

ME303 Introduction to Mechanical Design

Lecture 16

Mechanical Design for Advanced Robotics

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New Machines and Systems

New Demands for Mechanical Engineers

Driver of Design Intelligence

Mechanism

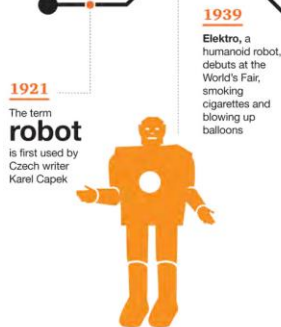
Machine

Robot

Upgrading Need for Interaction

The rise of Robotics and AI

Fueled by advances in computing power and connectivity, the fields of robotics and artificial intelligence have grown rapidly



1921
The term **robot** is first used by Czech writer Karel Capek

1929
Elektro, a humanoid robot, debuts at the World's Fair, smoking cigarettes and blowing up balloons

1948
William Grey Walter creates the first autonomous robot with complex behavior

1950
Alan Turing publishes paper about the possibility of machines that think, develops idea known as the **Turing's Test**.

It tests a machine's ability to "think" by answering a series of questions. In essence, the tester must think the machine's answers are coming from a human

1958 IBM 305, the first hard disk drive **5MB**

1970 IBM 1330 **100MB** per pack

1985 IBM 0965, a 5.25" disk with **20-40MB**

Minimize and maximize
Shrinking disk sizes and exponentially growing capacity help fuel robotics and AI

1941 Isaac Asimov formulates the **Three Laws of Robotics**:

- A robot may not injure a human being or, through inaction, allow a human being to be harmed**
- A robot must obey orders given it by human beings except where such orders would conflict with the First Law**
- A robot must protect its own existence as long as such protection does not conflict with the First or Second Law**

1954
George Devol invents the first digitally operated and programmable robot

1956
Field of AI research founded at a conference at Dartmouth

1960
Frank Rosenblatt constructs **Mark I Perceptron**, a computer that learned new skills by trial and error

1968
Mobile robot "**Shakey**" is introduced. It's controlled by a computer the size of a room

1972
Stanford researcher develops **PARRY**, designed to simulate a paranoid schizophrenic.

1961
GM installs **Unimate** robot to lift and stack hot pieces of metal

1974
Intel produces its second-generation **8080** general-purpose chips

virtual reality



How are you feeling today?
I have had enough of this.

1984
The **RB5X**, developed by General Robotics Corp., includes software enabling it to learn from its environment

1985
Jaron Lanier's VPL Research, Inc., sells first VR glasses and gloves; Lanier coins the phrase

1988 Researchers launch **Jabberwacky**, an AI chatbot designed to learn through conversation

1986
Honda creates the **E0**, the first of a series of humanoid robots that walk on two feet

1988
The first **HelpMate** service robot begins work at Danbury Hospital

New Machines and Systems

New Demands for Mechanical Engineers

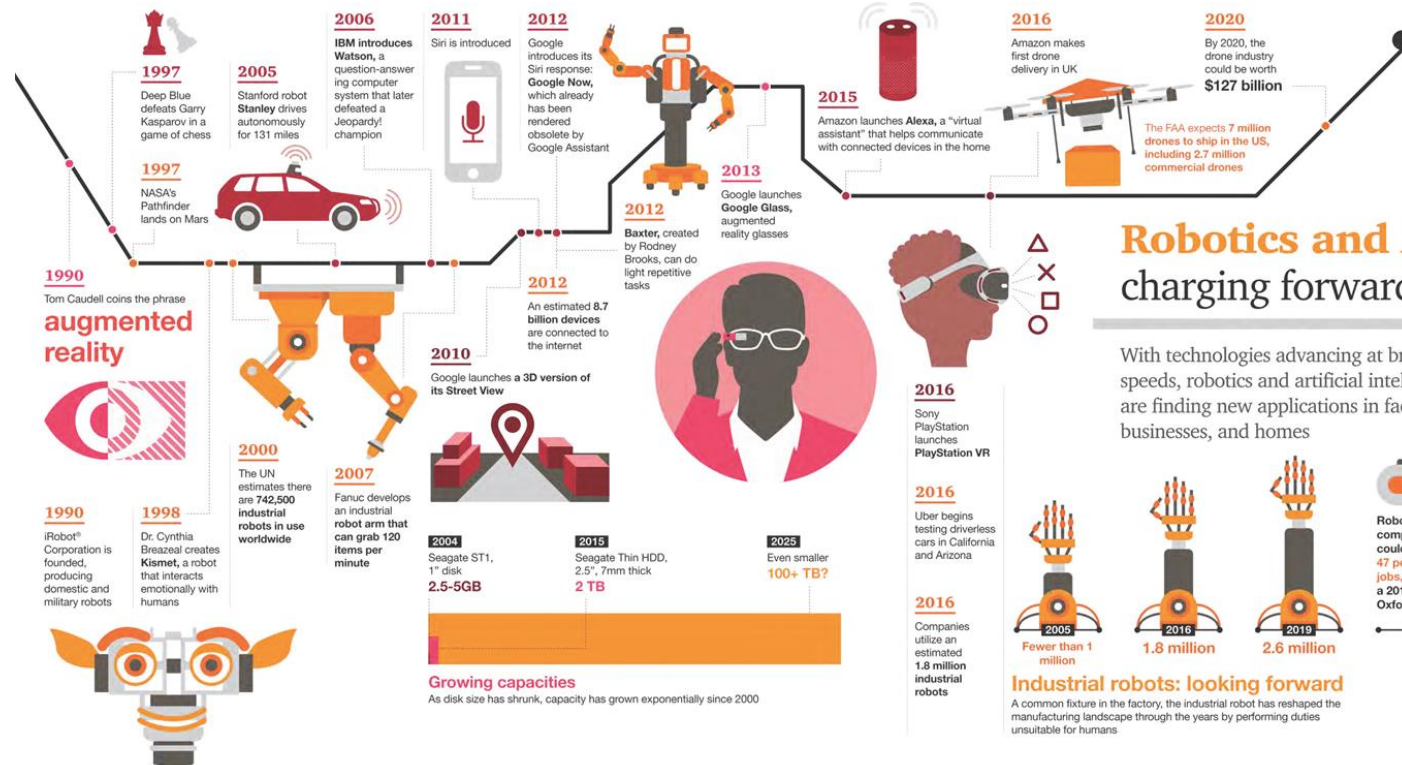
Driver of Design Intelligence

Mechanism

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Upgrading Need for Interaction



Five ways robots are going mainstream

They're not restricted to structured environments.



They can now handle dynamic, less predictable settings. In hospitals, robots can safely roam halls and deliver medications. In hotels, they can deliver towels, toiletries, and minibar items to guest rooms.

They can work with humans.



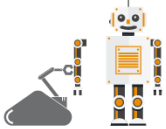
Thanks to sensors and smart technology, new-generation robots are much safer around humans.

They can learn.



The new robots can "learn" skills through trial and error, mimicking the way humans learn new tasks.

They are no longer single-task machines.



Robots are being designed with modularity in mind, beginning with a platform upon which a customized solution can be built.

They're moving beyond the factory floor.



Robots are engaged in functions across the enterprise, including positions where they interact directly with customers and employees.

Benefits of robotics

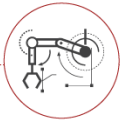
Robots are not just for manufacturing anymore. No matter the industry, they can:

Automate business operations

Boost efficiency, quality, and repeatability

Free up humans for higher-value tasks

Replace or augment humans in jobs where there are labor shortages



Potential challenges

Lack of expertise and support

Your company may not have the knowledge or the resources to buy and maintain robots.

Fallout from job losses

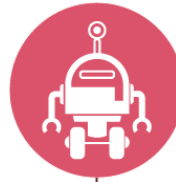
Robots could displace workers, which could lower morale and create conflict with labor unions.

Regulatory compliance

Safety rules and monitoring and reporting requirements can create burdens, particularly for smaller companies.

Costs

Prices for robots are dropping, but the cost of engineering the system, installing it, and managing the change can be prohibitive.



A look at robots ready for work

At a glance

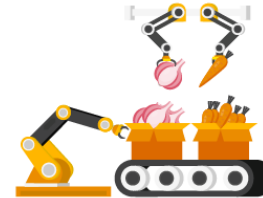
Robots once were viewed as expensive, limited in their abilities, and applicable only in manufacturing. Now, THEY are more capable, easier to use, and less COSTLY, making the technology more desirable and accessible. But competing operating systems, form factors, and interfaces make for a fragmented robotics marketplace. We believe widespread adoption will accelerate when dominant vendors and platforms begin to emerge.

Potential new applications



Collaboration

Robots can replace or work as "cobots," in tandem with humans.



Handling more complex tasks

Robots can be instrumental in warehousing and fulfillment by fetching, monitoring inventory, moving pallets, picking, packing, screening, and inspecting. They can also greet, direct, and assist customers.



Mitigating labor shortages

Robots can be used to automate tasks too difficult and expensive for human manual labor. For example, robots won't just plant and harvest crops; they'll also monitor their health, size, and maturity, and target-spray fertilizer, herbicides, and fungicides where most needed.

Source: PwC, 2017

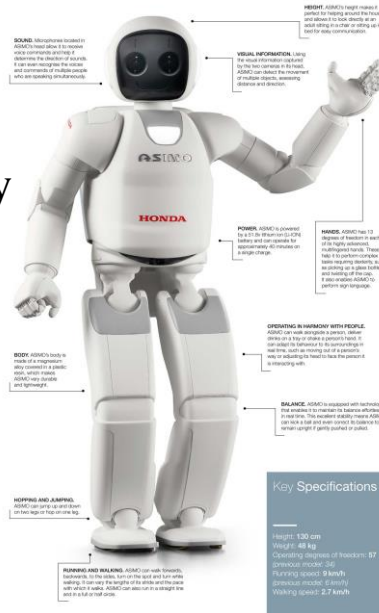
Design Iterations

HONDA's ASIMO

Advanced Step in Innovative MObility

Mechanical Design for Advanced Robotics usually takes an iterative process that requires a great amount of **time, money, technology** and **public acceptance**.

All-New ASIMO

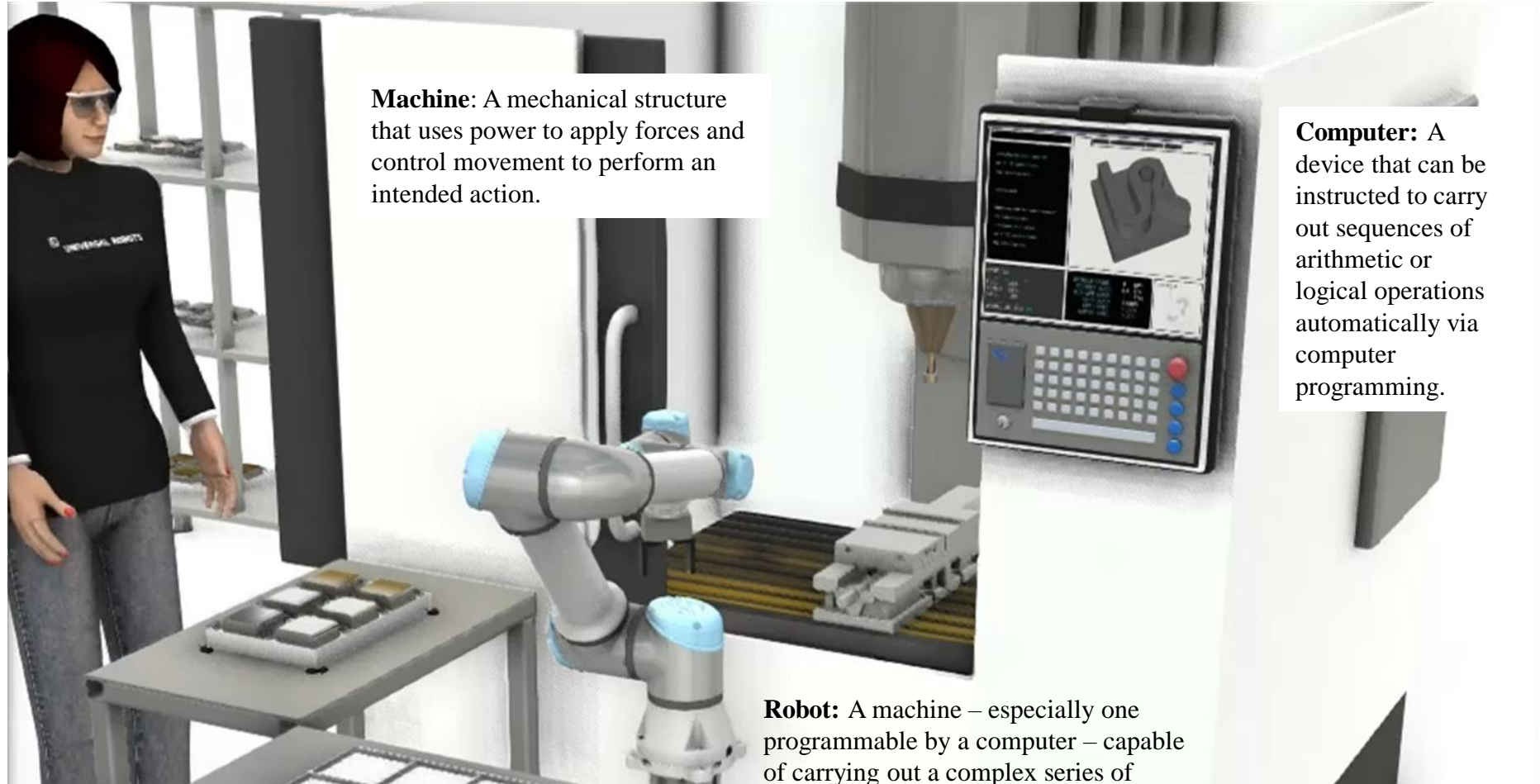


Honda Robotics



Some Differentiations

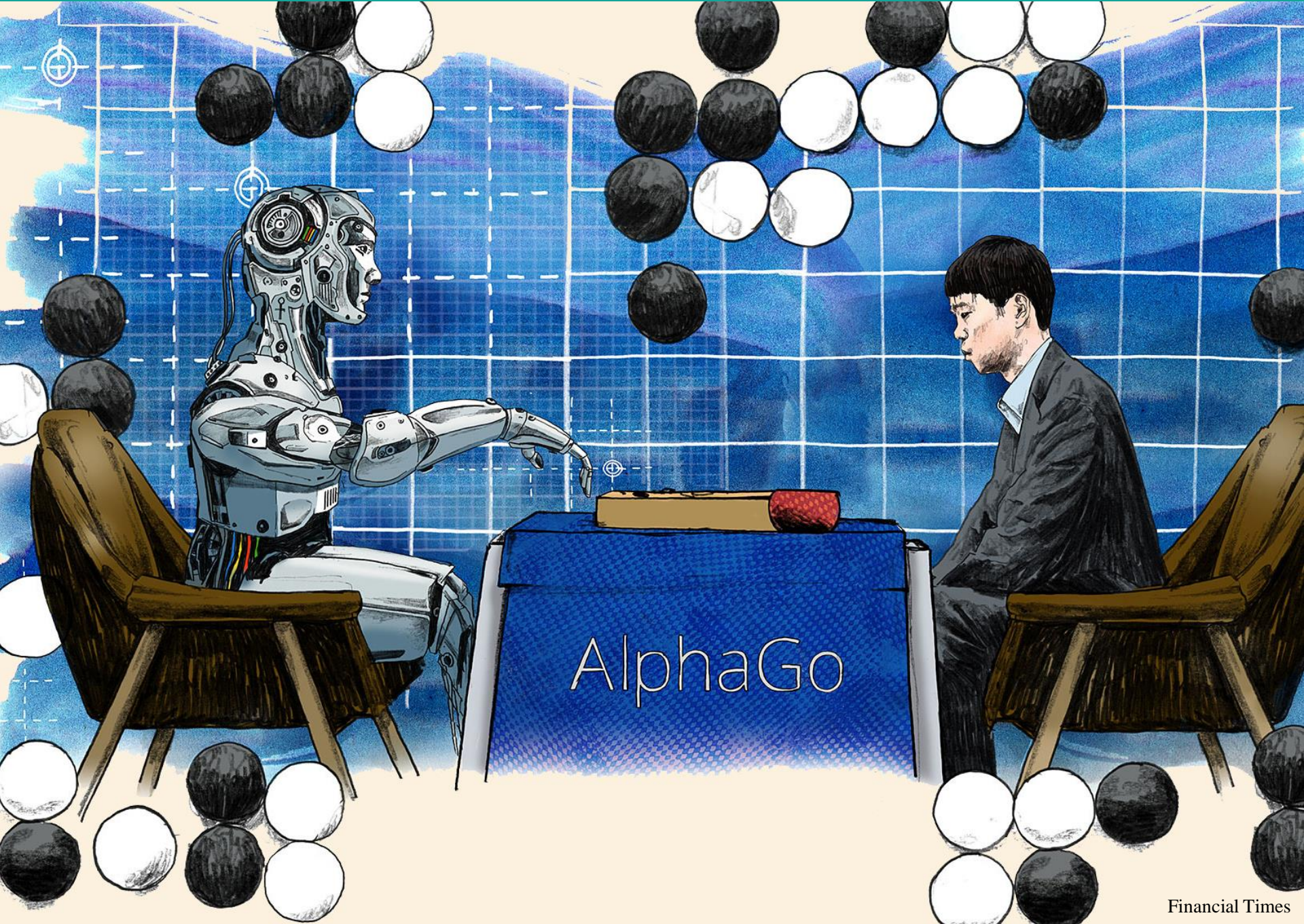
Devices designed by human for different level of interactions



Machine: A mechanical structure that uses power to apply forces and control movement to perform an intended action.

Computer: A device that can be instructed to carry out sequences of arithmetic or logical operations automatically via computer programming.

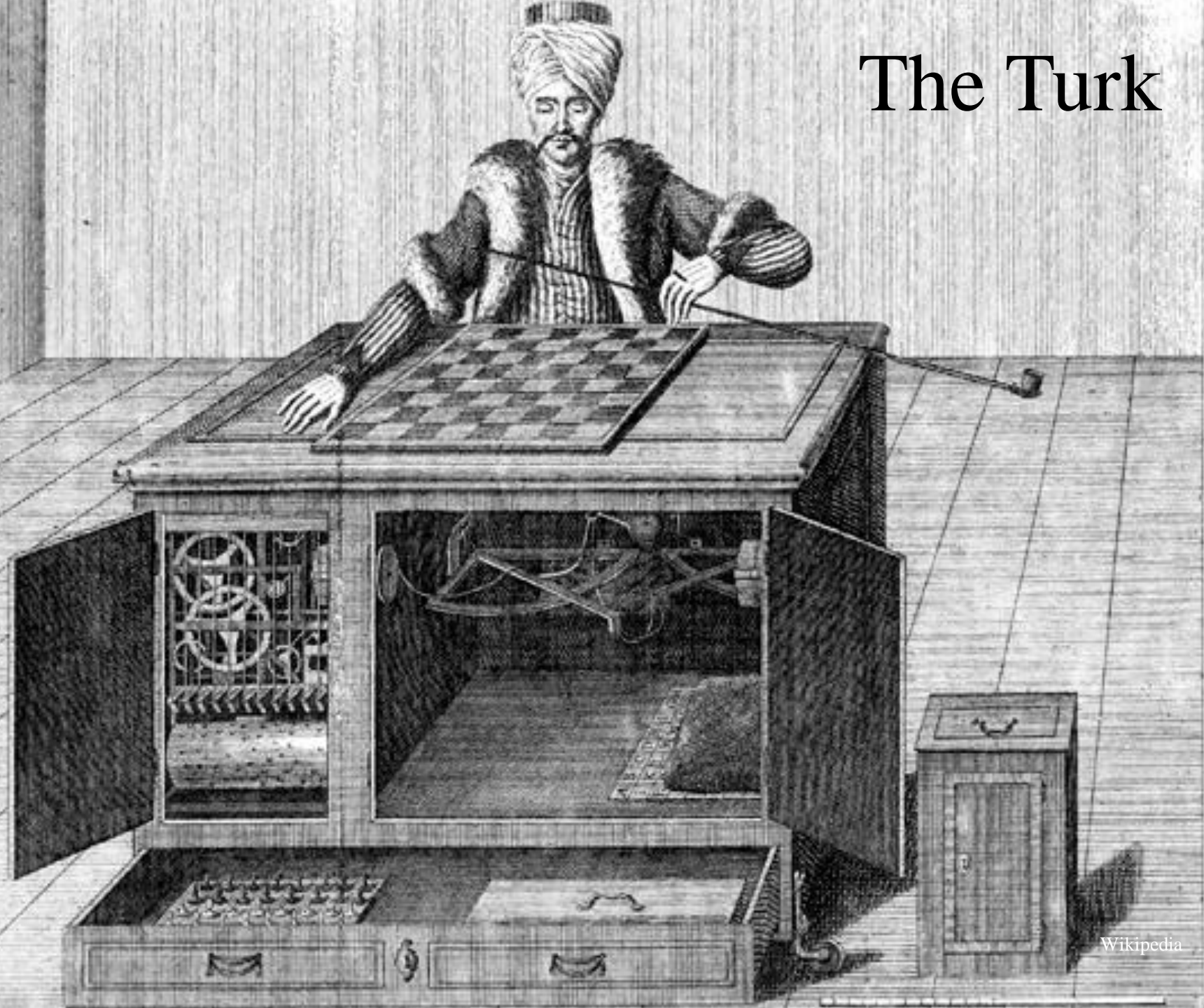
Robot: A machine – especially one programmable by a computer – capable of carrying out a complex series of actions automatically.

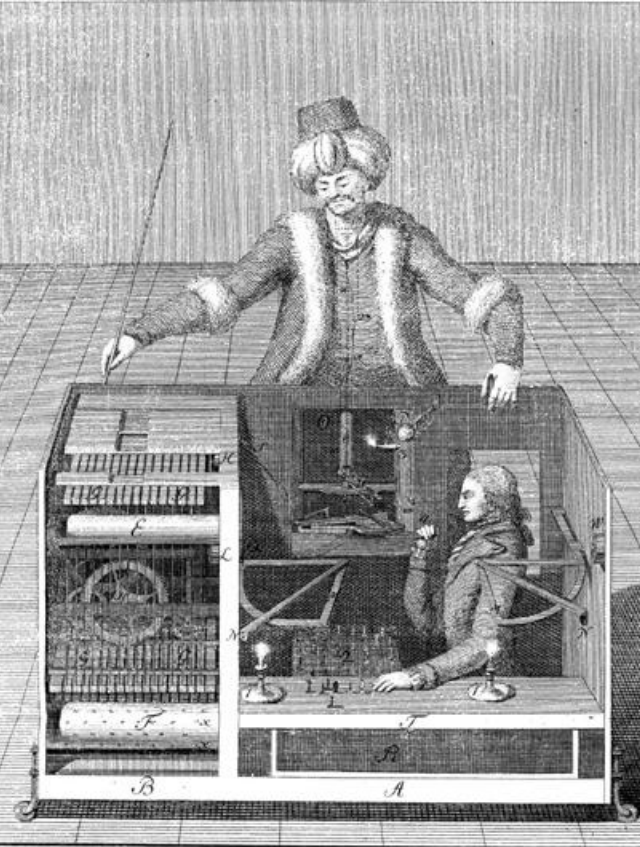


AlphaGo

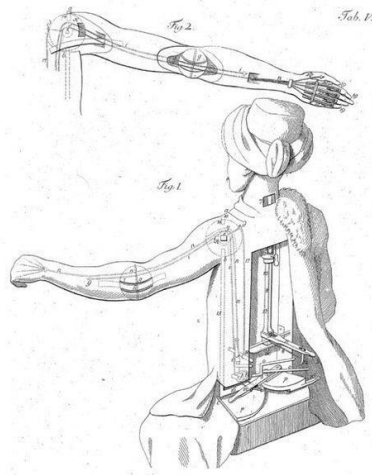


The Turk





The Fake Chess Player



Defining Moment of A Robot

Physical Interactions in A Real-World Environment



The Role of Mechanical Design in Advanced Robotics

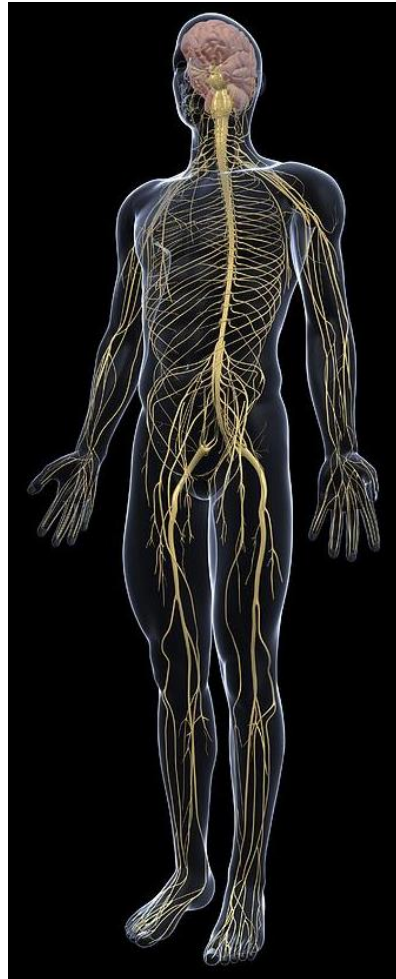
An Over-Simplification of the Engineering Roles

**Mechanical
Engineers**

**Electrical
Engineers**

**Computer
Engineers**

**Design
Engineers**



The Body: in charge of the physical system that makes up the robot, including pieces of the robots (like motors and actuators) and how the robotic will function in a production setting. The safety measures and physical operating protocols fall under this branch of engineering.

The Nervous System: gives the electronic foundation of the robot, including the embedded systems, low-level circuit programming, electrical resistance, and control theory.

The Brain: focuses on the software and programming language rather than the hardware, encompassing such topics as artificial intelligence (AI) and machine learning.

The Balance: focuses on the integration of the overall hardware and software that enables the robot to operate in a structured/unstructured environment with programmable interaction to fulfill designated tasks. All engineering roles must coordinate with the design of the robot to perform in a robust and reliable manner.

Robot Design Process

1. Kinematic topology
2. Geometric dimensioning
3. Structural dimensioning for static loading
4. Structural dimensioning for dynamic loading
5. Elastodynamic dimensioning of the overall structural
6. Actuator and transmission selections

Mechanical Design Considerations

For Advanced Robotics

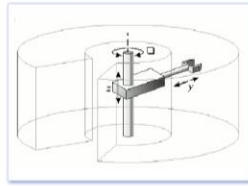
- Materials
- Function
 - Safety
- Efficiency
- Cost-Effectiveness
 - Modularity
 - Inspiration
 - Aesthetics
- User Interface
 - Ethics
 - ...

STATIONARY ROBOTS

Cartesian Robots



Cylindrical



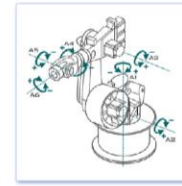
Spherical



SCARA



Articulated

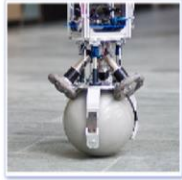


Parallel

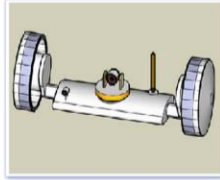


WHEELED ROBOTS

Single Wheel



2 Wheeled



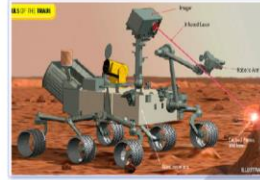
3 Wheeled



4 Wheeled



6 Wheeled



Tracked Robots



LEGGED ROBOTS

One Leg



Bipedal



Tripedal



Quadrupedal



Hexapod



Many Legs



Mechanical Design reflects the physical embodiment of the robots

SWIMMING ROBOTS



FLYING ROBOTS



Robotic Balls



SWARM ROBOTS



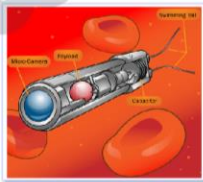
MODULAR ROBOTS



MICRO Robots



NANO Robots



SOFT ROBOTS



SNAKE Robots



CRAWLER Robots

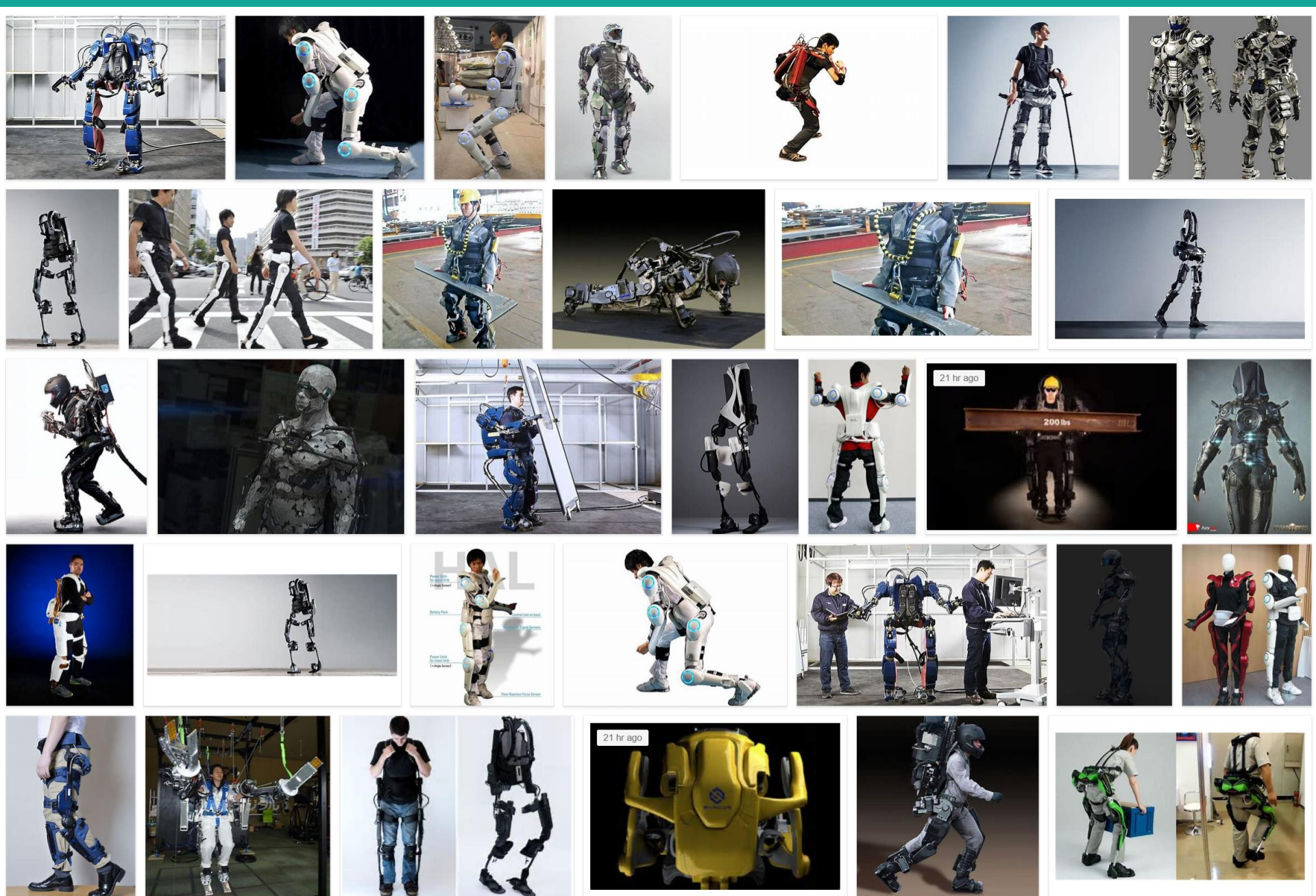


HYBRID Robots









Class Arrangements

The Final Weeks

- This Friday: Design Consultation
- Next Wednesday: Final Report
 - Before class starts (link at course webpage)
 - Submit online before Next Wednesday Noon (1200 @ 25 Dec)
 - 5 min video presentation
 - A 20-page engineering report
 - During the class
 - Cross evaluation based on Video Presentation
 - All students must show up, otherwise zero points for the whole team
- Next Friday: In-class Demonstration
 - During the class
 - Cross evaluation based on Live Demonstration
 - All students must show up, otherwise zero points for the whole team

Next Wednesday

Cross Evaluation

- Each student is assigned with 100 credits
 - *Evaluation based on Video presentation only*
- Submit online before 1530 during the class
 - *bring your laptop would be convenient*
- Each student must spend all 100 credits
 - *Any unused credits will be deducted against your team's credits*
- Each student can only give credits to team other than yours
 - *Any credit to your own team will be deducted against your team*
- Each team will have a second chance in Friday's class
 - *Teams with the most & least total credits will receive a prize*



Next class

- **Lab for Group 2:** Design Consultation
- Friday 0800-1000, Dec 20
- Room 412, 5 Wisdom Valley

- **Discussion for Group 1:** Design Consultation
- Friday 0800-1000, Dec 20
- Room 202, 1 Lychee Park

Thank you & Good Luck!

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