett, MIT 1996)



- Amigobot (ActivMedia, ca 2000)



- Aibo (Sony, 1999)



- Asimo (Honda, 2000)

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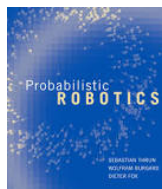
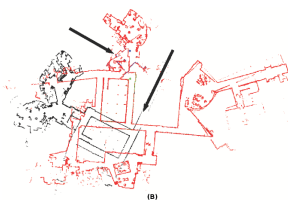
## 2000



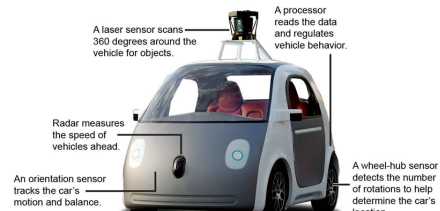
- Roomba (i-Robot, 2002)



- Stanley (DARPA Grand Challenge, Stanford 2005)



- SLAM (Simultaneous Localization & Mapping)



Source: Google

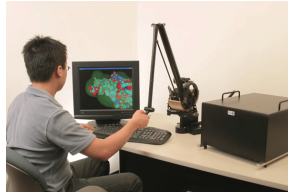
Raoul Raïoa / @latimesgraphics

- Autonomous Driving (Google Waymo)

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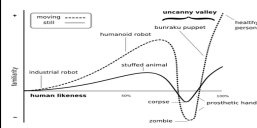
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## 2000



- Phantom (Sensable/Stanford)
- CHAI-3D

- da Vinci (Intuitive Surgical)



- Andriod Robot (H. Ishiguro)
- Uncanny valley



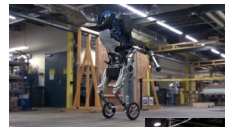
- PR2 (Willow Garage/Stanford)
- ROS

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## 2010-

- Boston Dynamics



- Cheetah (MIT, S. Kim)

- Collaborative Robot with JTS (KUKA LBR iiwa/DLR)

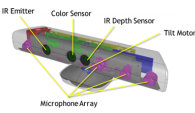


- DRC Hubo (KAIST, J. Oh)

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## 2010-



• Microsoft Kinect



• Microsoft HoloLens



• Oculus Rift



• Google Tango 3D



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## 2010-



• DJI Phantom 5, Mavic Pro, Spark



• HAL-3 (U. Tsukuba)



• Amazon KIVA

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