Lecture 01
Introduction to Robots

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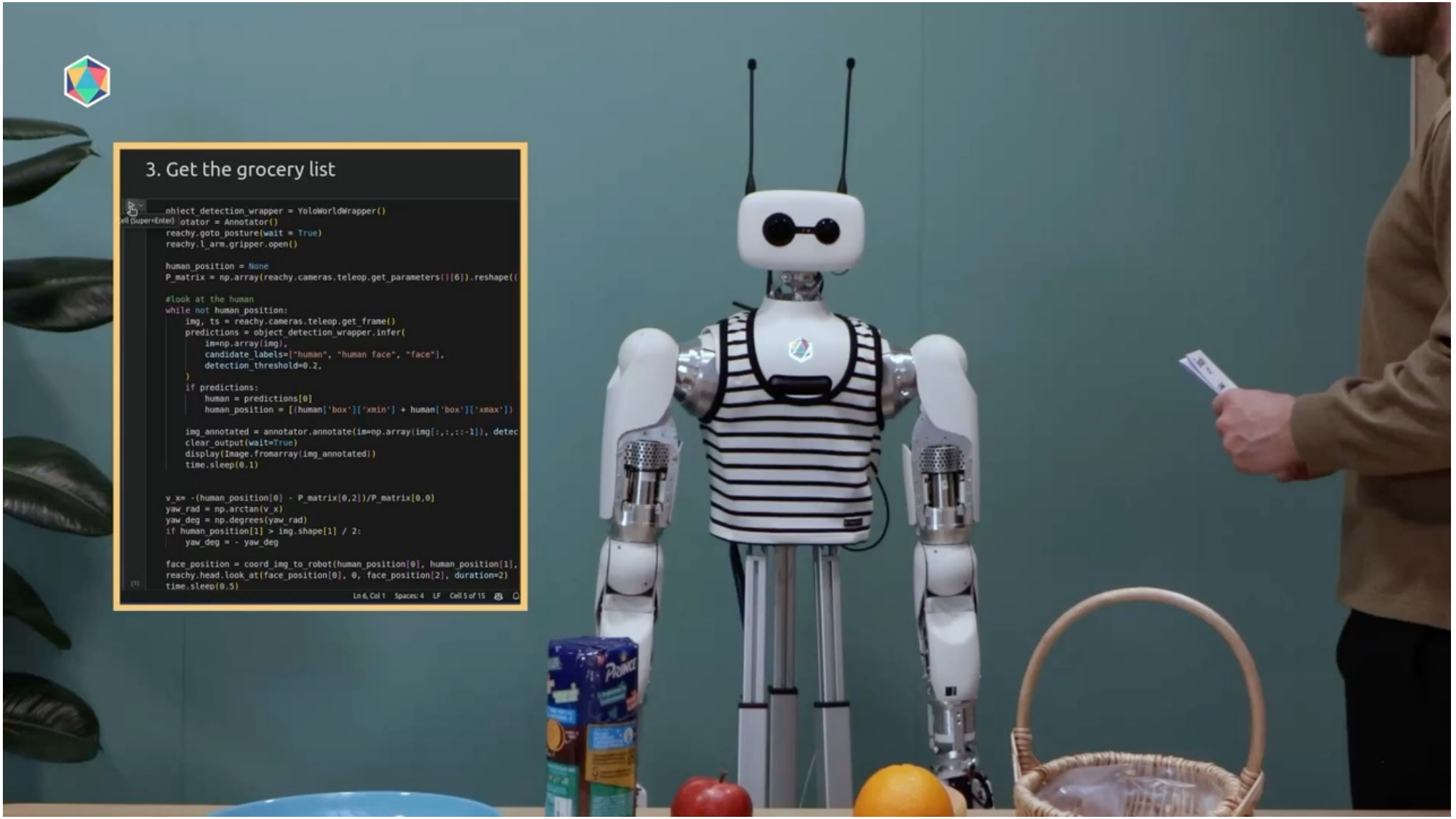
Robot of the Day

Reachy 2 by Pollen Robotics



Reachy mini by Pollen Robotics

Microduck by Pollen Robotics

Introduction to Robots

- Type of Robots
  - by Concepts / Applications / Kinematics
- Define Robots
  - Sense, Plan, and Act
- The Human Side
  - Collaboration and Social Characteristics

Which one do you like the most, and why?

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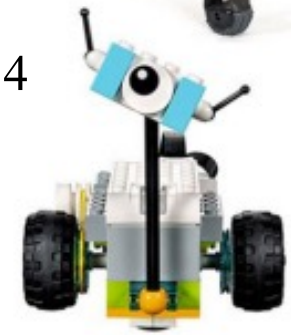

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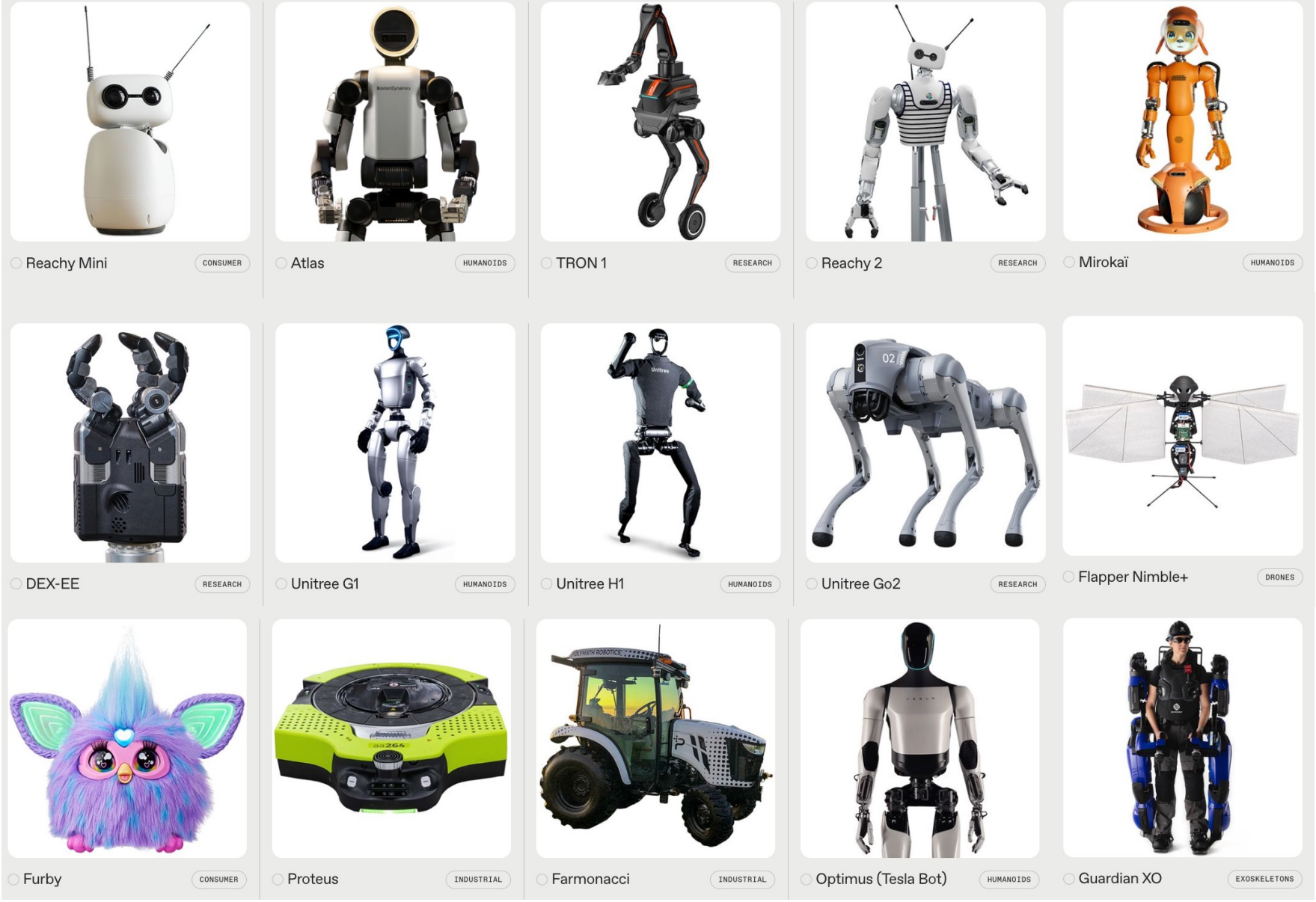
Types

- It’s not easy to categorize them either.
  - Each robot has its own unique features
  - Robots vary hugely in size, shape, and capabilities
  - Still, many robots share a variety of features

- A General Classification by Concepts
- A Utility Classification by Applications
- A Technical Classification by Kinematics

A Library of Robots



Types of Robots

Designed with familar concepts to your daily lives



Humanoids: This is probably the type of robot that most people think of when they think of a robot. Examples of humanoid robots include Honda's Asimo, which has a mechanical appearance, and also androids like the Geminoid series, which are designed to look like people.



Entertainment: These robots are designed to evoke an emotional response and make us laugh or feel surprise or in awe. Among them are robot comedian RoboThespian, Disney's theme park robots like Navi Shaman, and musically inclined bots like Partner.



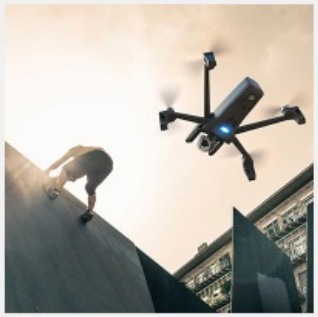
Consumer: Consumer robots are robots you can buy and use just for fun or to help you with tasks and chores. Examples are the robot dog Aibo, the Roomba vacuum, AI-powered robot assistants, and a growing variety of robotic toys and kits.



Education: This broad category is aimed at the next generation of roboticists, for use at home or in classrooms. It includes hands-on programmable sets from Lego, 3D printers with lesson plans, and even teacher robots like EMYS.

Types of Robots

Designed with advanced modes of mobility

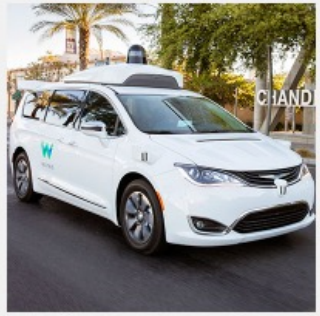




Drones: Also called unmanned aerial vehicles, drones come in different sizes and have different levels of autonomy. Examples include DJI's popular Phantom series and Parrot's Anafi, as well as military systems like Global Hawk, used for long-duration surveillance.



Telepresence: Telepresence robots allow you to be present at a place without actually going there. You log on to a robot avatar via the internet and drive it around, seeing what it sees, and talking with people. Workers can use it to collaborate with colleagues at a distant office, and doctors can use it to check on patients.





Self-Driving Cars: Many robots can drive themselves around, and an increasing number of them can now drive *you* around. Early autonomous vehicles include the ones built for DARPA's autonomous-vehicle competitions and also Google's pioneering self-driving Toyota Prius, later spun out to form Waymo.



Exoskeletons: Robotic exoskeletons can be used for physical rehabilitation and for enabling a paralyzed patient walk again. Some have industrial or military applications, by giving the wearer added mobility, endurance, or capacity to carry heavy loads.

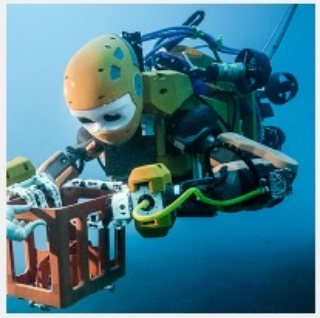
Types of Robots

Designed for applications in specialized environment


Industrial: The traditional industrial robot consists of a manipulator arm designed to perform repetitive tasks. An example is the Unimate, the grandfather of all factory robots. This category includes also systems like Amazon's warehouse robots and collaborative factory robots that can operate alongside human workers.

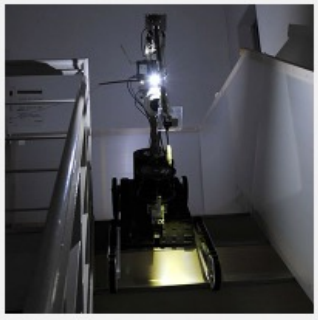


Medical: Medical and health-care robots include systems such as the da Vinci surgical robot and bionic prostheses, as well as robotic exoskeletons. A system that may fit in this category but is not a robot is Watson, the IBM question-answering supercomputer, which has been used in healthcare applications.


Underwater: The favorite place for these robots is in the water. They consist of deep-sea submersibles like Aquanaut, diving humanoids like Ocean One, and bio-inspired systems like the ACM-R5H snakebot.





Disaster Response: These robots perform dangerous jobs like searching for survivors in the aftermath of an emergency. For example, after an earthquake and tsunami struck Japan in 2011, Packbots were used to inspect damage at the Fukushima Daiichi nuclear power station.

Types of Robots

Designed for applications in specialized environment



Aerospace: This is a broad category. It includes all sorts of flying robots—the SmartBird robotic seagull and the Raven surveillance drone, for example—but also robots that can operate in space, such as Mars rovers and NASA's Robonaut, the humanoid that flew to the International Space Station and is now back on Earth.



Military & Security: Military robots include ground systems like Endeavor Robotics' PackBot, used in Iraq and Afghanistan to scout for improvised explosive devices, and BigDog, designed to assist troops in carrying heavy gear. Security robots include autonomous mobile systems such as Cobalt.



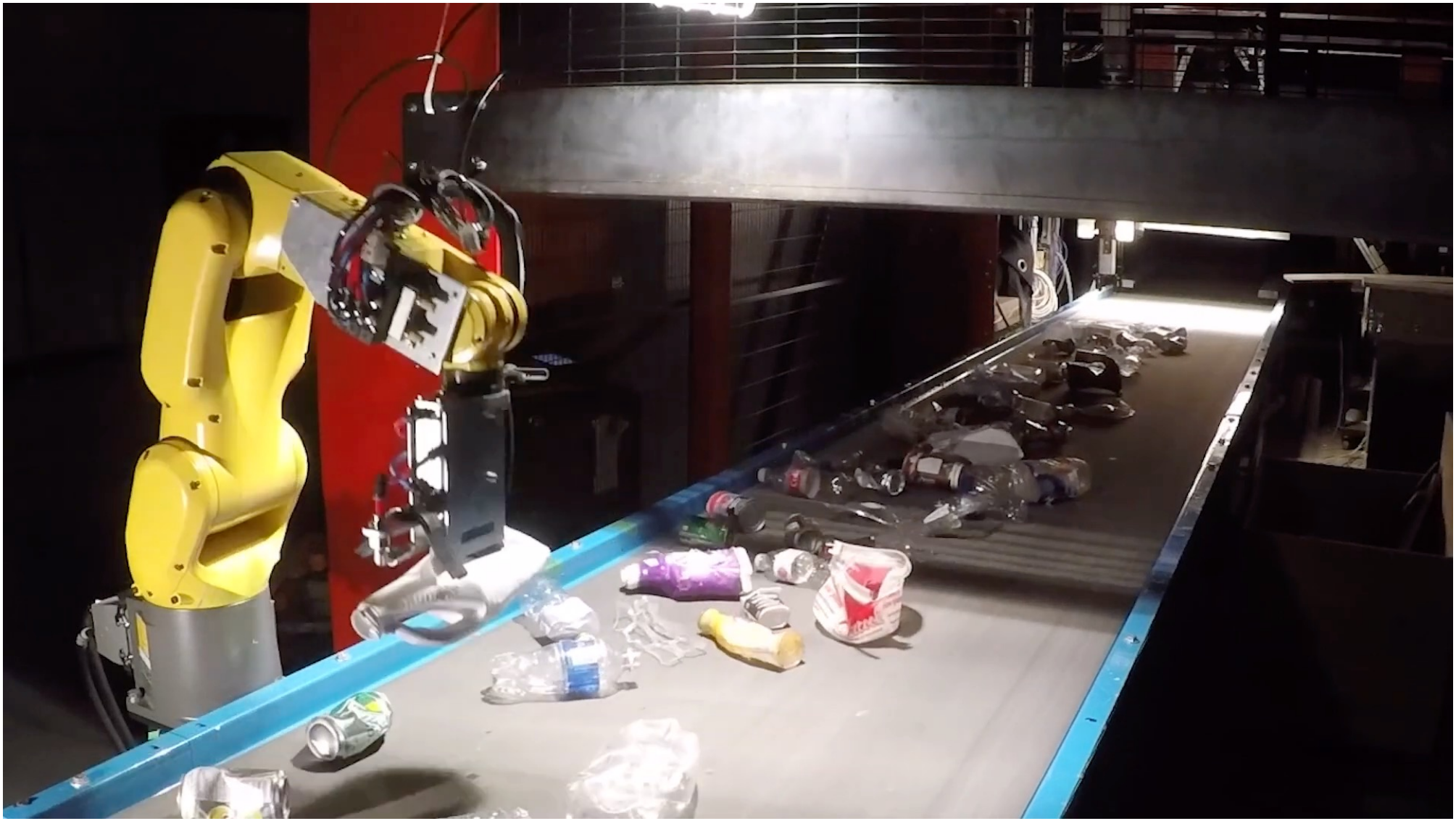
Research: The vast majority of today's robots are born in universities and corporate research labs. Though these robots may be able to do useful things, they're primarily intended to help researchers do, well, research. So although some robots may fit other categories described here, they can also be called research

Common Designs of Robot @ Work

Articulated Robot

Features a rotary axis and can range from simple three-axis structures to 10 or more joints

- The manipulator connects to the base with a twisting joint.
- A rotary axis connects the links in the manipulator.
- Each axis provides an additional degree of freedom, or range of motion.



Cartesian Robot

Also called rectilinear or gantry robots

- Cartesian robots have three linear axes that use the Cartesian coordinate system (x, y and z).
- They may have an attached axis that enables rotational movement.
- Three prismatic joints facilitate linear motion along the axis.

SCARA

Selective Compliance Assembly Robot Arm

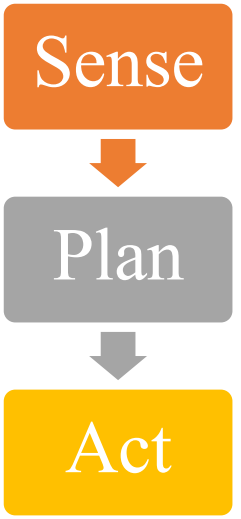
- This selectively compliant manipulator for robotic assembly is primarily cylindrical in design.
- It features two parallel axes that provide compliance in one selected plane.

Delta Robot

Jointed parallelograms connected to a common base

- 3 axes for the parallelograms; 1~3 axes for the end effector
- Delicate, precise movements in a dome-shaped work area
- Heavily used in food, pharmaceutical and electronic industries

What makes a robot?



- A robot is ***<u>an autonomous machine</u>*** capable of
  - ***sensing*** its environment,
  - carrying out ***computations*** to make decisions, and
  - performing ***actions*** in the real world.

<u>Think of the Roomba robotic vacuum.</u> It uses sensors to autonomously drive around a room, going around furniture and avoiding stairs; it carries out computations to make sure it covers the entire room and when deciding if a spot needs a more thorough cleaning; and it performs an action by "sucking dirt."

<u>Question</u>: What about an elevator? What about cruise control for cars?

It senses how fast the vehicle is going, compares it to a preset speed, and accelerates or brakes as needed. Is cruise control a robot?

More on the notion of **autonomy**

1 DECISION AUTHORITY

MANUAL

A human decides and performs all actions.

SHARED

Human and robot divide decision-making and execution.

AUTONOMOUS

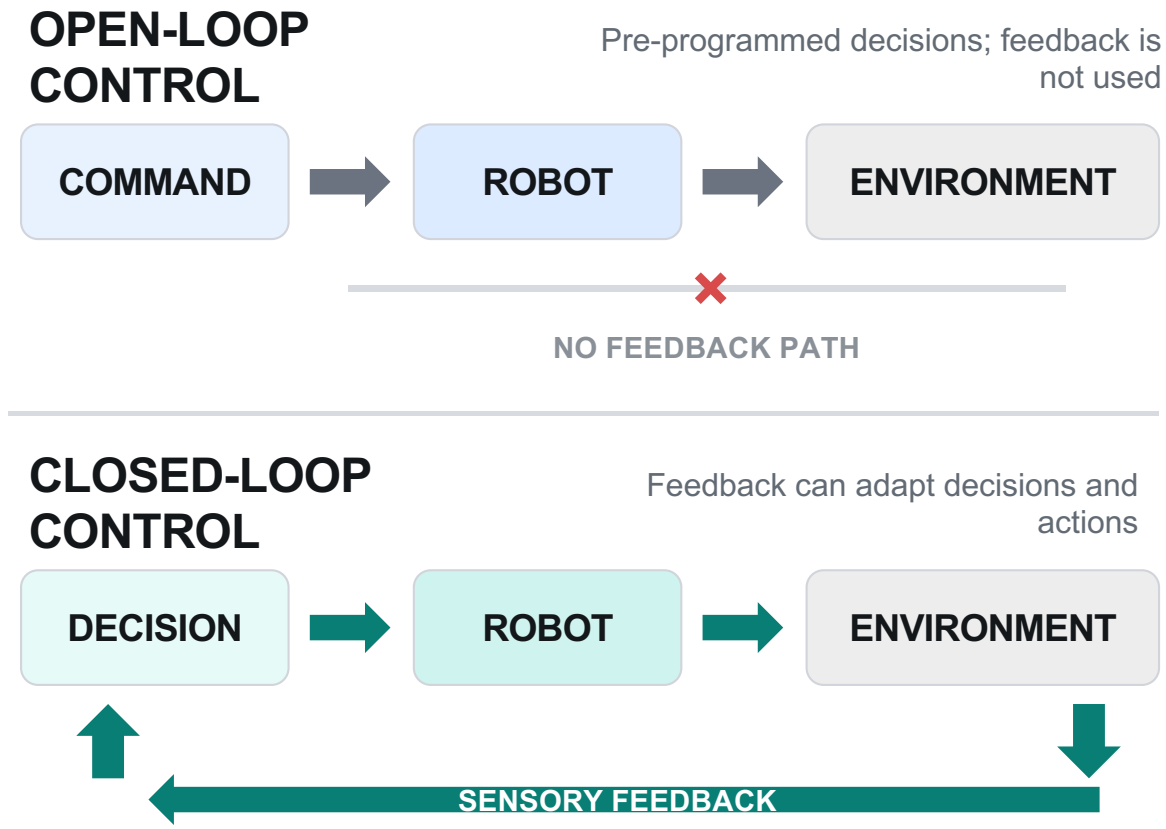
The robot decides and acts without required human intervention.

MORE HUMAN AUTHORITY

MORE ROBOT AUTHORITY

More on the notion of **autonomy**

2 FEEDBACK USE



Sensing for Structured Perception

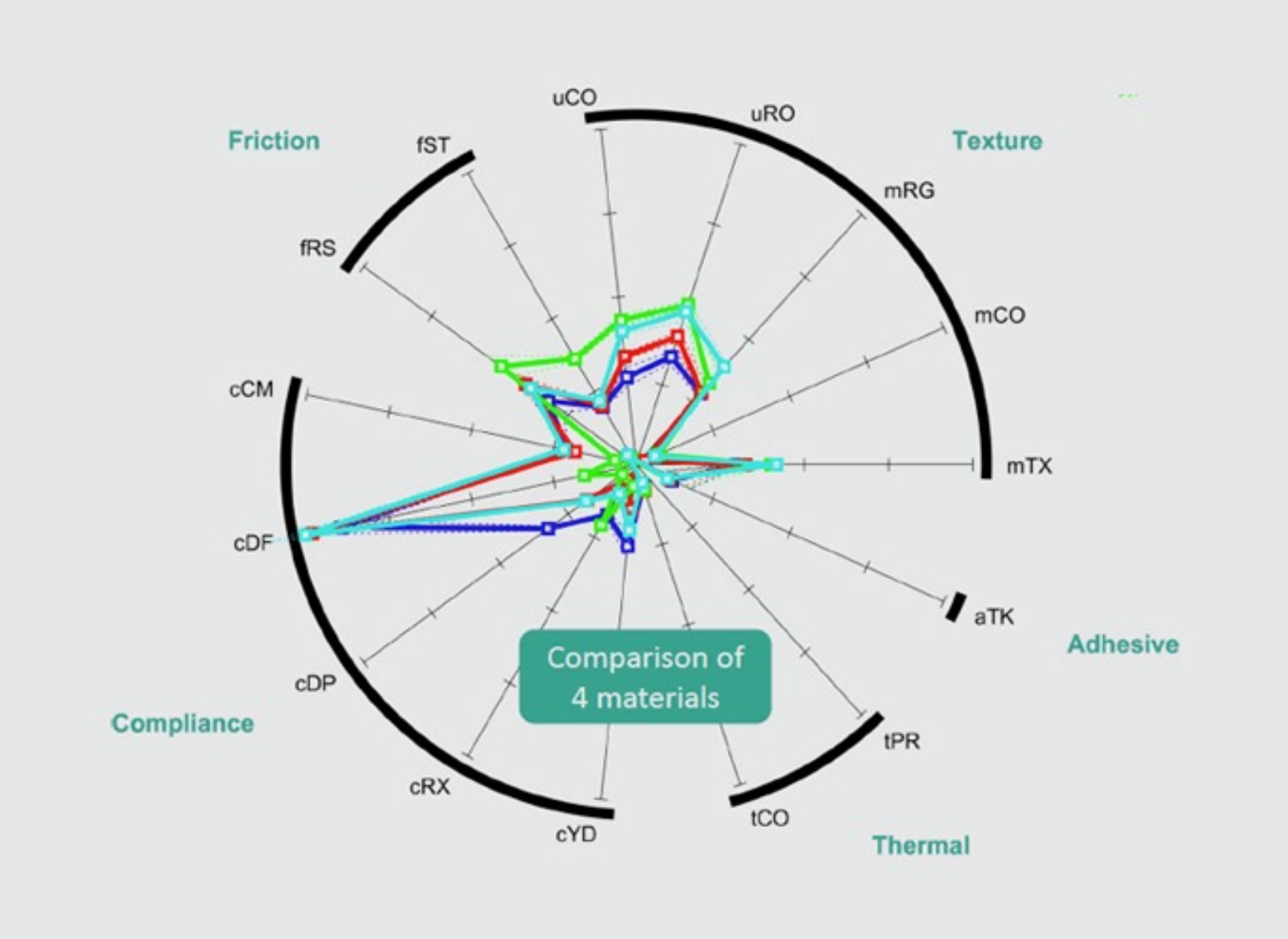
- Perception is the organization, identification, and interpretation of **sensory <u>information</u>** in order to represent and understand the interactions or environment.

Physical Environment

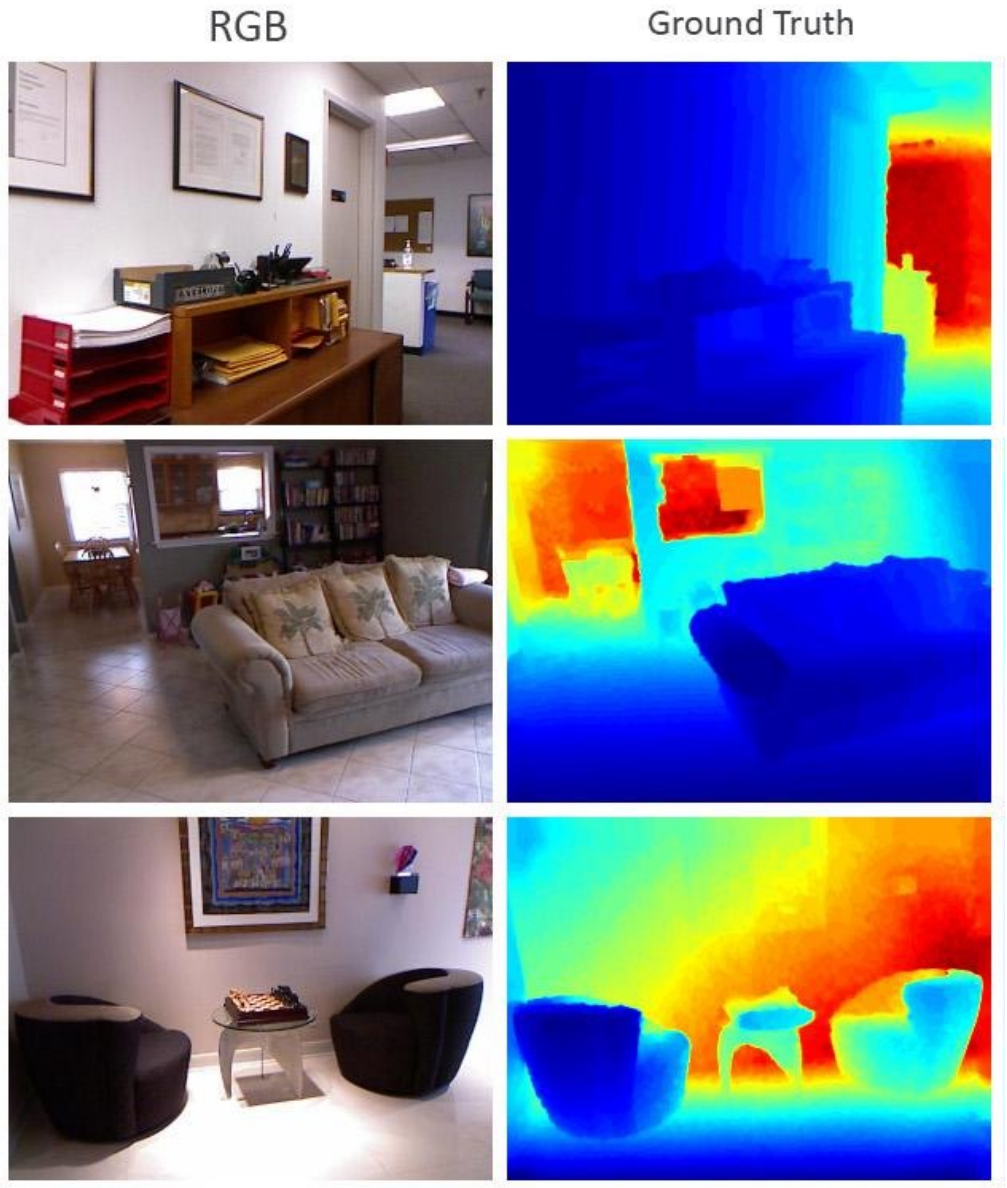
Sensory Perception

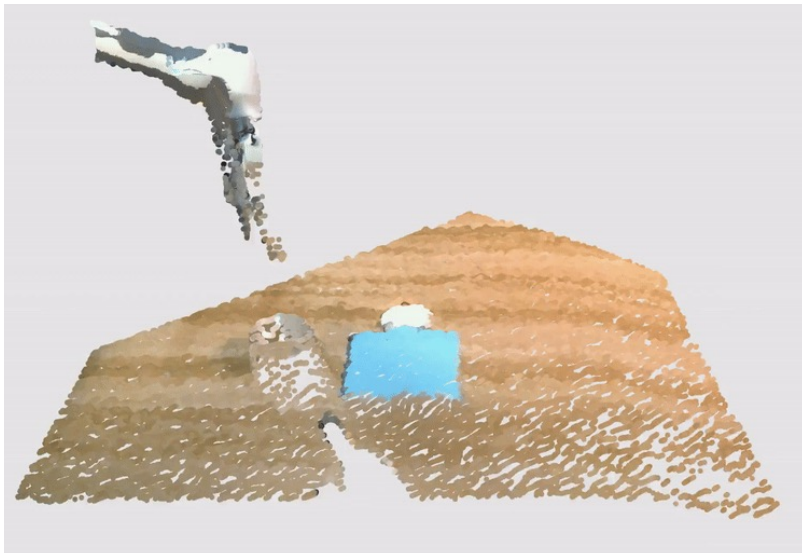
Structured Data

Tactile Perception



Visual Perception

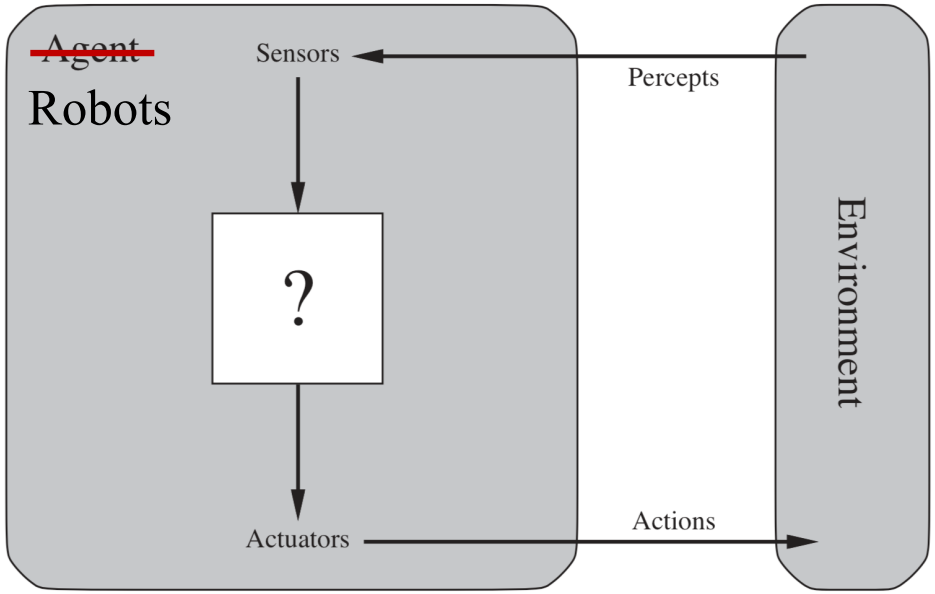




Computing for Algorithmic Rationality

- An algorithm is a **finite sequence** of rigorous instructions, typically used to solve a class of **specific** problems or to perform a **computation**.

  - An agent (or robot) is an entity that perceives and acts.
    - Intelligence is concerned mainly with rational action
  - Ideally, an intelligent agent takes the best possible action in a situation.
    - A rational agent selects actions that maximize its (expected) utility.
  - Characteristics of the percepts, environment, and action space dictate techniques for selecting rational actions.



Frontier models for robot decisions

Model family	Current examples	Role in a robot
Vision–language models (VLMs)	Gemini Robotics ER 2	Interpret scenes and goals. Plan steps and check progress.
Vision–language–action models (VLAs)	Gemini Robotics 2 π0.7 Isaac GR00T N1.7	Use vision, instructions and robot state to generate actions.
World models	NVIDIA Cosmos 3	Predict possible futures and generate training scenarios.

Cloud and edge computing for robots

CLOUD / DATA CENTER

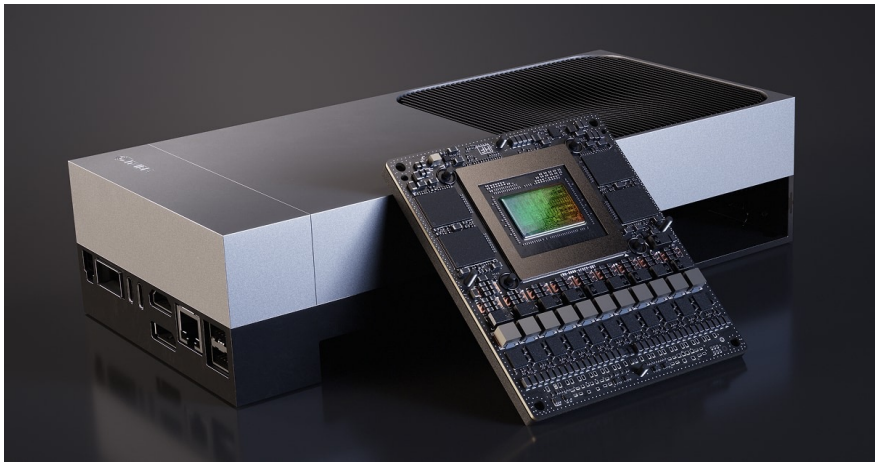
NVIDIA GB300 NVL72

72 Blackwell Ultra GPUs + 36 Grace CPUs

Large-scale training and simulation
Heavy model inference and fleet learning

Network delay and connectivity matter

EDGE / ON THE ROBOT



Jetson AGX Thor / T5000

128 GB memory, 40–130 W module power

Jetson Orin NX: 16 GB, 10–25 W
Local perception and compact AI policies

Memory, cooling and battery limit scale

Actuating for Physical Interactions

DC Motor

DC Gear Motor

RC Servo motor

Stepper motor

BLDC Motor

Smart Servo motors

Harmonic drives

Linear electric actuator

https://robocademy.com/2020/04/13/how-to-choose-an-actuator-for-your-robot/

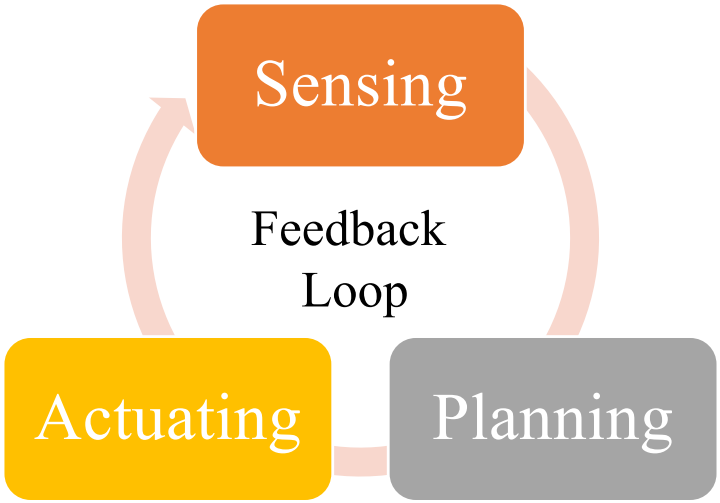
Define Robots

Actuator type	Main advantages	Main limitations	Robot examples
RC servo	Low cost, compact, simple wiring, and easy to use; suitable for basic position-controlled systems.	Usually provides little or no state feedback; limited torque-control capability; relatively large friction and backlash; limited bandwidth and lifetime.	Otto DIY, servo-based SpotMicro, early Stanford Pupper, and educational hexapods
Smart servo	Provides position, velocity, current, temperature, and fault feedback; may support position, velocity, and current/torque control; allows daisy-chain communication.	Frequently uses a relatively high gear ratio, resulting in poor backdrivability, noticeable friction, and backlash. Output torque estimated from motor current may be inaccurate.	ROBOTIS OP3, DARwIn-OP, Bioloid, and OpenMANIPULATOR-X; DYNAMIXEL is a representative product family
Harmonic-drive joint	High reduction ratio, high output torque, compact size, low backlash, and high positioning accuracy; widely used in robotic manipulators.	Relatively high friction and low backdrivability; transmission elasticity and hysteresis; limited impact tolerance; accurate torque control often requires a joint torque sensor or careful calibration.	Industrial manipulators, UR collaborative robots, Franka Emika Panda, and some high-load humanoid robots
Quasi-direct-drive (QDD) joint	Good backdrivability, low reflected inertia, relatively low friction, high torque-control bandwidth, and strong impact tolerance; suitable for dynamic contact and locomotion.	Requires a relatively large motor and high peak current; demanding motor-drive and thermal-management requirements; less efficient for prolonged static torque generation than high-ratio actuators.	MIT Mini Cheetah, MIT Cheetah 3, and Stanford Doggo; Unitree Go1/Go2 are generally considered QDD-like

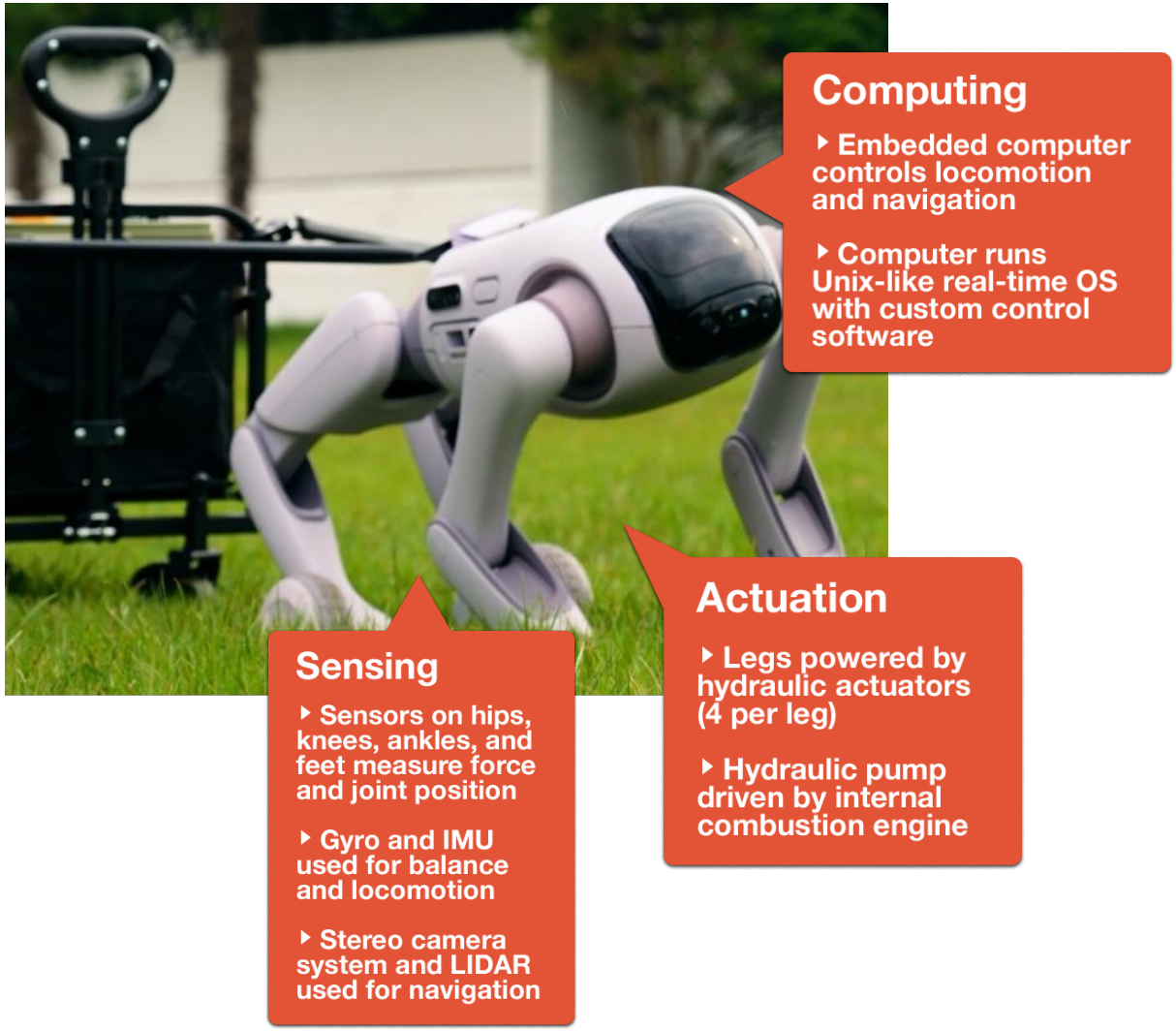
Define Robots

Property	RC servo	Smart servo	Harmonic-drive joint	QDD joint
Cost	Low	Medium	High	Medium–high
Reduction ratio	High	Usually high	Very high	Low
Position control	Moderate	Good	Excellent	Good
Accurate torque control	Poor	Limited	Requires sensing or calibration	Good
Backdrivability	Poor	Relatively poor	Poor	Good
Impact tolerance	Low	Moderate	Moderate	High
Dynamic response	Relatively slow	Moderate	Moderate	Fast
Typical applications	Educational and small robots	Educational robots and lightweight manipulators	Industrial manipulators and precision positioning	Quadrupeds, humanoids, and dynamic robots

Feedback Loop Towards Autonomy

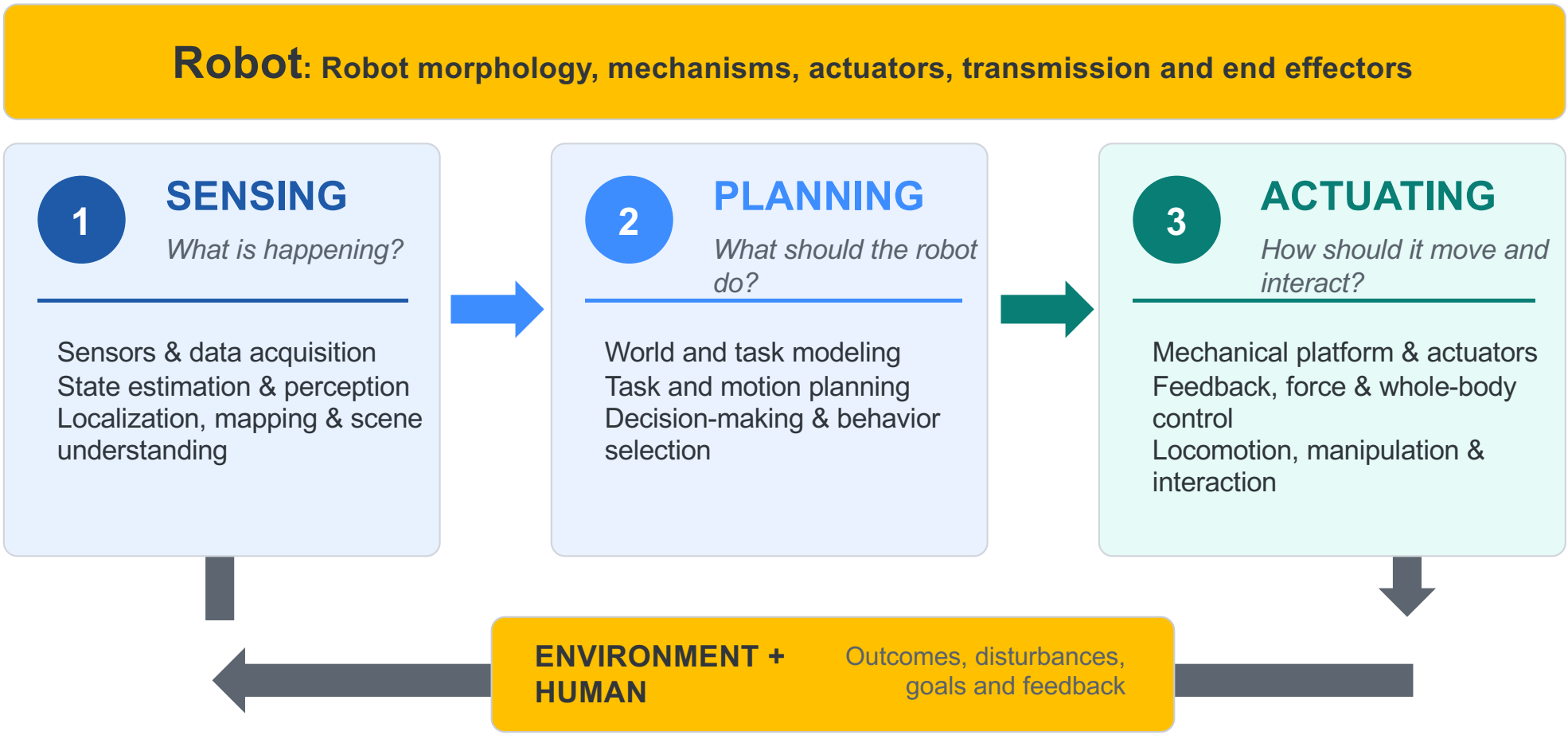


The sensors feed measurements to a controller or computer, which processes them and then sends control signals to motors and actuators.



Transformer 1, developed by AGIBOT.

The Technical Roadmap



CAPABILITIES THAT SPAN THE ENTIRE LOOP

MODELING & SIMULATION	ROBOT LEARNING & SIM-TO-REAL	HRI, INTEGRATION & SAFETY

F.O.R

——章鱼仿生水下海草种植机器人

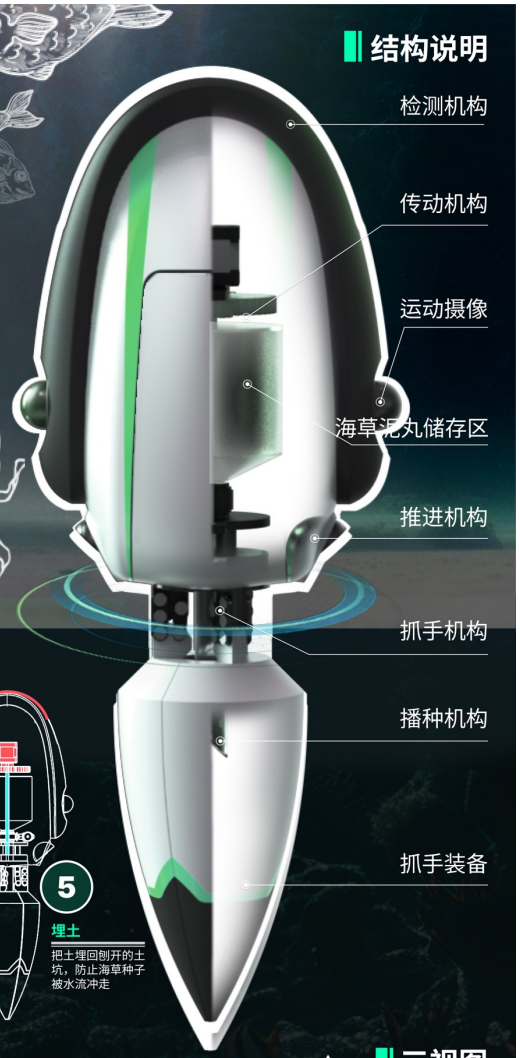
13 CLIMATE ACTION　14 LIFE BELOW WATER

设计说明

海草床还有着“水下热带森林”之称，在维持海洋生物多样性、净化和调控水质、固碳和调节气候变化等方面具有重要的生态学意义。基于此我们设计了这款章鱼仿生水下海草种植机器人，集数据监测及采集，自动寻址和自动种植功能于一身，实现了海草种植从选址到选种到种植的全流程自动化，有效降低人工成本并提高了海草的存活率。

DES5002
机器人设计科学与社会价值
龚　多　12333216
包博宇　12333215
陈梓杰　12333205

结构说明



背景分析

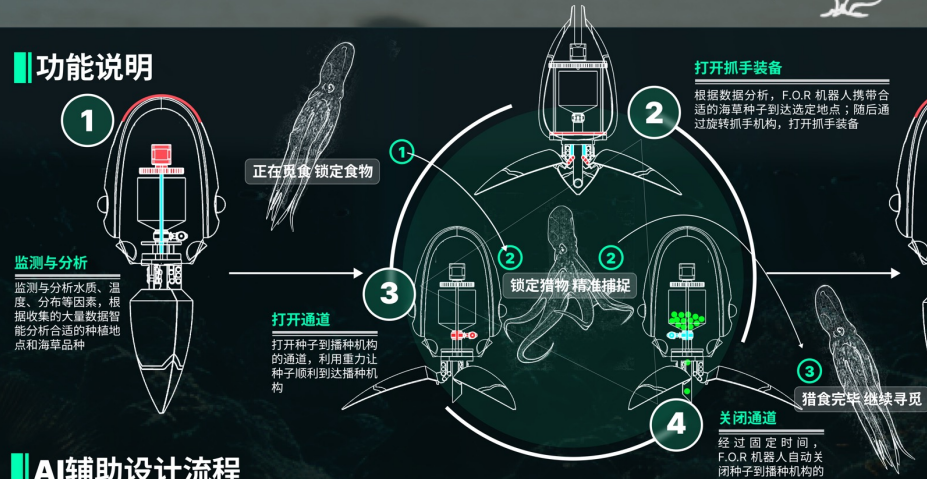
固碳神器
0.2%　海草床全球占比
83000吨/km²

海草床损坏
29%　海草床消失
10平方公里/年　消失率

生物多样性
支撑2.4亿种鱼类以及
3000亿个无脊椎动物生存

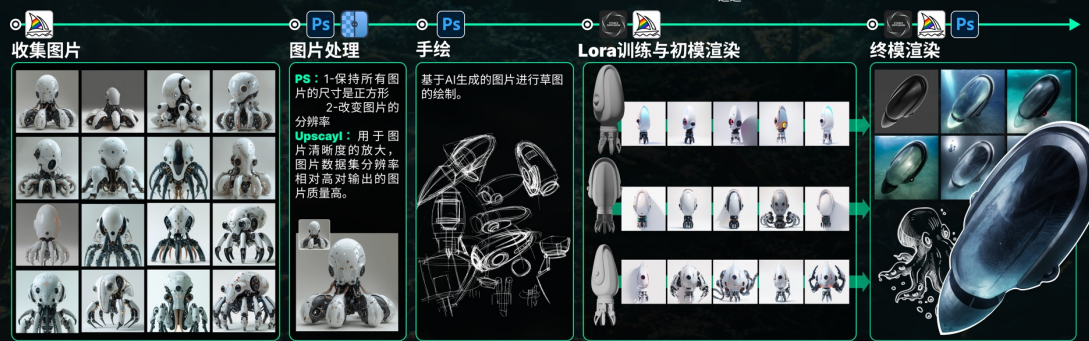
粤港澳大湾区
18.71%　自然岸线保有率
289.62 km　海岸线减少

功能说明

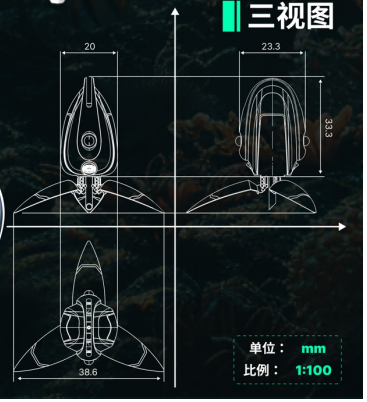


产品定位

AI辅助设计流程



三视图



Past Projects

F.O.R

——章鱼仿生水下海草种植机器人

系统图

技术分析

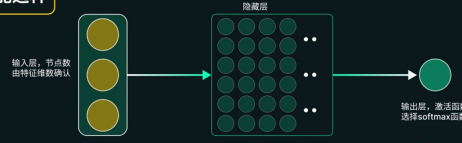
水下巡航

SLAM（Simultaneous Localization and Mapping）即同时定位与地图构建技术。水下视觉SLAM，即是在水下场景中，通过对所采集的图像进行特征匹配与追踪，完成对相机的轨迹定位与对周围环境的构建。在我们的机器人中，通过搭载IMU（惯性测量单元）实现相机轨迹定位和ORB-SLAM算法实现环境构建。同时，由于水下环境光照不均，且机器人本体或推进器的扰动容易扬起水下沉积物，所以我们将图像进行特征增强和滤波除尘的预处理后，再输入到ORB-SLAM系统。

海草识别

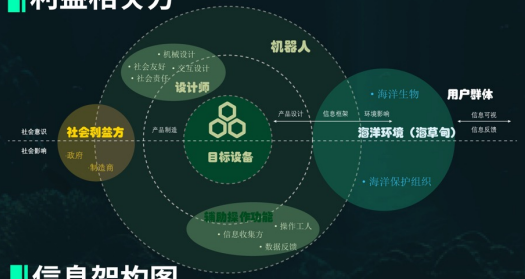
对海草的正确识别是F.O.R机器人服务流程中的重要一环。首先在选种过程中，水下环境中海草的分布情况是选种的重要依据之一，需要机器人在巡航探测过程中及时有效地将检测到的海草正确识别出来；其次，在检测之前也要求机器人能够正确识别先前已种植的海草。我们基于ORB-SLAM系统输出的图像特征点，判断是否属于海草，若是则采用预训练的Yolo视觉模型进一步判断属于哪种海草类别。

智能选种

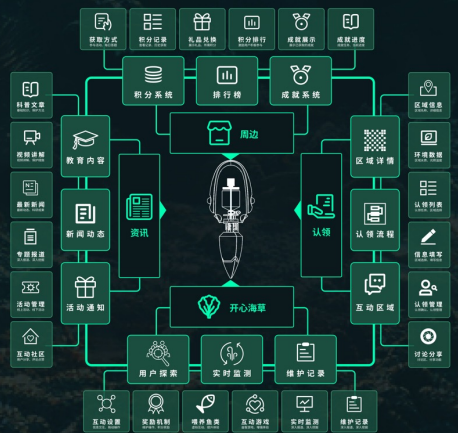


海草的选种工作特别讲究，最根本的是要满足海草的基本生存条件，同时还要考虑水动力、海水透明度等因素影响。传统的选种工作需要依据已有的信息，根据专家知识人为判别，这受限于已收集的信息和个人经验。我们的F.O.R机器人自身携带环境监测传感器，在水下收集到了大量关于海草选址选种的必要信息，基于在巡航过程中收集的数据，结合深度学习算法，智能给出选种建议，为选种工作提供大数据的指导。

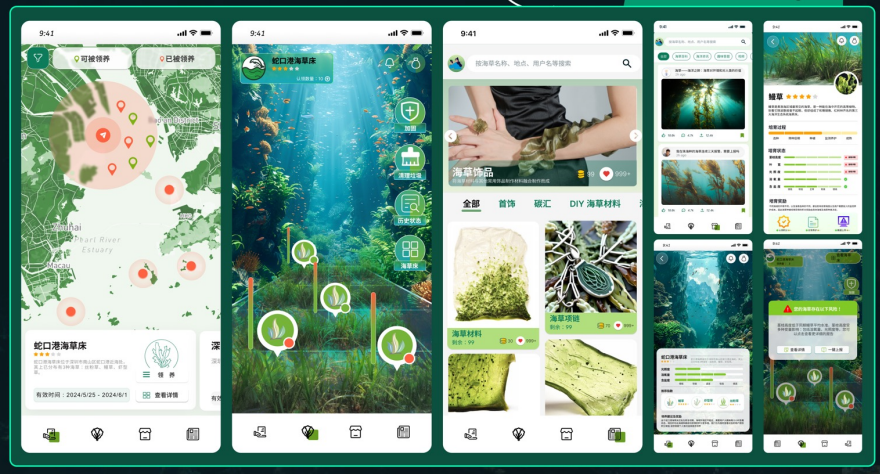
利益相关方



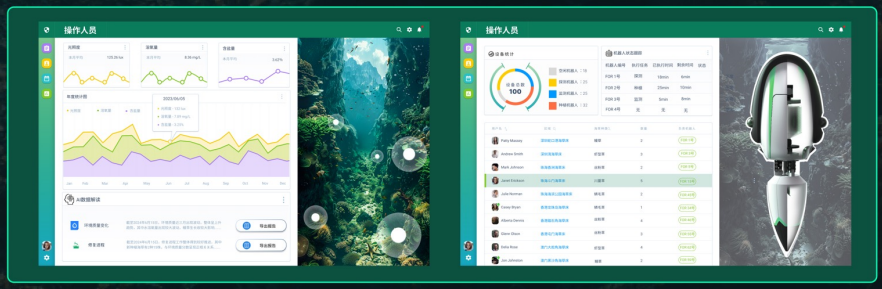
信息架构图



APP用户交互界面



WEB操作人员交互界面



2024.10-2024.12

PHYGITAL框架下的光影互动机器人设计

SHADOW HUNTER *Light and shadow interactive robot design in Phygital framework*

游戏介绍：

“影子猎人”是一款前所未有的竞技类社交游戏，将智能机器人与混合现实玩法完美结合，以影子为核心互动元素，开启全新游戏体验！在这个充满创意与挑战的世界中，玩家化身为“猫”或“老鼠”，利用机器人进行影子捕捉、能量收集和策略对抗。通过影子的独特玩法和借助机器人的智能互动，让你感受策略博弈的快感和沉浸式的未来竞技。

Shadow Hunter "is an unprecedented competitive social game that perfectly combines intelligent robots with mixed reality gameplay, with shadows as the core interactive element, opening up a new gaming experience! In this creative and challenging world, players transform into "cats" or "mice" and use robots for shadow capture, energy harvesting, and strategic confrontation. Through the unique gameplay of Shadow and the intelligent interaction of robots, you can experience the thrill of strategic gaming and immersive future competition.

准备好踏入影子的战场了吗？

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DES5002 Robot design science and value's interim review Fall 2024

游玩视频：*https://www.bilibili.com/video/BV1Ae6zYsENk/?spm_id_from=333.1387.homepage.video_card.click&vd_source=a10aba0cb6aaea8fc6eca4bcc9d69451*

Preliminary research

Today's young people repeat a dull and boring life every day, gradually picking up their phones in their work and life, hoping to escape social reality with the help of their phones.

However, market research shows that most young people still aspire to enrich their daily lives through social games. We extract their core needs and match game features to create more attractive interactive experiences:

Design background

We are committed to integrating gaming behavior into reality, by combining digital tools with physical elements, researching how to make stepping on shadows more interesting and strategic, and integrating physical therapy to create a new gaming experience that combines leisure and social interaction for young people.

Feasibility analysis:

Market Analysis

玩家人群画像 / User Profile	年龄：18-35岁 性别：60%男性，40%女性 价格：50-150元/次 频率：季度1-2次
市场规模 / Market size	2023年市场总值：10亿人民币 年增长率：25% 主流市场：一线城市+二线城市
消费行为与动机 / Consumer behavior and motivation	主要动机：休闲娱乐、合作、解压 用户需求：成就感、博弈、社交

Competition and Business Ecology

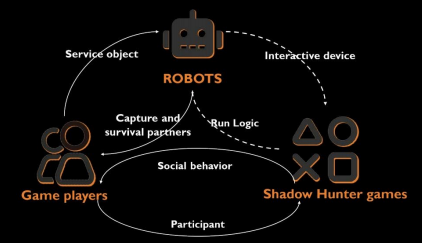
行业上下游 / Industry upstream and downstream	上游：场景、服装、道具 下游：社交媒体、线上内容、平台(高德地图)
品牌竞争策略 / Brand competition strategy	差异化策略：多样化游戏、沉浸环境 用户粘性提升：会员体系、季节性主题
其他竞争优势 / Other competitive advantages	客制化剧本、活动式体验提升吸引力 IP联动增加品牌识别度

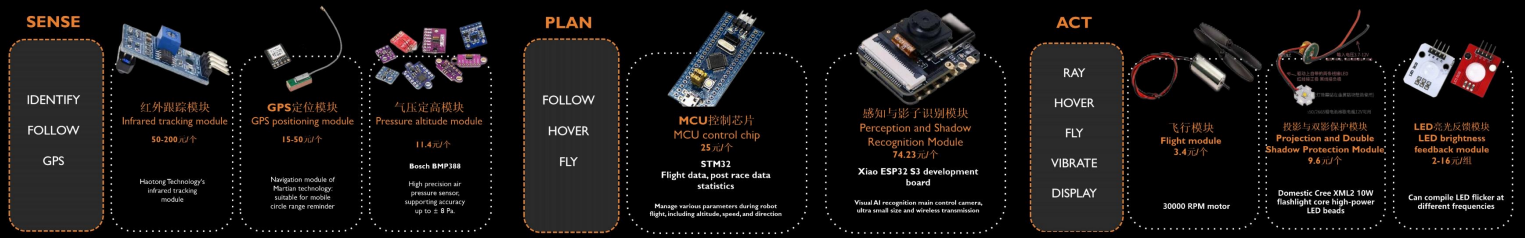
Benefit and Cost Structure

收入来源 / Source of income	收入构成：入场费80%，会员充值10%，IP联动5%，周边5%
主要成本 / Main costs	场地租赁：20-40% 布置维护：15-25% 薪资：10-15% 营销：5%
盈利模式 / Profit model	收费项目多样化，延长用户停留时间 定期活动提高用户到访频率
未来发展潜力 / Future development potential	拓展二线市场，探索线上与线下联动 扩充沉浸式主题，提升体验附加值

Past Projects

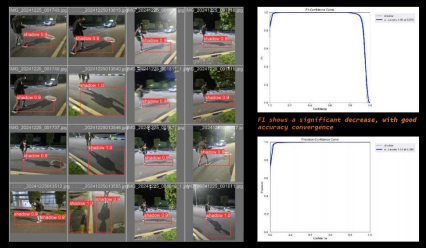
Systems design

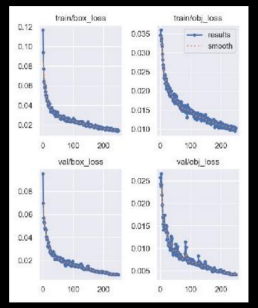


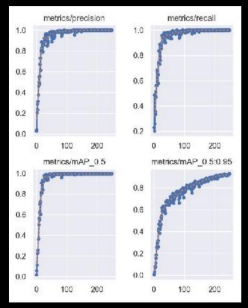


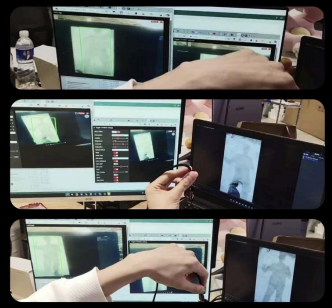
Technical validation

Software level: Shadow capture model based on yolo V5

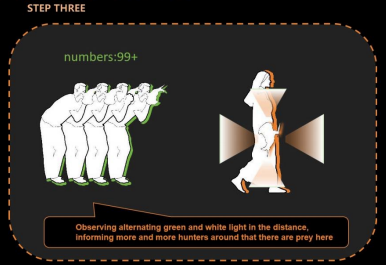




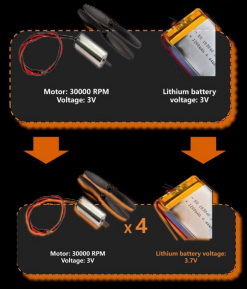




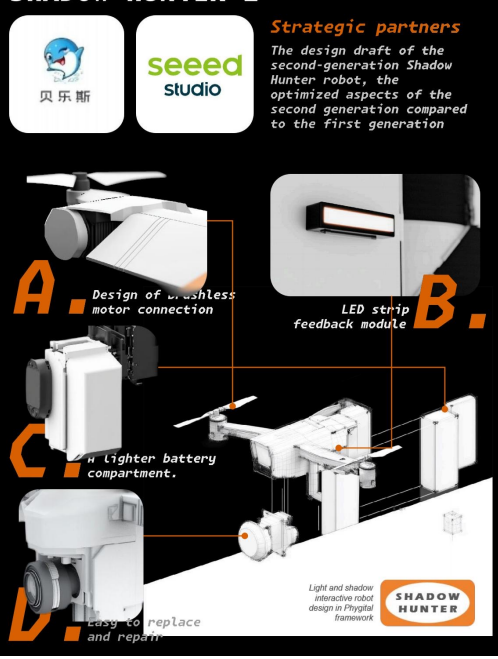
Hardware level: Enhance the user experience of robots



Hardware level: Enhance the load-bearing capacity



Product Display



https://des5002.ancorasir.com/

Thank you~

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