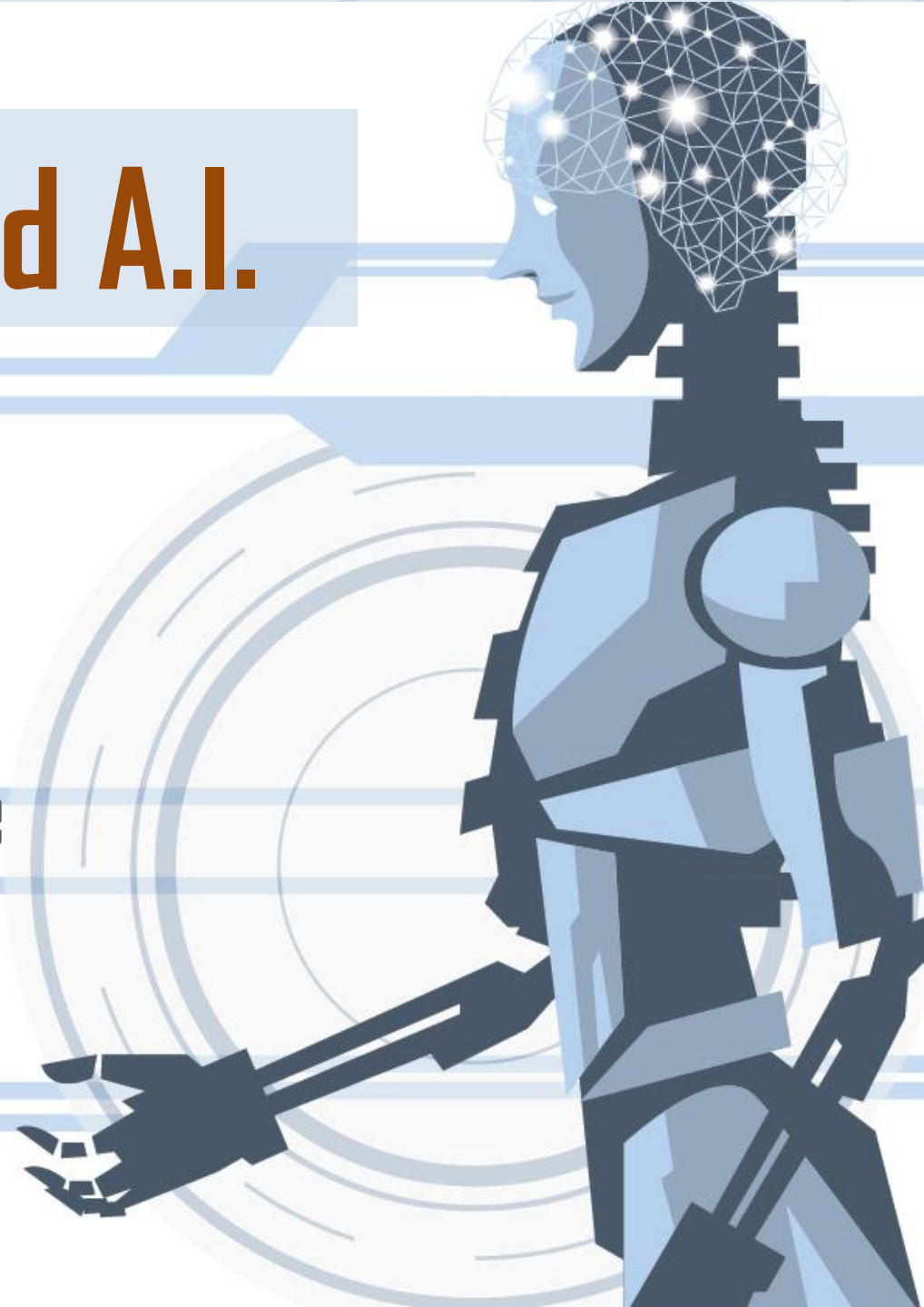
ROBOTICS and A.I.

CSCI 446

Fall 2019

Greg Marlowe

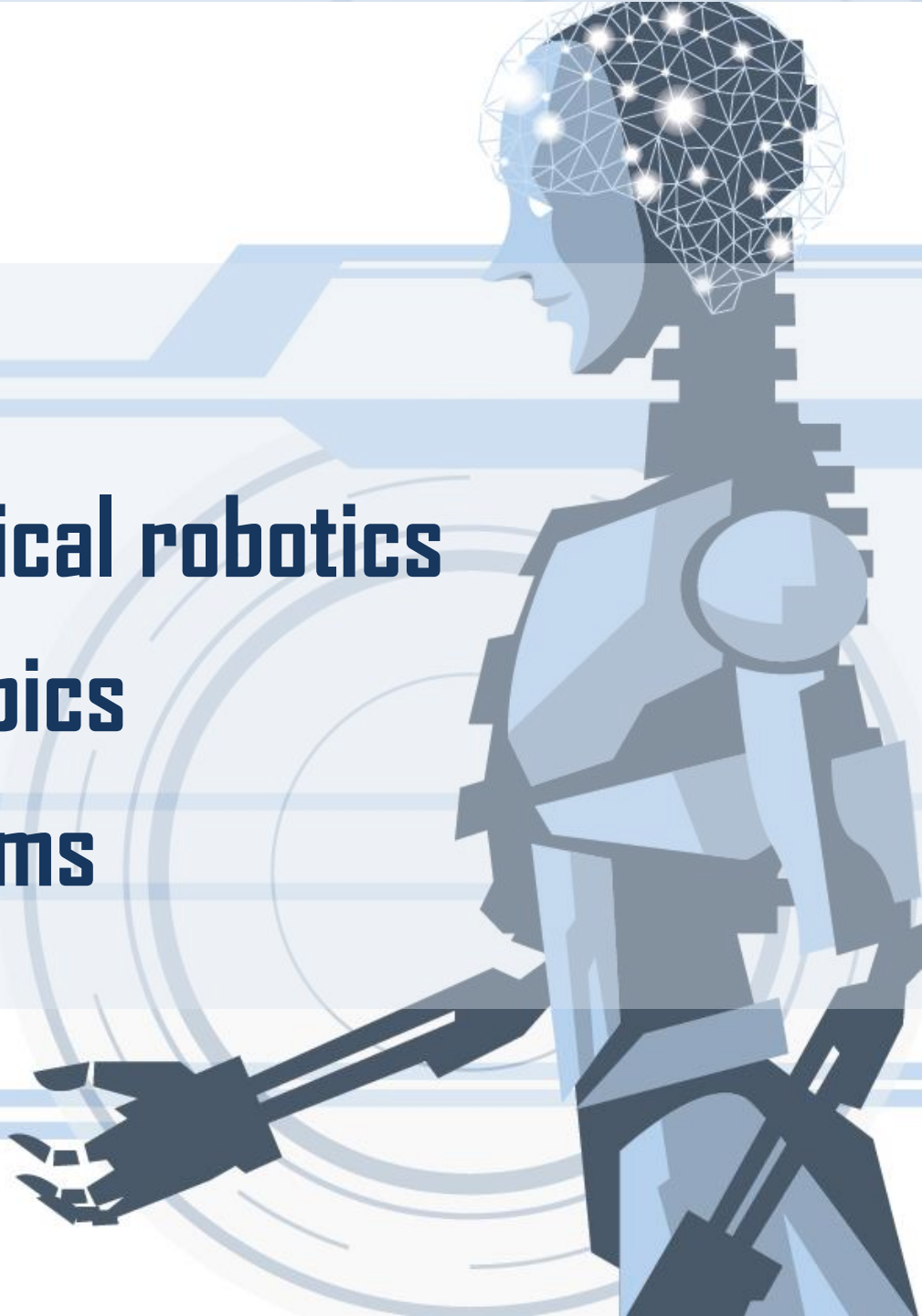


» Obligatory
Asimov's Laws

- A robot may not injure a human being or, through inaction, allow a human being to come to harm.
- A robot must obey the 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 Laws.

- A few points
- Robotics is a vast topic
- Challenges with organization
- Trade secrets and paywalls

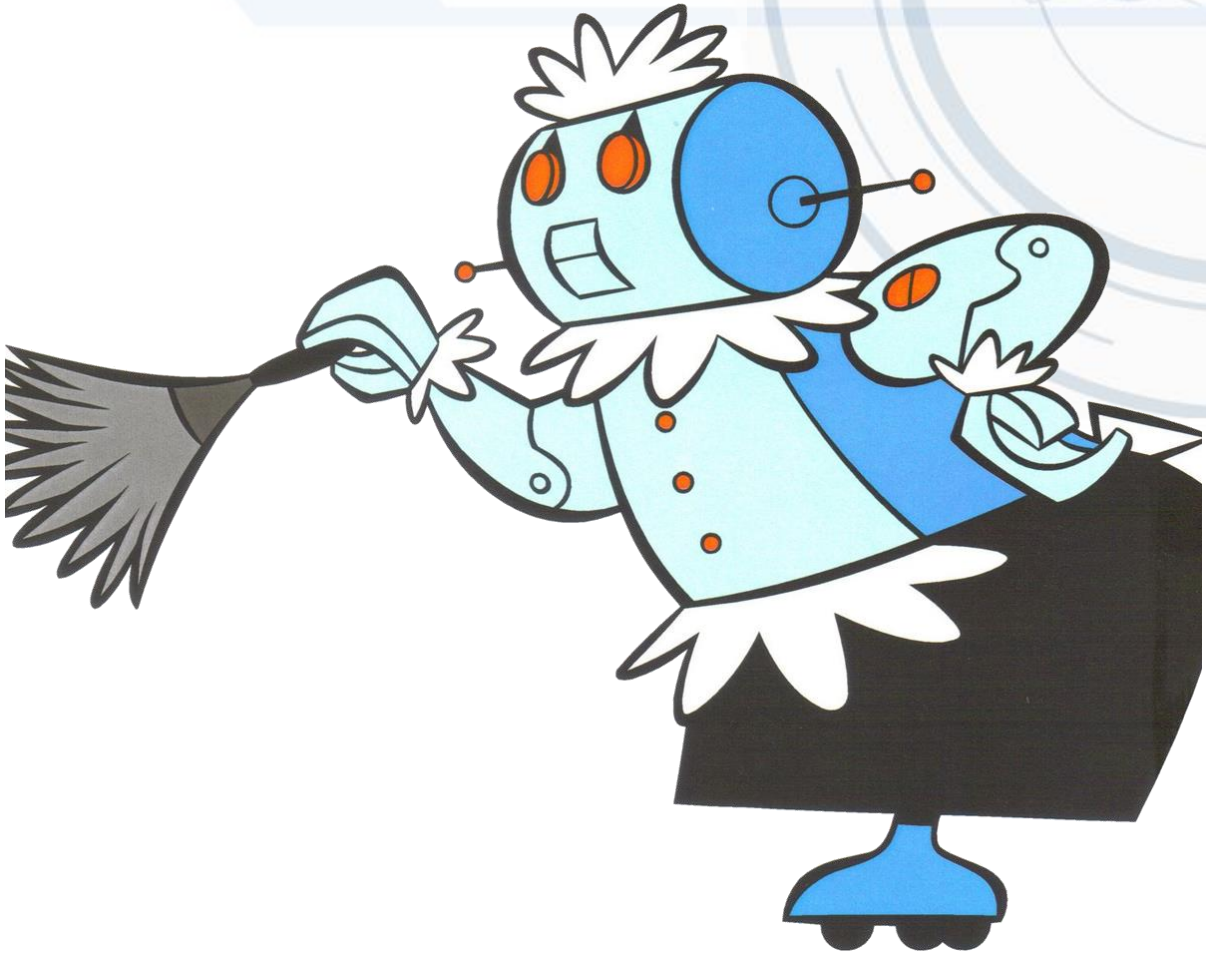
- A few points
- Focus on mechanical robotics
- Culmination of topics
- Systems of systems



- Presentation outline
- Origins and history
- Robotic uses and components
- Ethics and future

History

What is a "Robot"?



History

What is a "Robot"?

History

What is a "Robot"?

History

Credit to Karel Capek

History

Credit to Karel Capek

- 1920 play "Rossum's Universal Robots"
- Asimov claims this introduced "Robot" into science fiction
- Derived from Czech word "robota" – forced labor
- Derived from Czech word "rab" - slave

History

What is a "Robot"?

- Dictionary: "A person or machine who works mechanically without original thought, especially one who responds automatically to the commands others."

History

Credit to Karel Capek – side note: synthetic matter

History

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History

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History

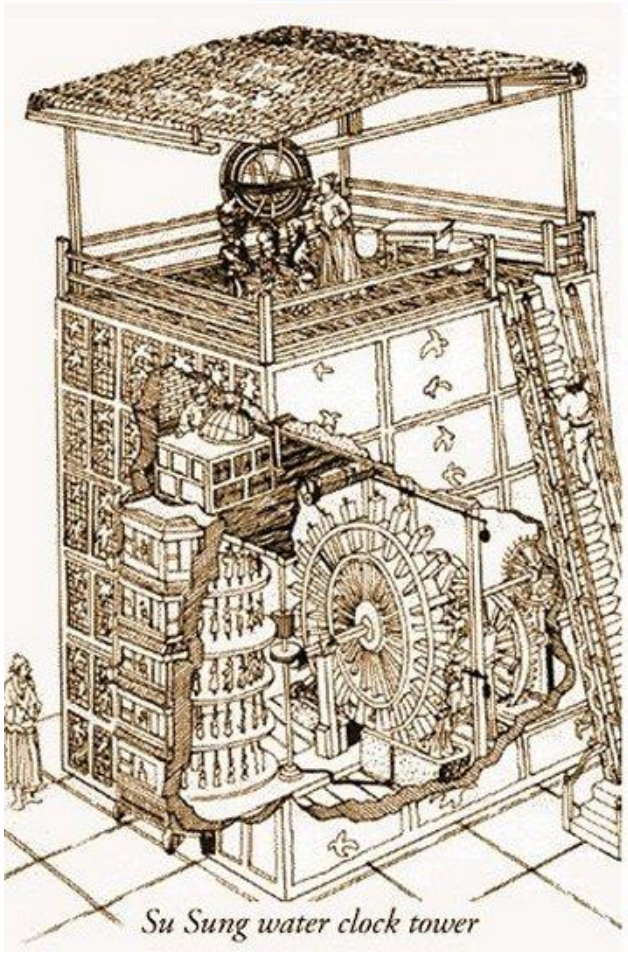
Talking mechanical handmaidens of ancient Greece

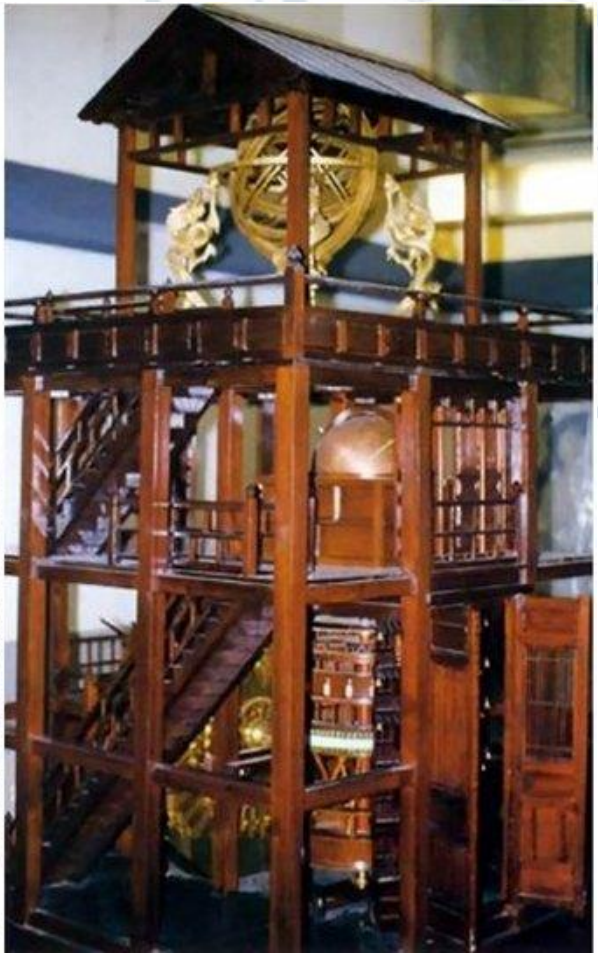
History

Animated ancient Egypt divinities

History

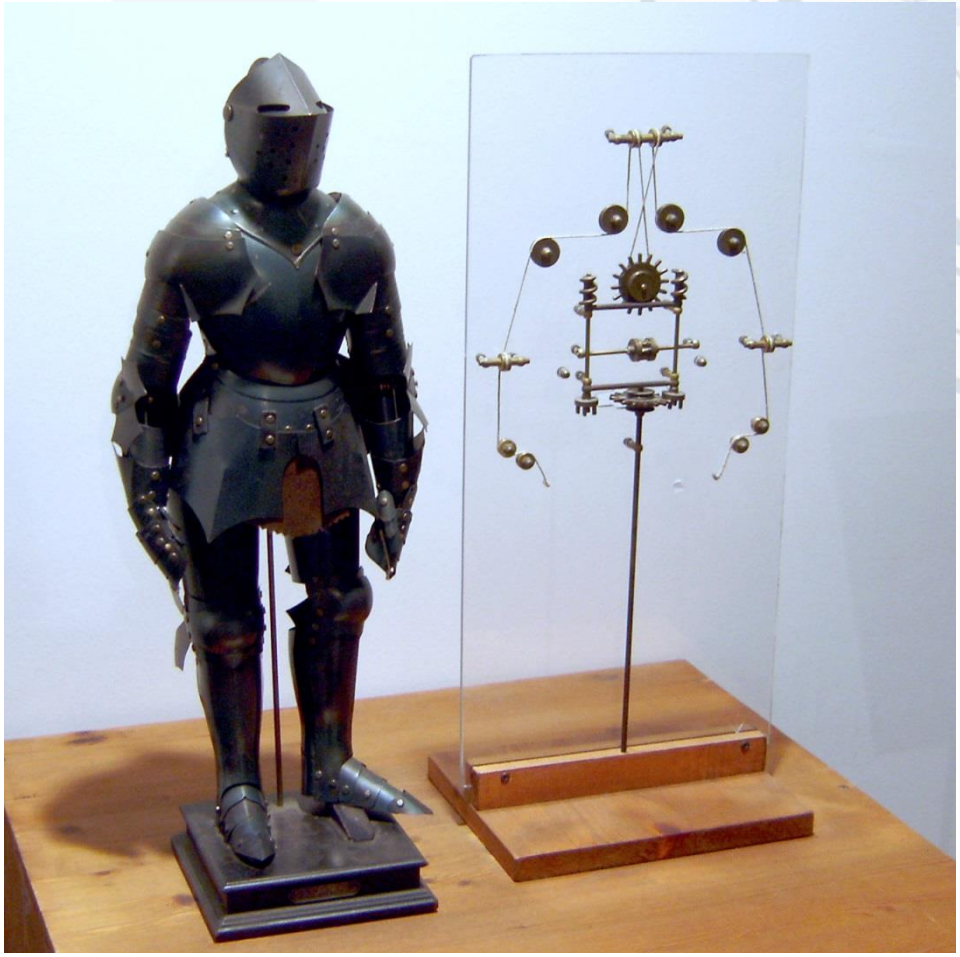
Su Song – Cosmic Engine: 1088 A.D.





History

Leonardo da Vinci – Mechanical Knight: 1495 A.D.



History - Modern

George Devol – Unimate: 1954

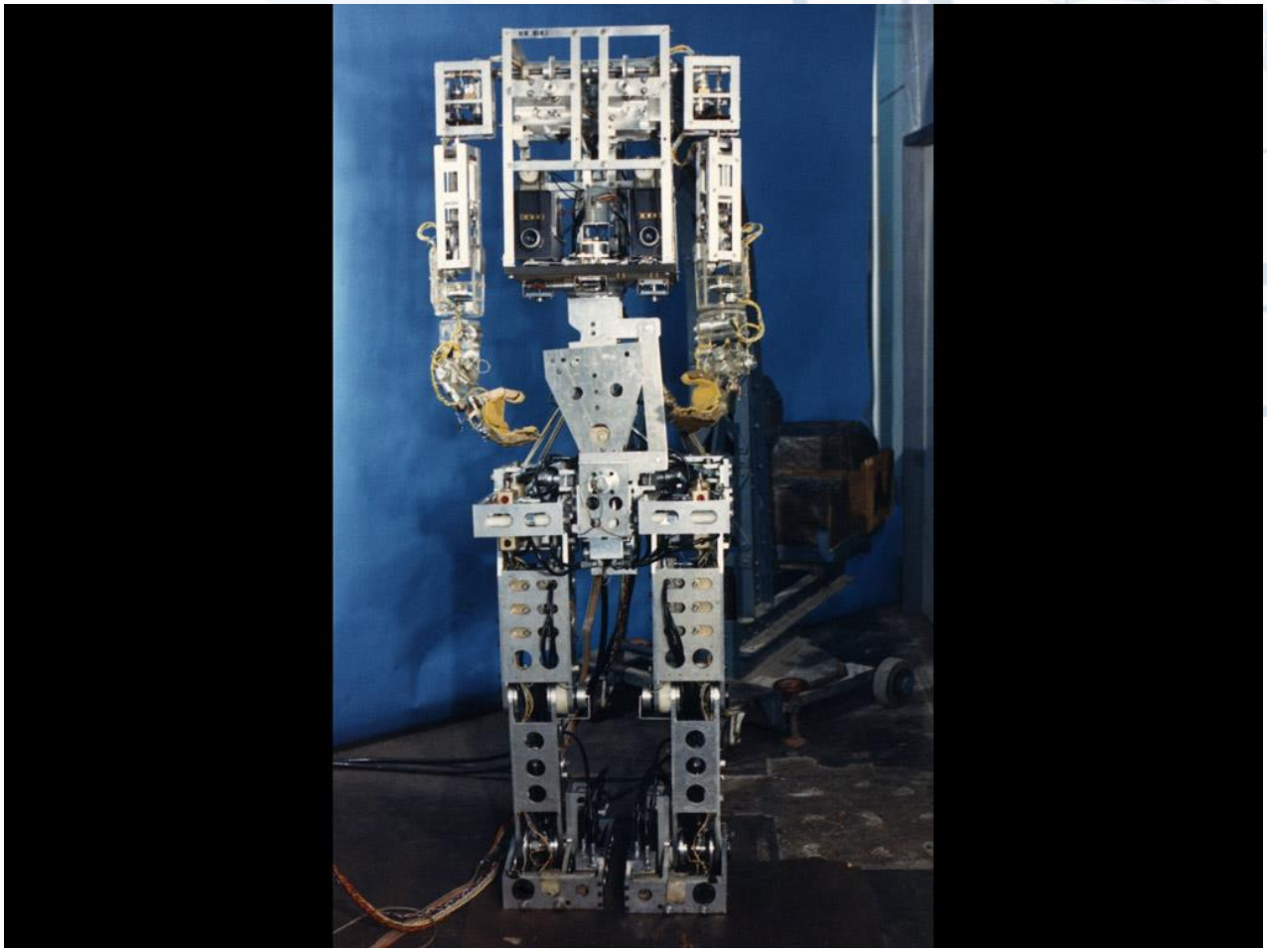
History - Modern

George Devol – Unimate: 1954

- Used by General Motors
- Lifted hot metal from die casting
- First digitally operated and programmable robot as opposed to analogue
- Side note – BEAM Robotics mimicking neurons via analogue circuits

History - Modern

Waseda University – WABOT-1: 1970's



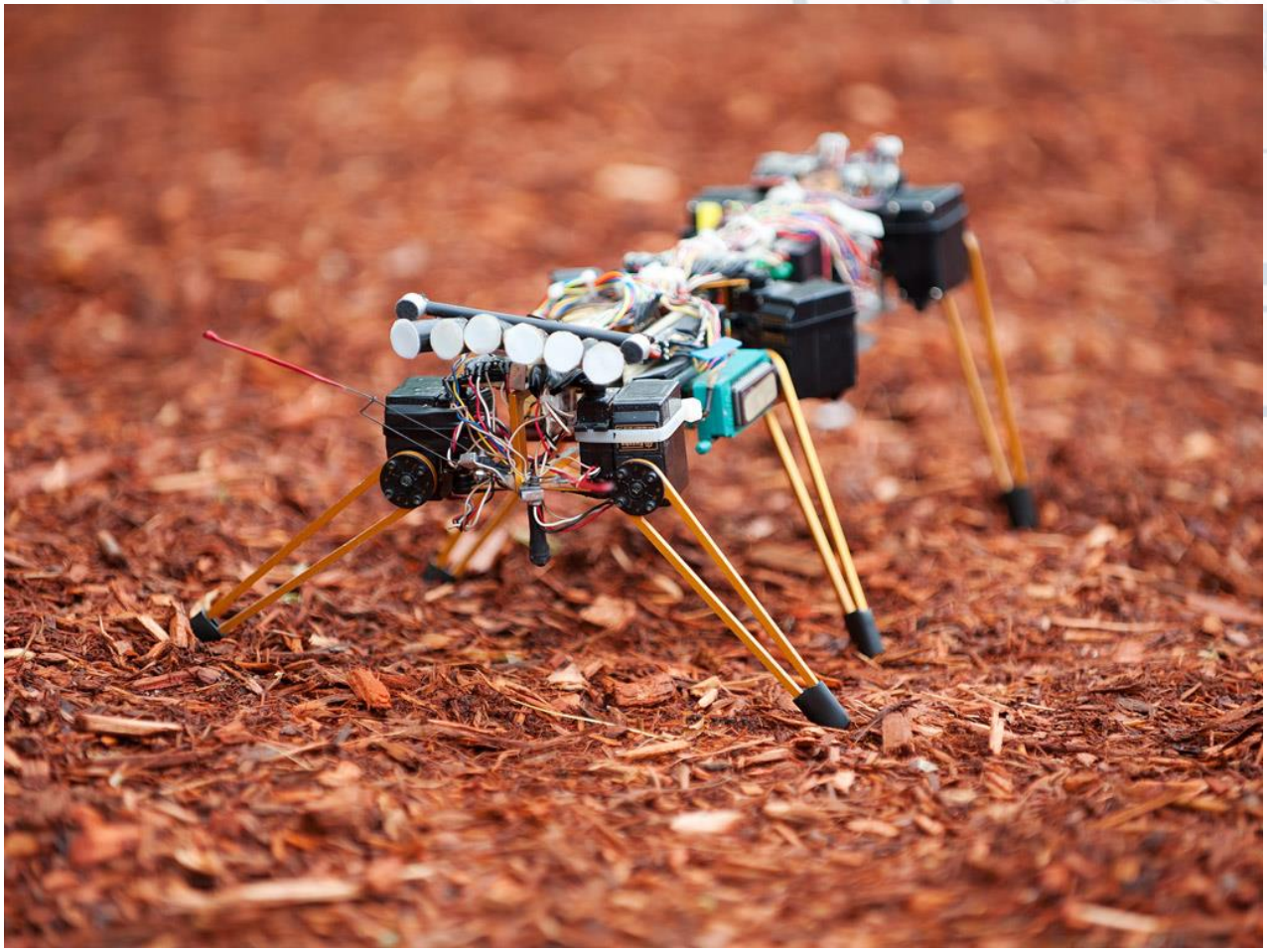
History - Modern

Waseda University – WABOT-1: 1970's

- Considered the first android
- Vision system
- Limb control system
- Conversation system
- Receptors: Walking, gripping, hearing

History - Modern

MIT – Genghis: 1980's



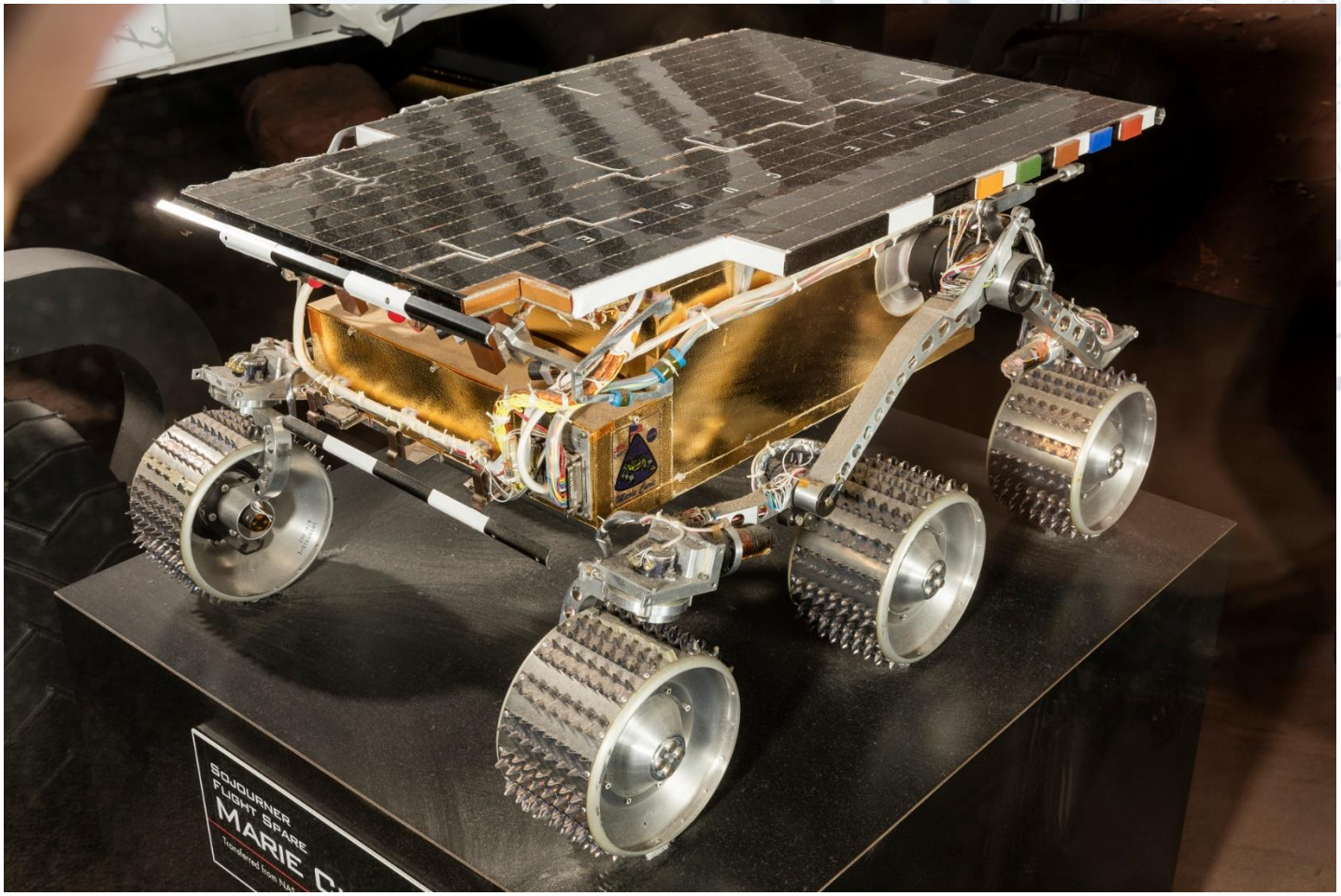
History - Modern

MIT – Genghis: 1980's

- Hexapodal "insect" robot
- Four microprocessors
- 22 sensors
- 12 servo motors
- Proof-of-concept for cheap space exploration

History - Modern

NASA – Sojourner: 1990's



History - Modern

NASA – Sojourner: 1990's

- Semi-autonomous
- Obstacle avoidance
- Navigation

History - Modern

Accuray Inc. – Cyberknife: 1990's

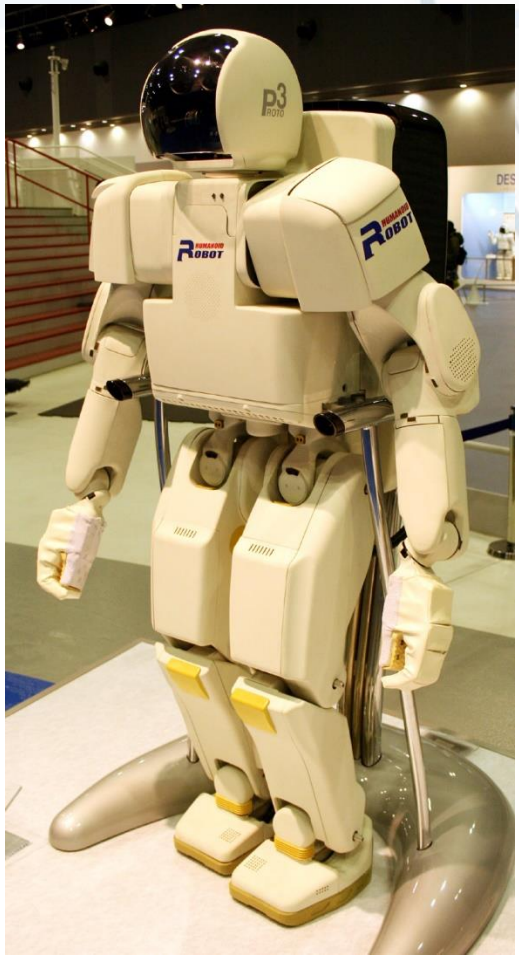
History - Modern

Accuray Inc. – Cyberknife: 1990's

- First FDA approved robot-assisted surgery appliance

History - Modern

Honda – P3: 2002



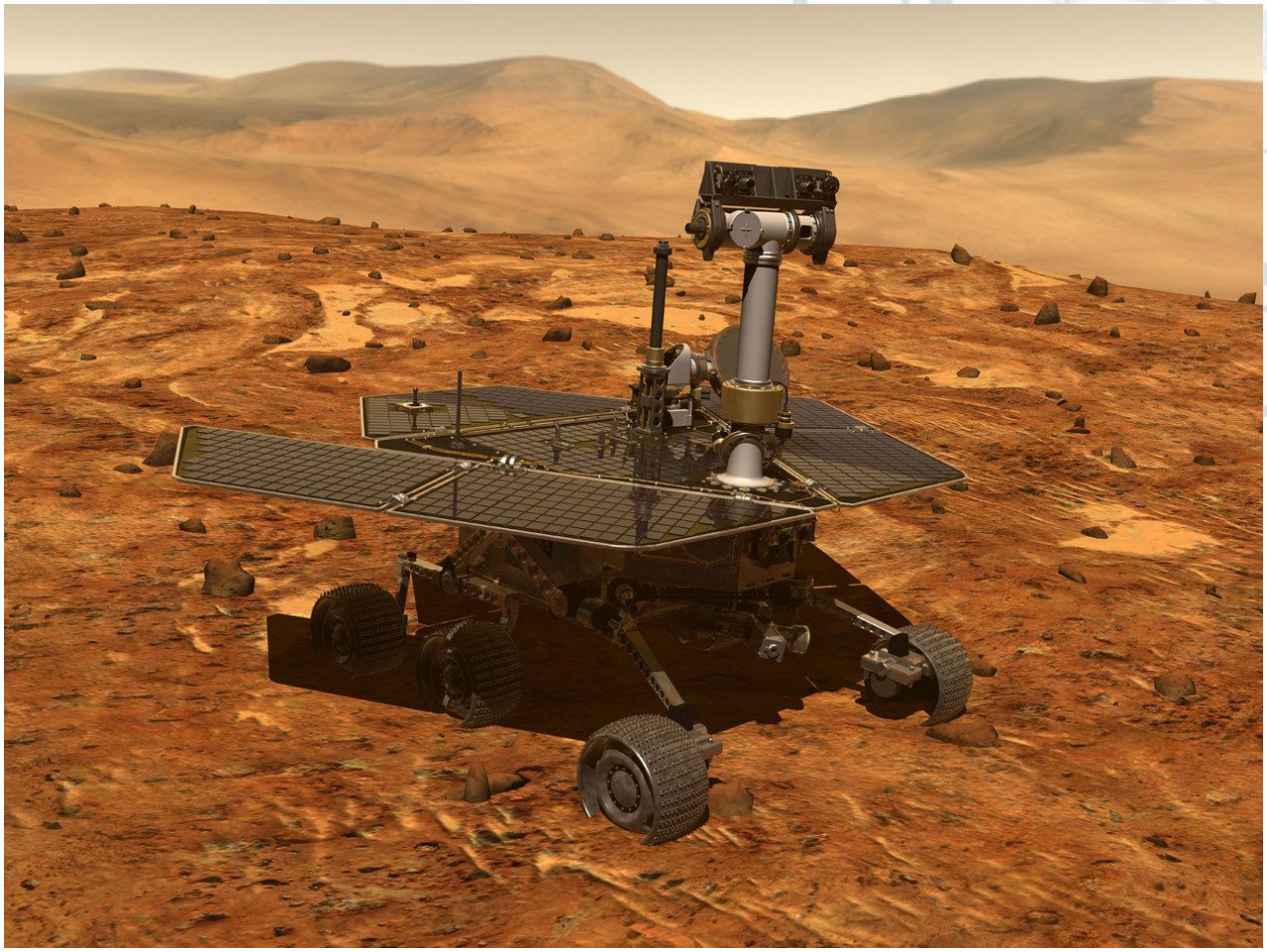
History - Modern

Honda – P3: 2002

- First completely independent (non-tethered) bi-pedal walking robot

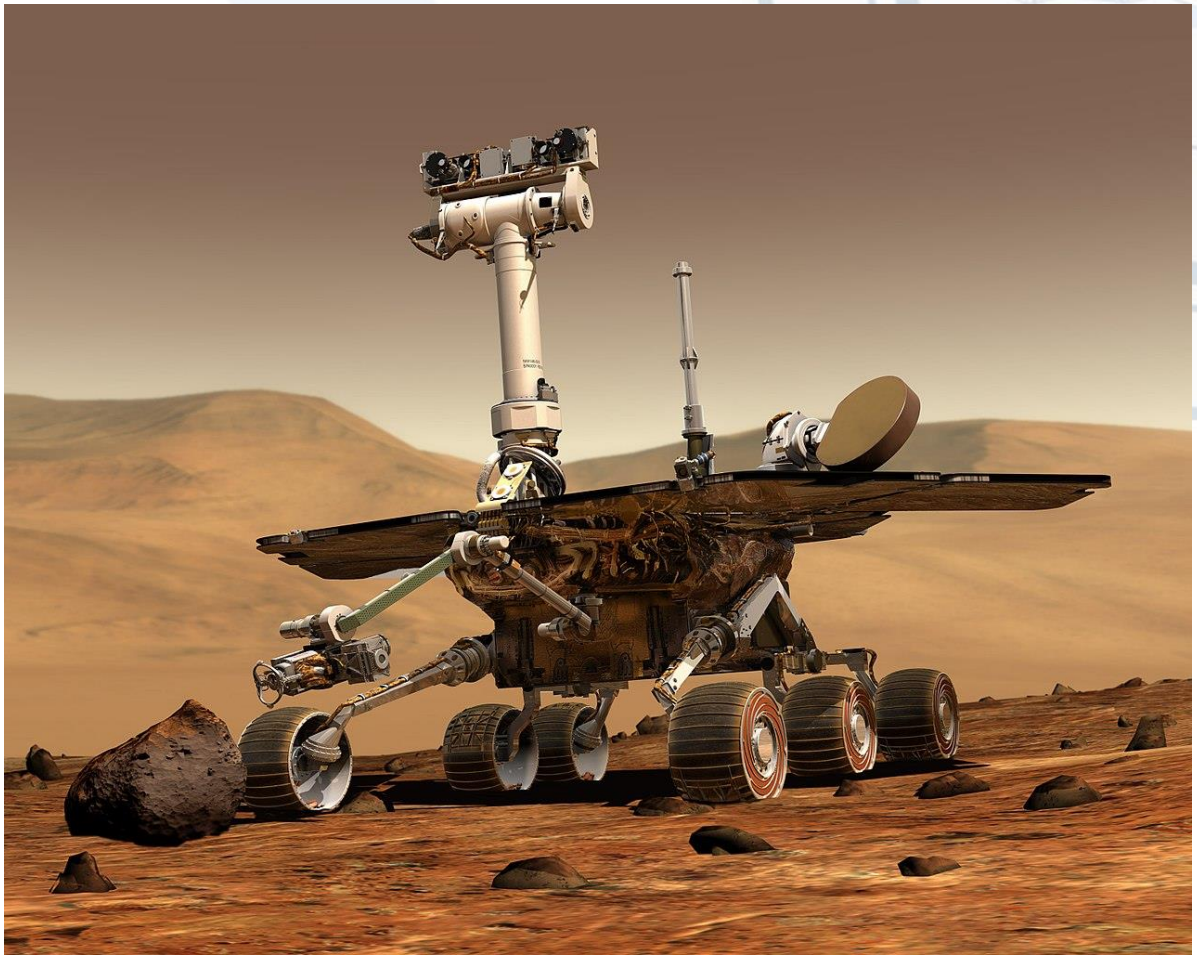
Robotics - Present

NASA: Spirit



Robotics - Present

NASA: Opportunity



Robotics - Present

iRobot: Roomba

Robotics - Present

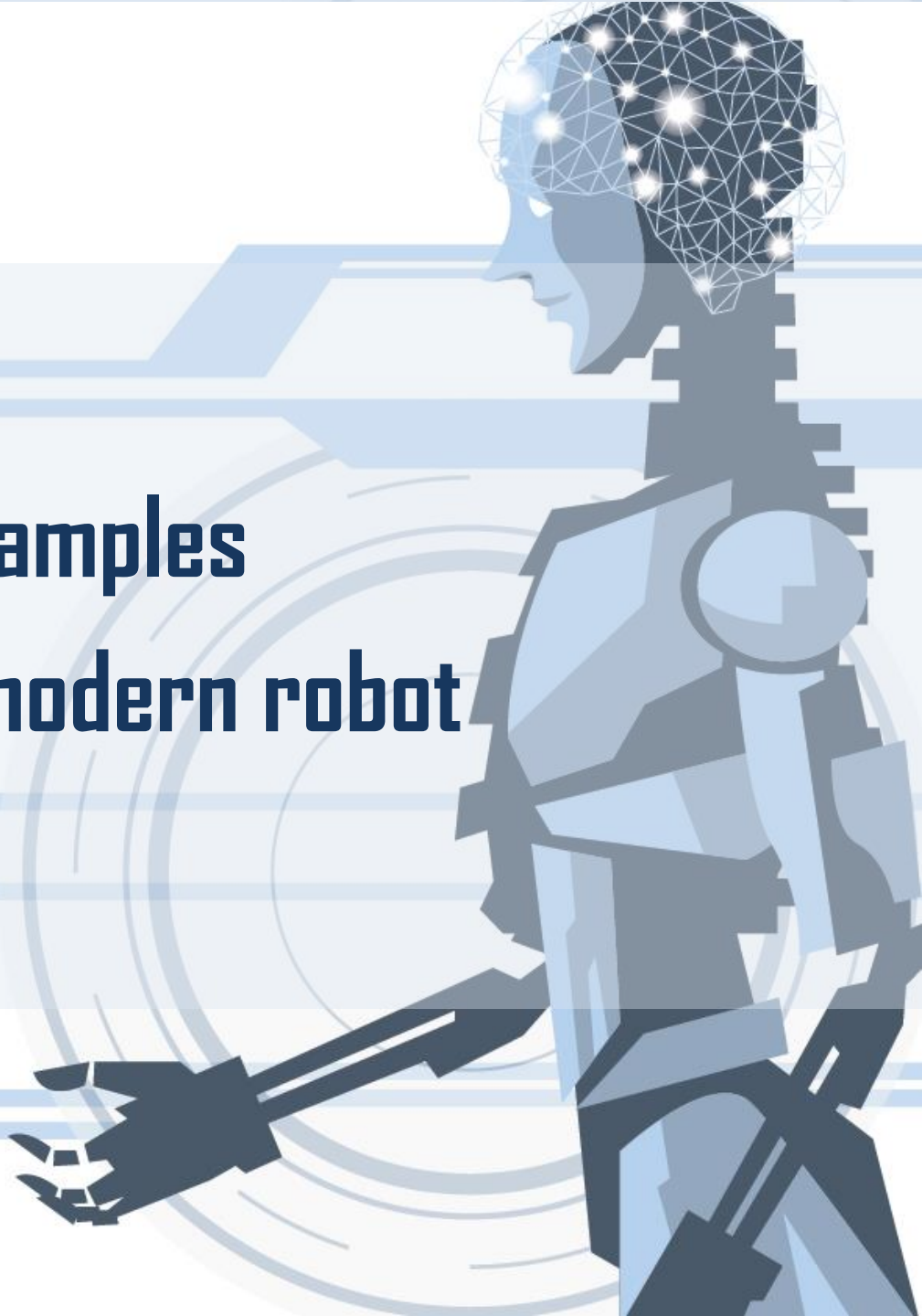
Tesla: Cybertruck?!

Robotics - Present

The point..

- Robots are in use everywhere today
- Commercial and industry applications
- Work too dirty or dangerous
- Work requiring precision and accuracy

- Part II
- Use cases and examples
- Ingredients of a modern robot



Modern robotic use cases

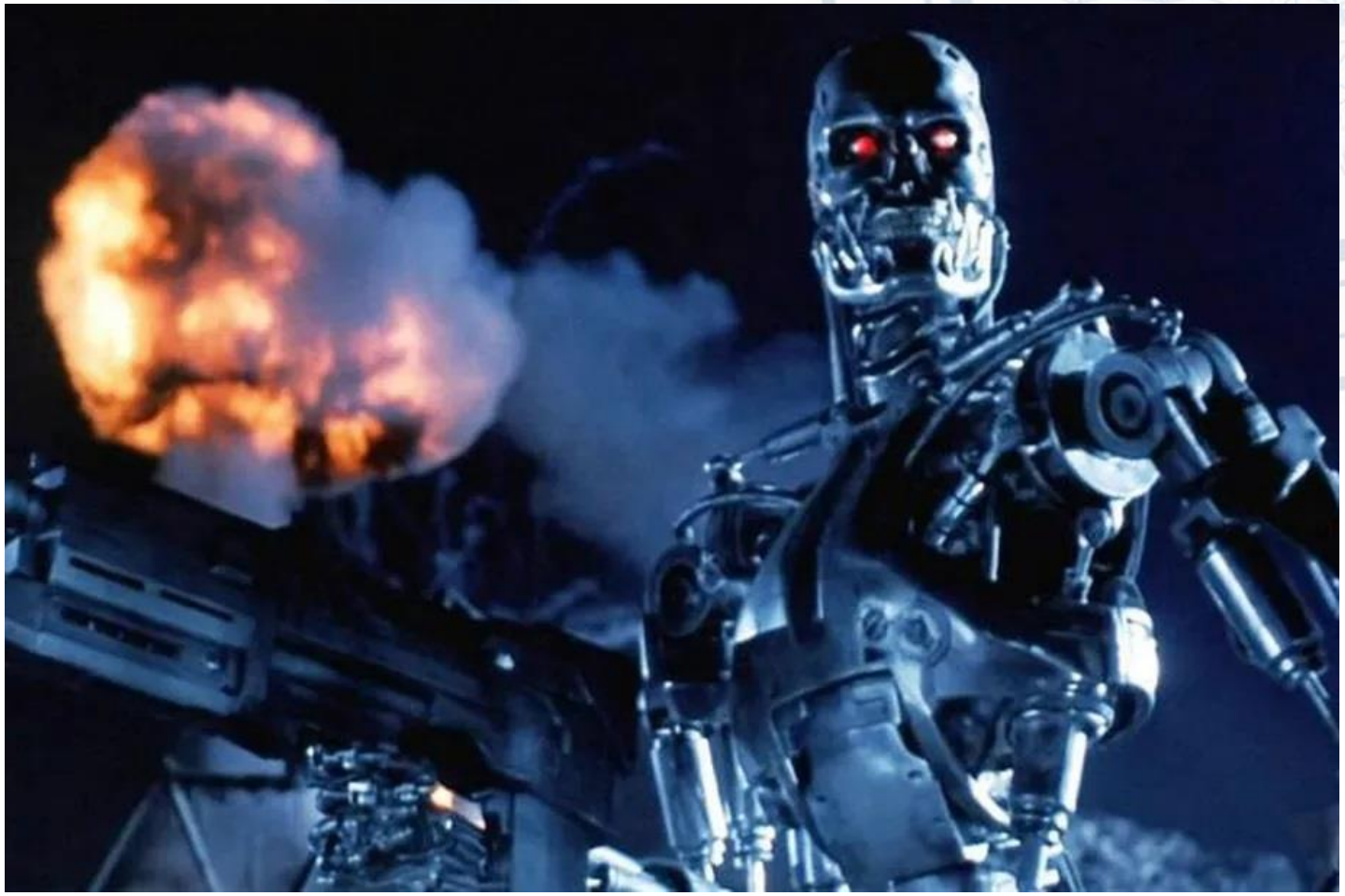
Military

Modern robotic use cases

Military

Modern robotic use cases

Military - ??

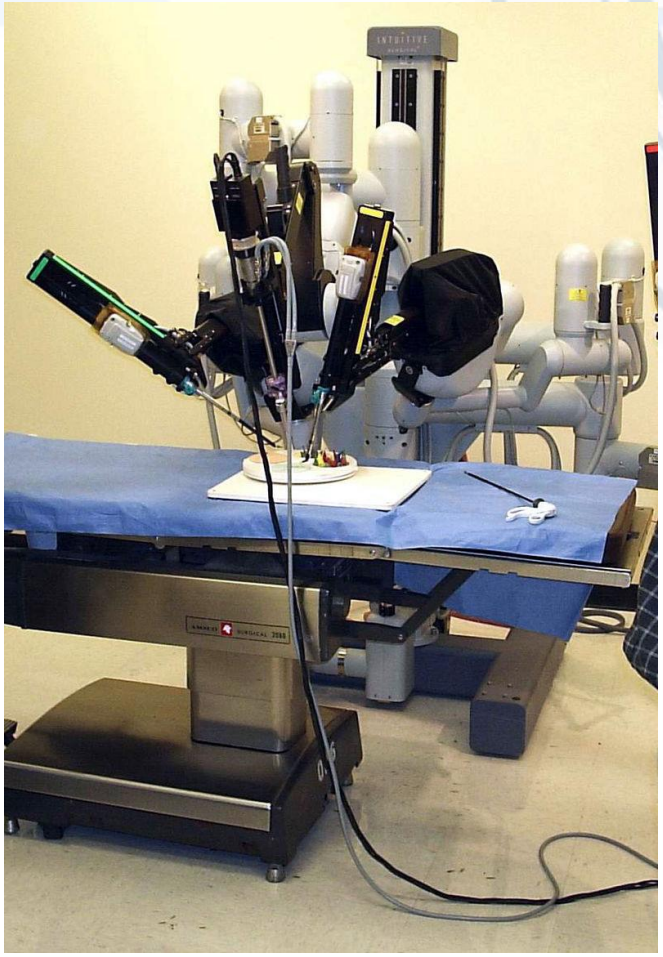


Modern robotic use cases

Agriculture

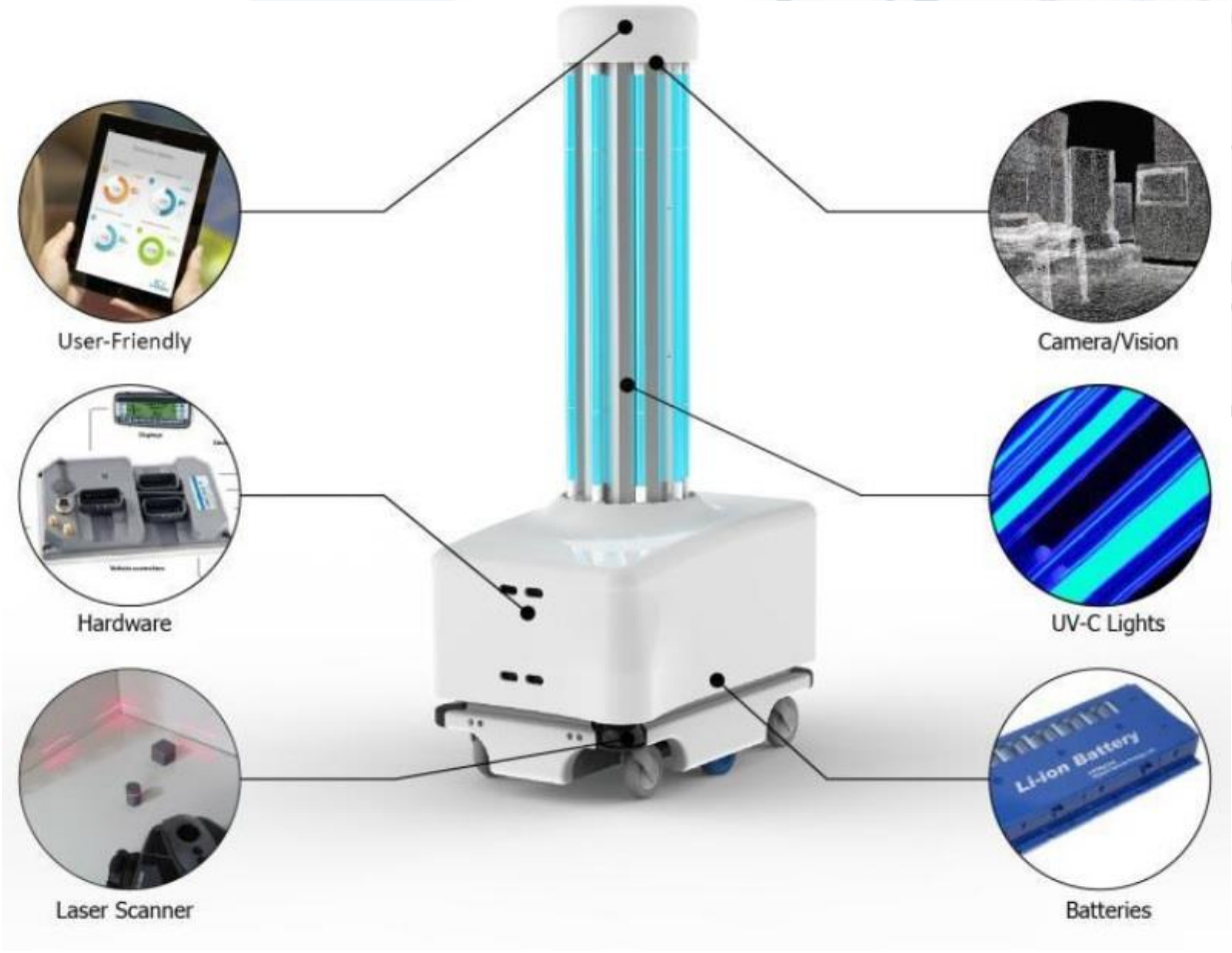
Modern robotic use cases

Healthcare



Modern robotic use cases

Healthcare



Modern robotic use cases

Food preparation

Modern robotic use cases

Food preparation

Modern robotic use cases

Entertainment

Modern robotic use cases

Cleanup / Safety

Modern robotic use cases

Cleanup / Safety

Modern robotic use cases

Domestic

Modern robotic use cases

Domestic

Modern robotic use cases

Domestic

Modern robotic use cases

Domestic

Modern robotic use cases

Domestic - ??

Robotic ingredients

Power and movement

- Typically battery or generator
- Generator: Hot, heavy, fuel, space
- Generator solution: Tether
- Battery: Not a generator, no tether
- Battery problem: Short life

Robotic ingredients

Power and movement

- Actuators (muscles)
- Electric Motor (turn wheels or gears)
- Linear actuators (push /pull / large force)
- Inflatable air tubes
- Memory retention wire (contracts)
- Electroactive polymers – plastic, high strain (current research)

Robotic ingredients

Senses - Touch

- Tactile sensors
- Measures object weight, temperature, stiffness, center of mass
- Mimic biological hands using fluid shift in sensor array

Robotic ingredients

Senses - Vision

- See Jacob's presentation
- Cameras used to create images
- Data extracted from images
- Object recognition and classification
- Image recognition mapping to robot actions

Robotic ingredients

Senses - LIDAR

- Light Detection And Ranging
- Laser used to measure distance to target
- Precise 3D mapping for driving / landing / aerial observation
- Control, navigation, classification
- Cons: Low light, weather

Robotic ingredients

Senses - Radar

- Radio Detection and Ranging
- Uses radio waves to measure distance
- Great in bad weather and lighting
- Less power
- Cons: Low resolution, false positives, stationary objects
- A.I. being applied to increase resolution

Robotic ingredients

Senses - Sonar

- Sound Navigation Ranging
- Uses sound to detect distance
- Works in no light conditions, LIDAR fails
- Works through dense fluid, Radar fails
- Convolutional neural networks being used to classify sonar images

Robotic ingredients

Senses - Sonar

- Sound Navigation Ranging
- Uses sound to detect distance
- Works in no light conditions, LIDAR fails
- Works through dense fluid, Radar fails
- Convolutional neural networks being used to classify sonar images

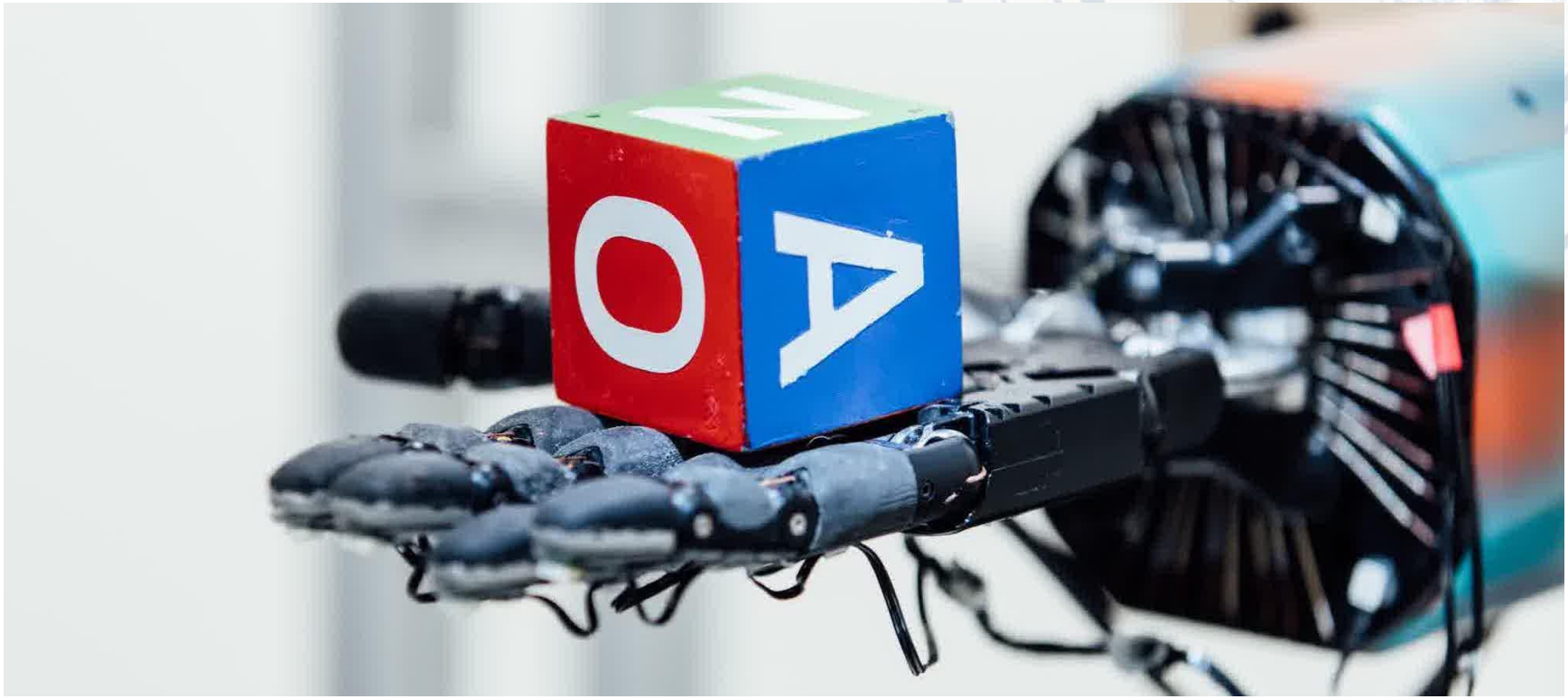
Robotic ingredients

Environment Manipulation

- Robotic “hands”
- Friction or pressure based “fingers”
- Scooping / jaw mechanisms
- Vacuums
- Magnetism

Robotic ingredients

Environment Manipulation – Shadow Hand



Robotic ingredients

Mobility - Wheels

- Four wheels or tracks most common
- Two wheeled gyroscope variations
- Example: Segway scooter, used in NASA's Robotic Mobility Platform, in turn used for humanoid space-faring Robonaut 1
- Single wheel/sphere "ballbots" and "orbs"

Robotic ingredients

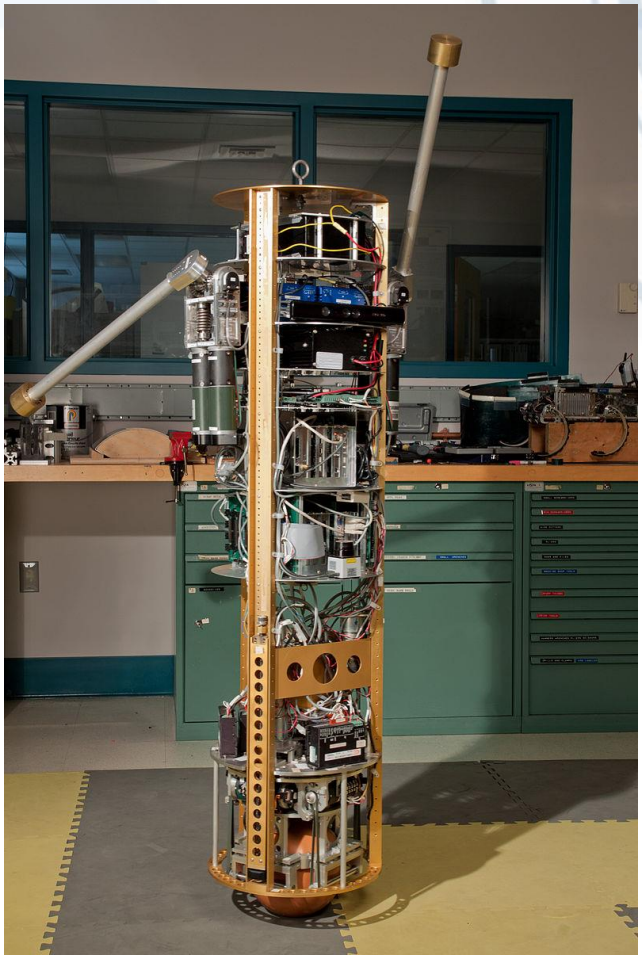
Mobility – Two wheels

Robotic ingredients

Mobility – One wheel ?!

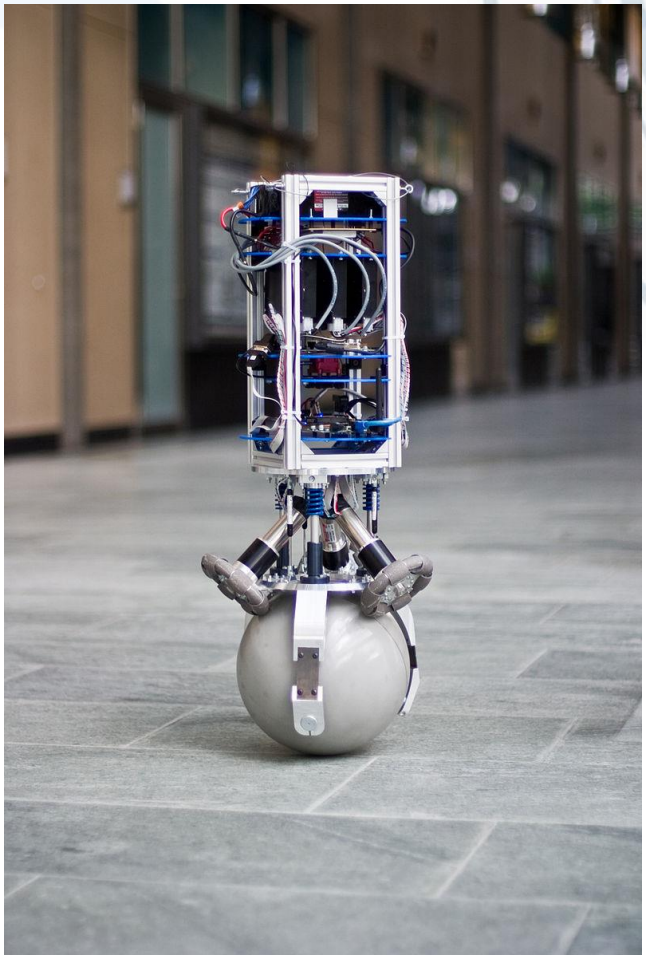
Robotic ingredients

Mobility – Single sphere



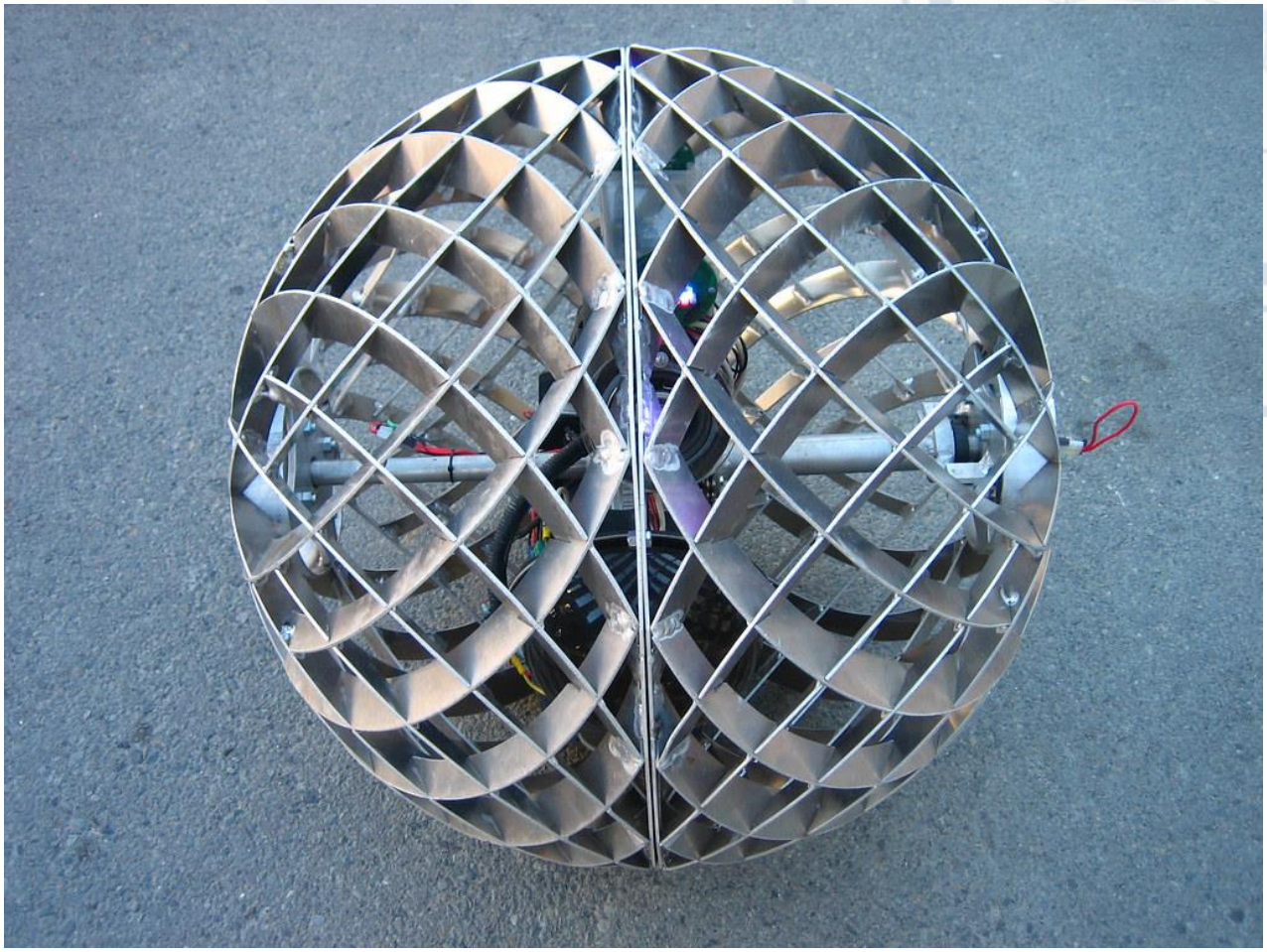
Robotic ingredients

Mobility – Single sphere



Robotic ingredients

Mobility – Single sphere



Robotic ingredients

Mobility – Single sphere ?!

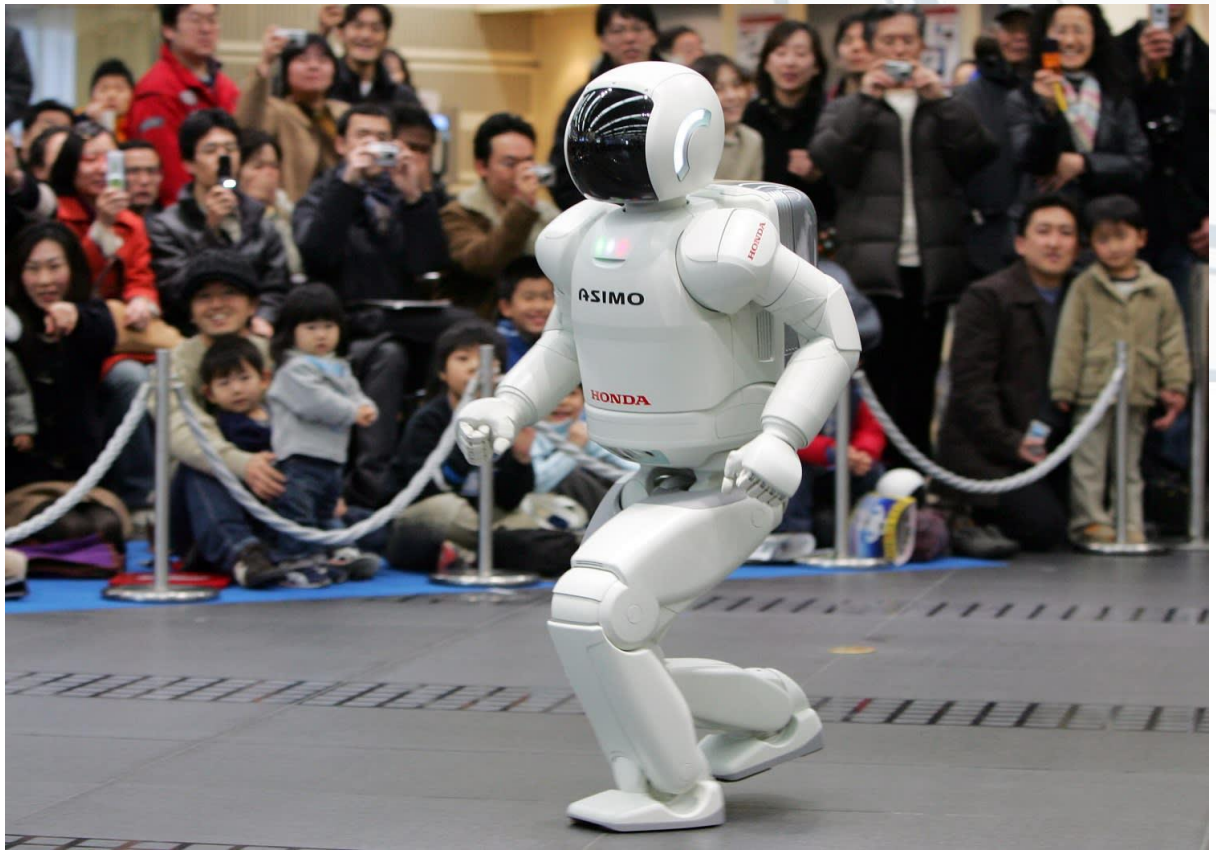
Robotic ingredients

Mobility – Walking

- Honda ASIMO one of the original functional bipedal robots.
- Zero moment point algorithm
- Required flat floor, no dynamic balancing

Robotic ingredients

Mobility – Walking – Honda ASIMO



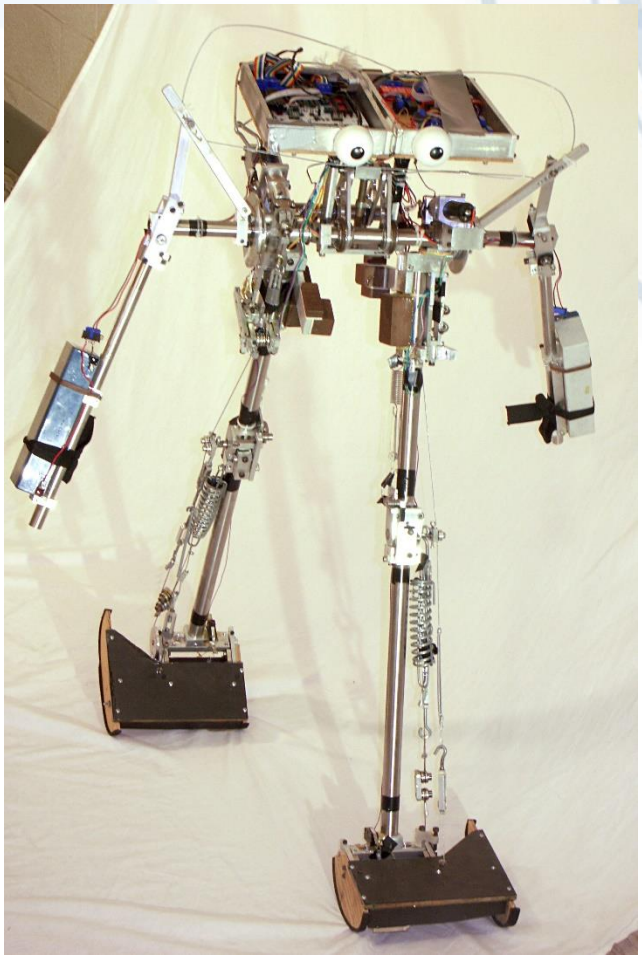
Robotic ingredients

Mobility – Walking

- Modern approach through dynamic balancing algorithm (controlled falling)
- Passive dynamics
- Allow free motion, gravity assist, flexible response to natural motion.
- Specific cost of transport
- ASIMO = 3.23, Cornell Efficient Biped = .20

Robotic ingredients

Mobility – Walking – Cornell Biped



Robotic ingredients

Mobility – Flying

- Obvious example: Drones
- Airplanes auto-pilot
- Cruise Missles

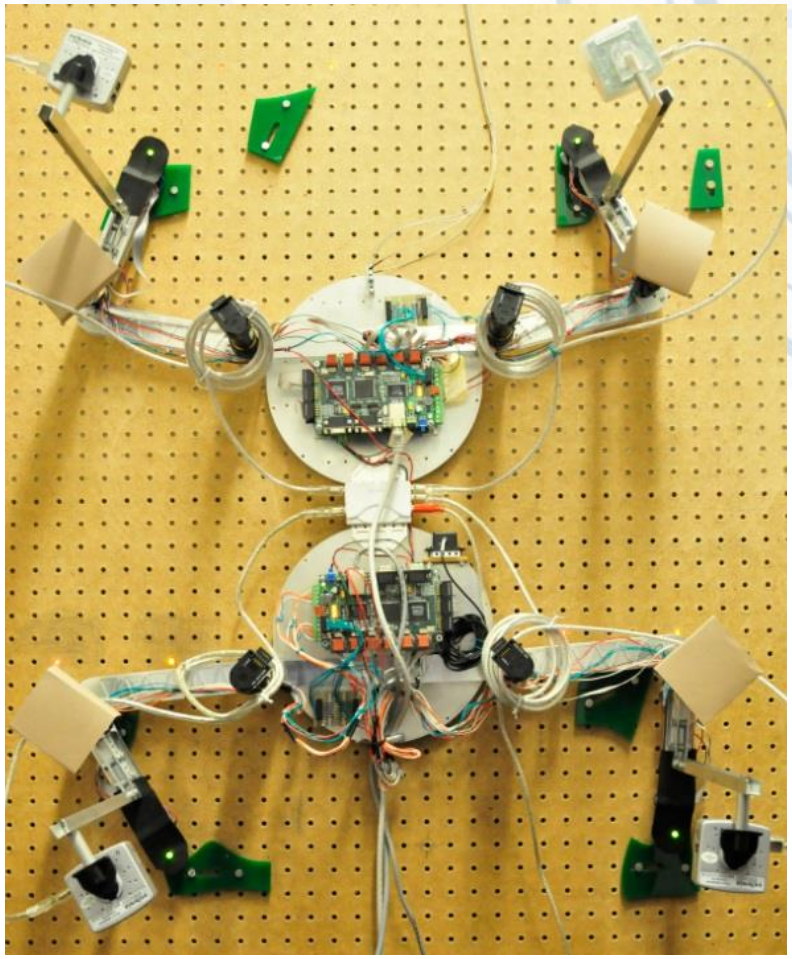
Robotic ingredients

Mobility – Climbing and crawling

- Climbing robots
- Mimic humans, move individual limbs
- Adjust center of mass
- Gecko style (sticky pads)
- Mimic snake – confined spaces

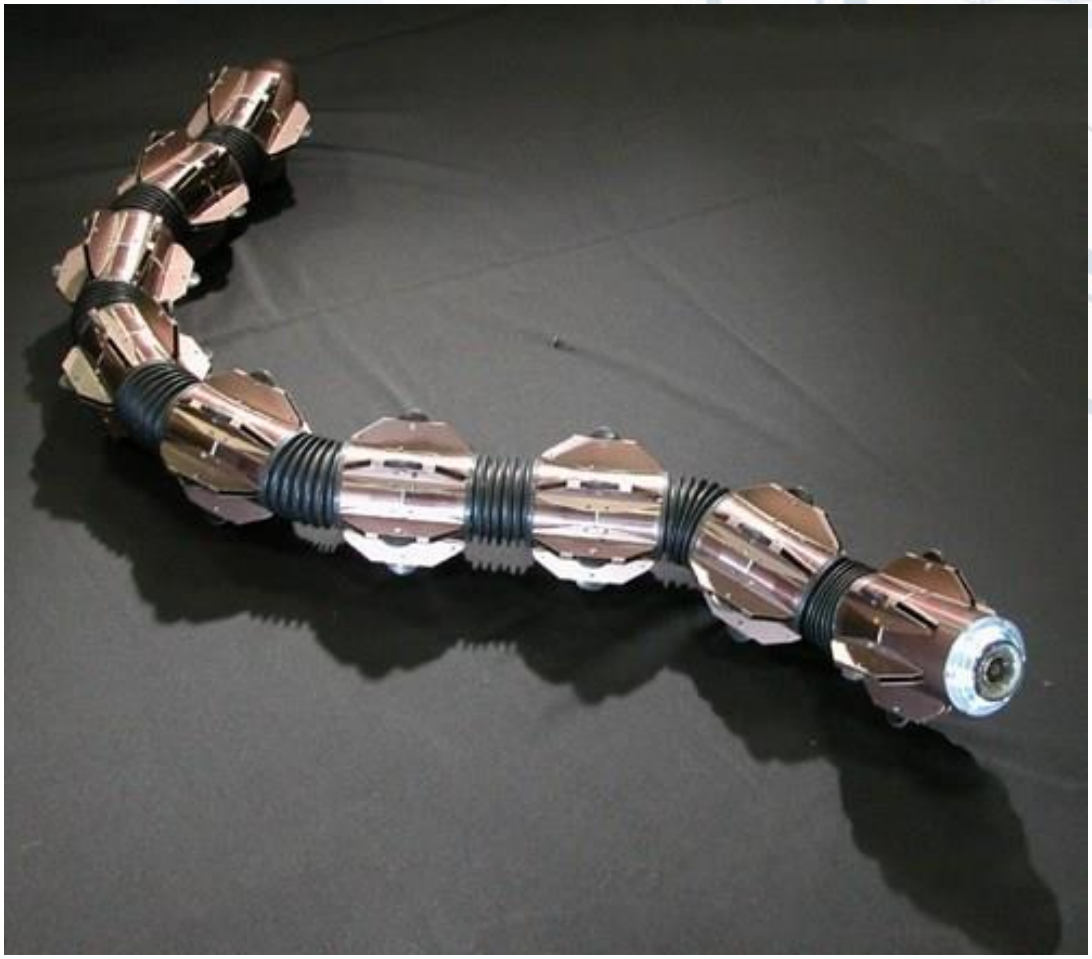
Robotic ingredients

Mobility – Climbing – Stanford University Capuchin



Robotic ingredients

Mobility – Snake – Japanese ACM-R5



Robotic ingredients

Mobility – Swimming and sailing

- Emulate high efficiency of fish
- Flippers and tails
- Sails used for wind propulsion
- Extremely high efficiency
- Battery used for navigation actuators

Robotic ingredients

Mobility – Swimming – iSpalsh-II

Robotic ingredients

Mobility – Sailing – Vaimos (350 km)

Robotic ingredients

Interaction

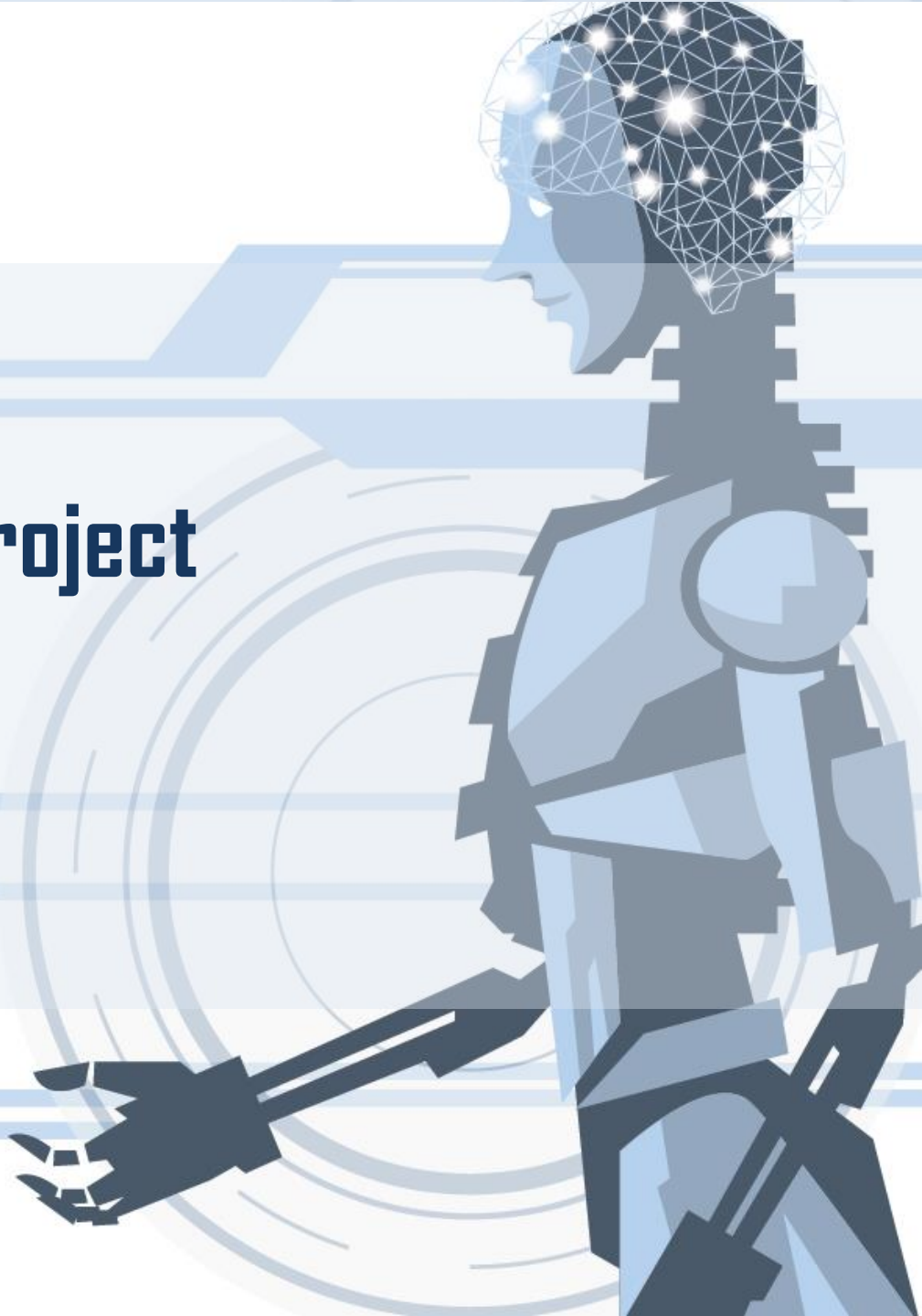
- Speech recognition systems
- Examples: Siri and Alexa
- Hand gestures
- Mimic human facial expressions
- Respond to human facial expressions
- Future: Emotions and/or personality?

Robotic ingredients

Kitchen is stocked

- Robots are NOT simple
- Robotics is challenging
- Multiple fields of expertise
- Systems of systems

- Part III
- Example future project
- Ethical questions



Future Project

Robot to robot communication

- MIT Professor Jonathan How
- Robots using reinforcement learning
- Multi-Agent reinforcement learning to study robot collective / consensus
- Attempt to contemplate what every other robot is doing, how they can work together, can a shared understanding change the task?

Ethical Questions

Exploiting robots with human likeness

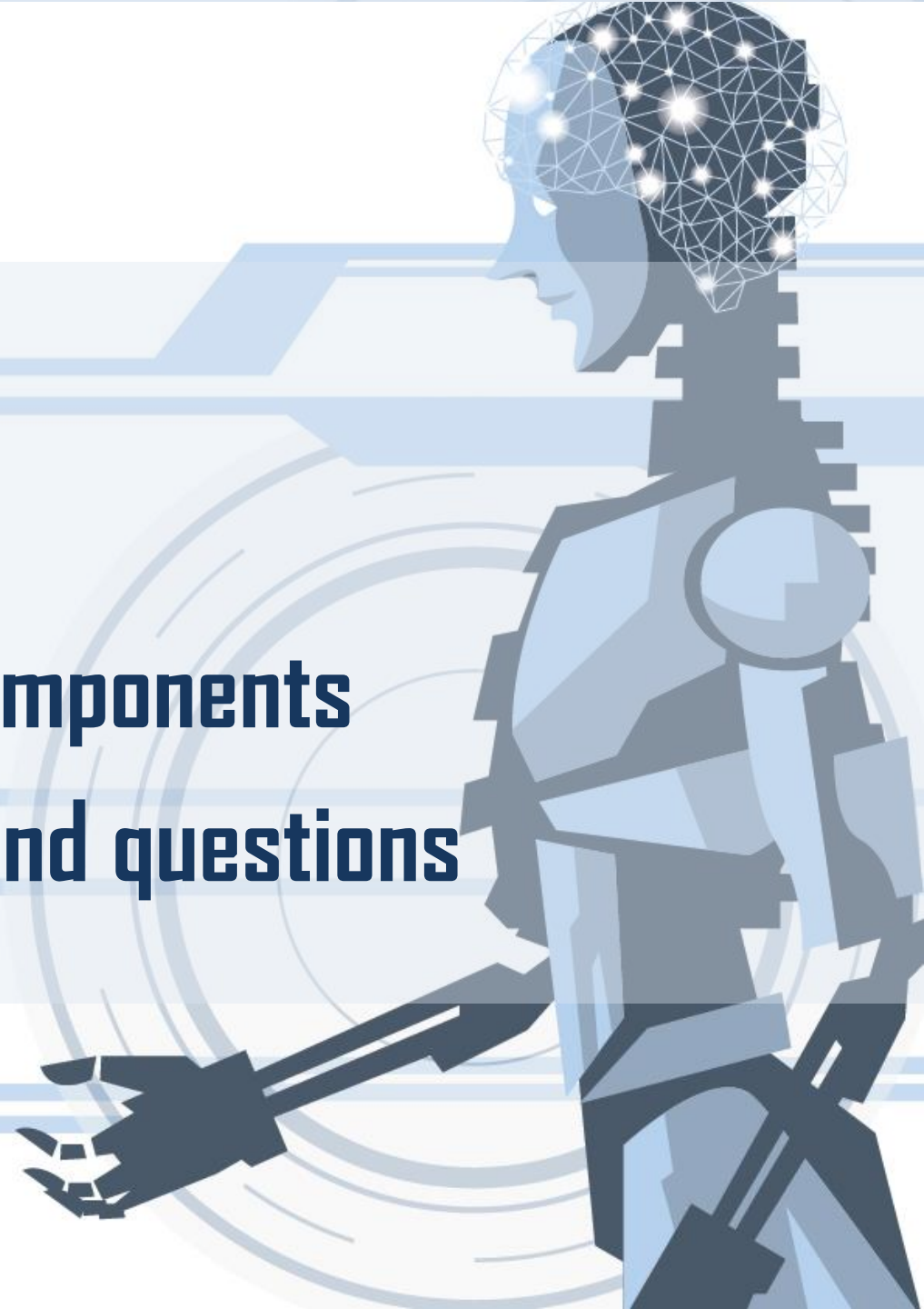
- What if we create robots we perceive as human?
- Moral complications of exploiting such a robot?
- How do we define intelligence?
- If we define a robot as intelligent is it “alive”?
- Does the robot have human rights?

Ethical Questions

Exploiting robots with human likeness

- Does the robot have "robot rights"?
- Would a robot deemed intelligent control its own existence?
- Or would it be a "robot" i.e. slave?
- Is this a goal we want to achieve?

- Conlusion!
- History
- Use cases and components
- Future projects and questions



QUESTIONS??

Answer: 42