Unit 5

Robot Applications

Applications of Robot in Manufacturing

Assembly: Robots perform repetitive tasks with high precision, improving productivity and reducing errors.

Welding: Ensure consistent, high-quality welds, even in hazardous environments.

Material Handling: Move heavy materials between workstations, increasing efficiency.

Packaging & Palletizing: Speed up packing and arrange products accurately for shipping.

Inspection & Quality Control: Use sensors/cameras to detect defects and ensure standards.

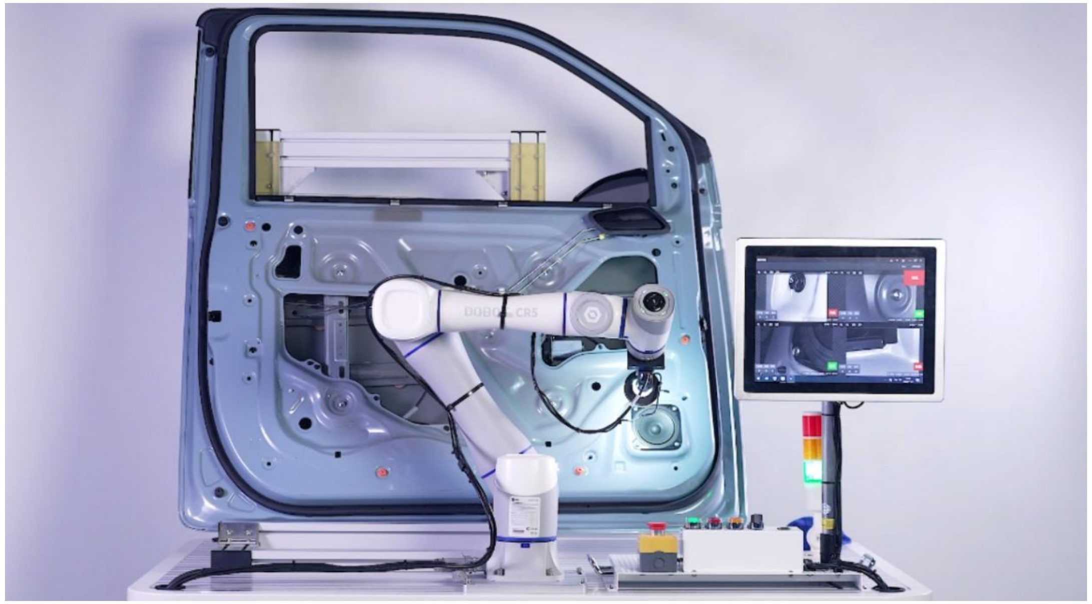
Machine Tending: Operate CNCs and other machines, loading/unloading parts and maintaining equipment.

Painting & Finishing: Apply coatings evenly and accurately with reduced waste.

Testing & Measurement: Conduct functional tests and verify product specs.

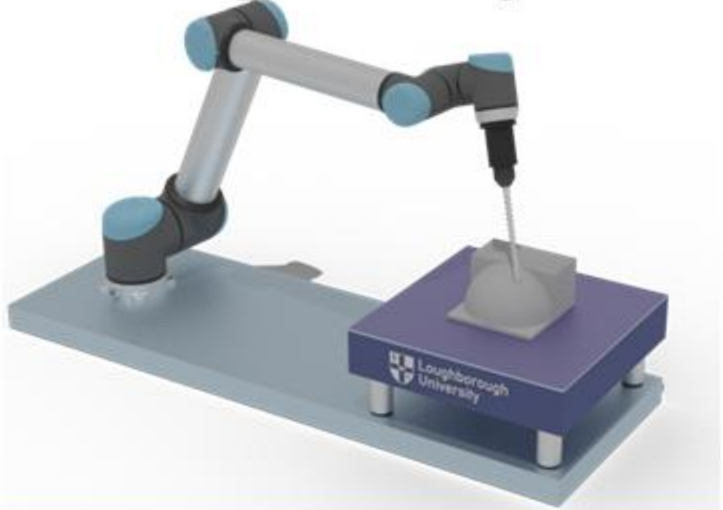
Collaborative Robots (Cobots): Work alongside humans to boost safety and ergonomics.

Inventory Management: Automate stocktaking, sorting, and storage optimization.

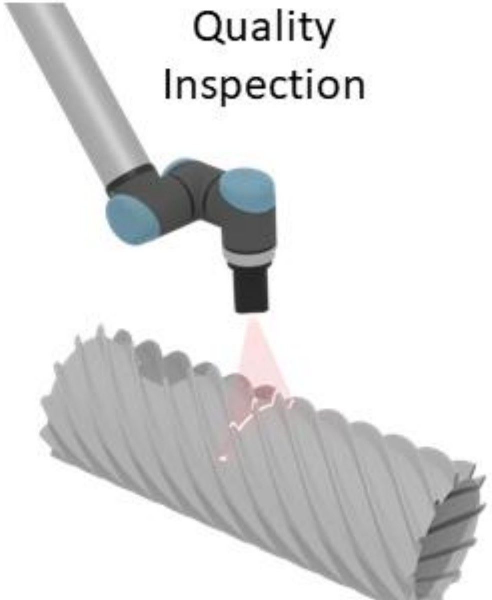


Material Handling/
Transport

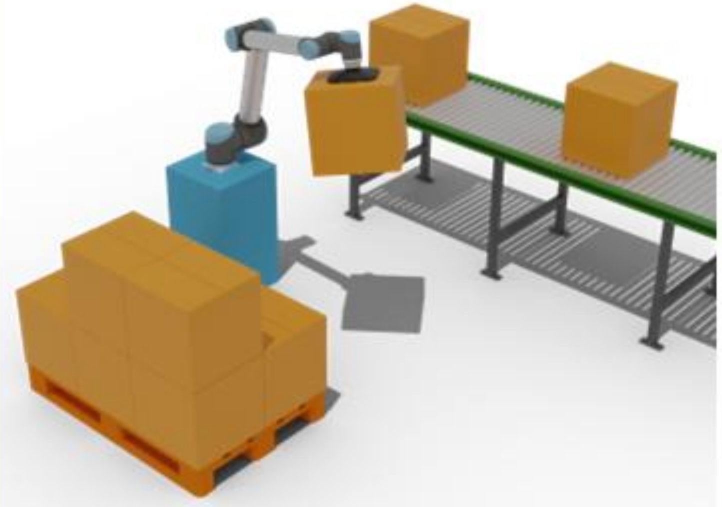
Assembly and
Light Machining



Quality
Inspection



Packing and
Palettization



Welding Robot

- A welding robot holds a welding torch and manipulates this around a work piece in a similar way as a human welder.
- Traditional robots such as 6 axis industrial robots are still extensively used for arc welding
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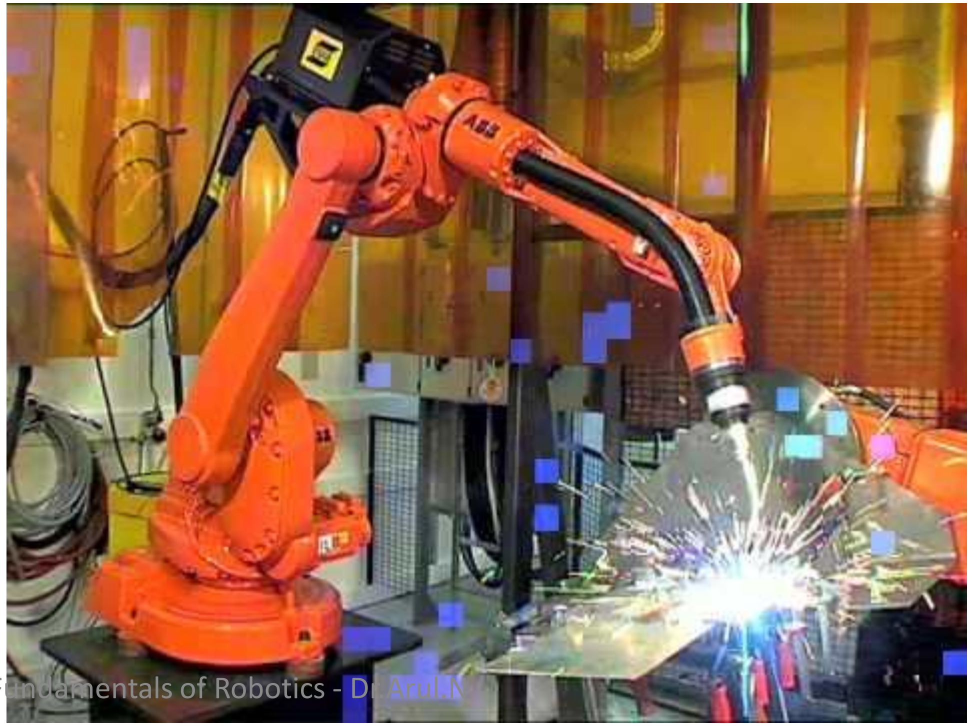


Applications

- Welding robots are not only used in the automobile manufacturing industry, but also have been widely used in engineering machinery, steel structures, nuclear power and wind power, aerospace, marine and marine engineering, rail transportation, national defense, industrial appliances, civilian hardware and other industries.

Robot Arc Welding system

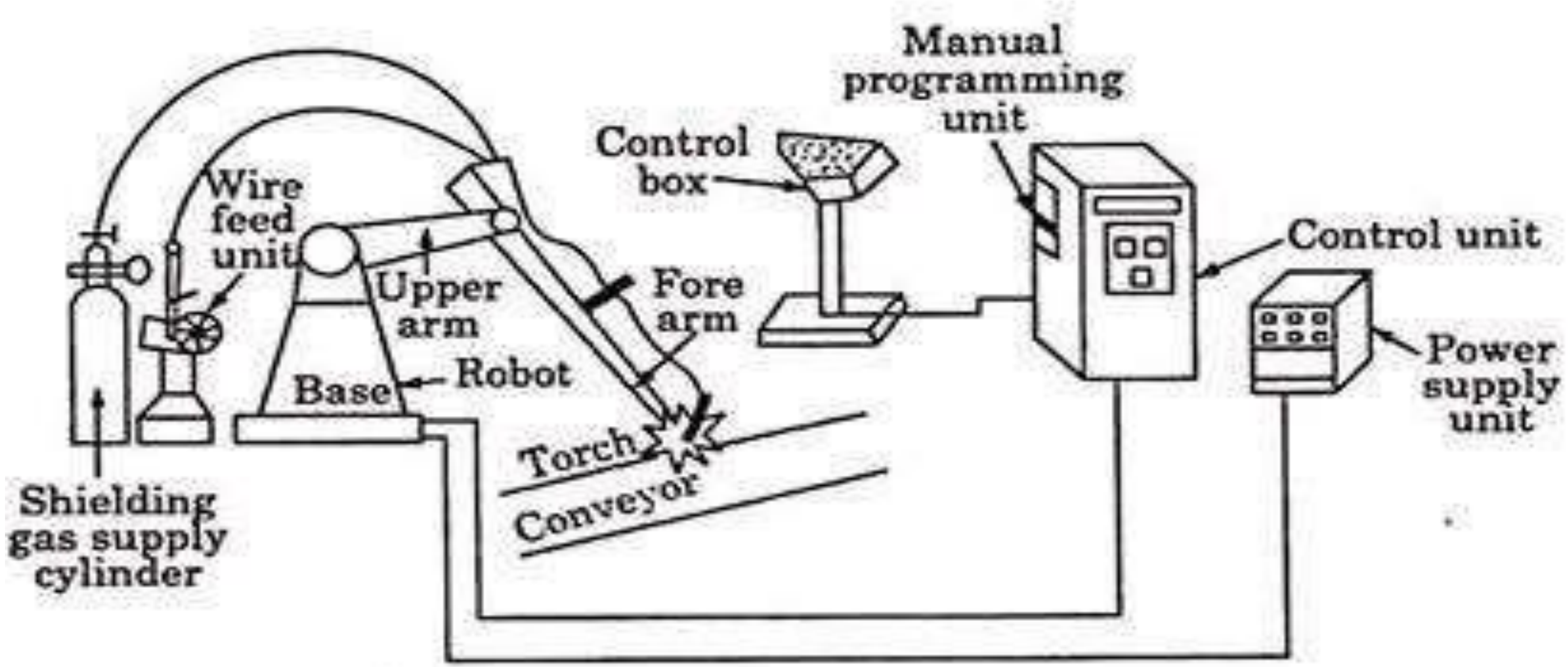


Fig. 9.57. Schematic arrangement of RAWS.

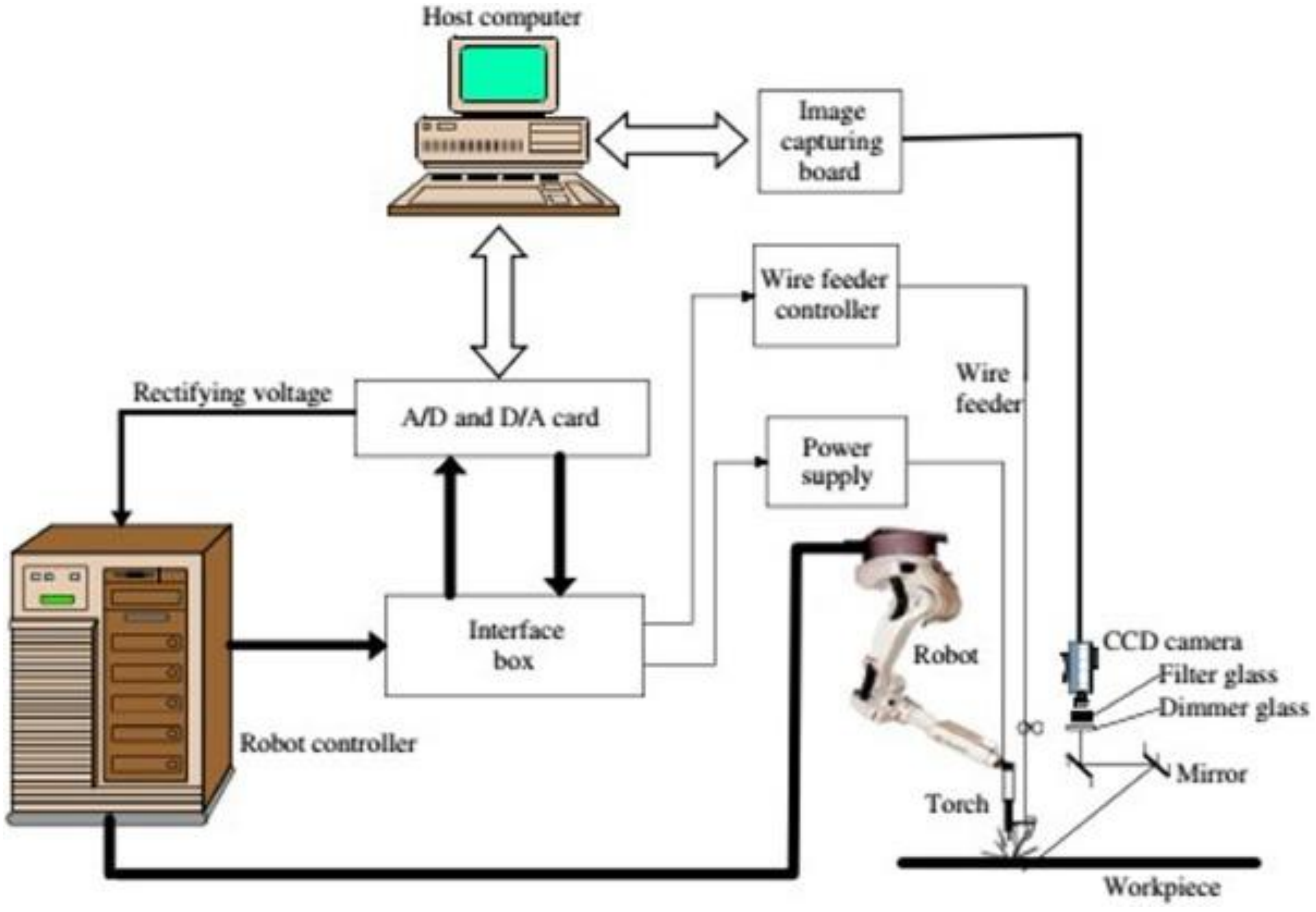
Robot Arm
Consists of base, upper arm, and forearm.
Moves the torch precisely for accurate welding.
Torch
Performs the welding operation on the workpiece.
Mounted on the robot's forearm.
Shielding Gas Supply Cylinder
Provides protective gas (e.g., Argon) to prevent weld contamination.
Wire Feed Unit
Feeds welding wire continuously to the torch during welding.

Conveyor
Moves the workpieces into position for welding automatically.
Control Box
Interfaces with the robot and other units for system coordination.
Manual Programming Unit
Allows users to program and teach the robot welding paths and parameters.
Control Unit
Central controller that sends instructions to the robot and other devices.
Power Supply Unit
Supplies electrical power for welding operations.

A* (A-Star) Algorithm
RRT (Rapidly-exploring Random Tree)
Dijkstra’s Algorithm
Genetic Algorithm

COMPONENTS OF A ROBOT WELDING CELL

- Wire Feeder
- Welding Robot
- Welding Robot
- Wire Cleaner
- Torch
- Work Area
- Controller
- Teach Pendant
- Welding Power Supply
- Stack Light
- Operation Box
- Safety Features



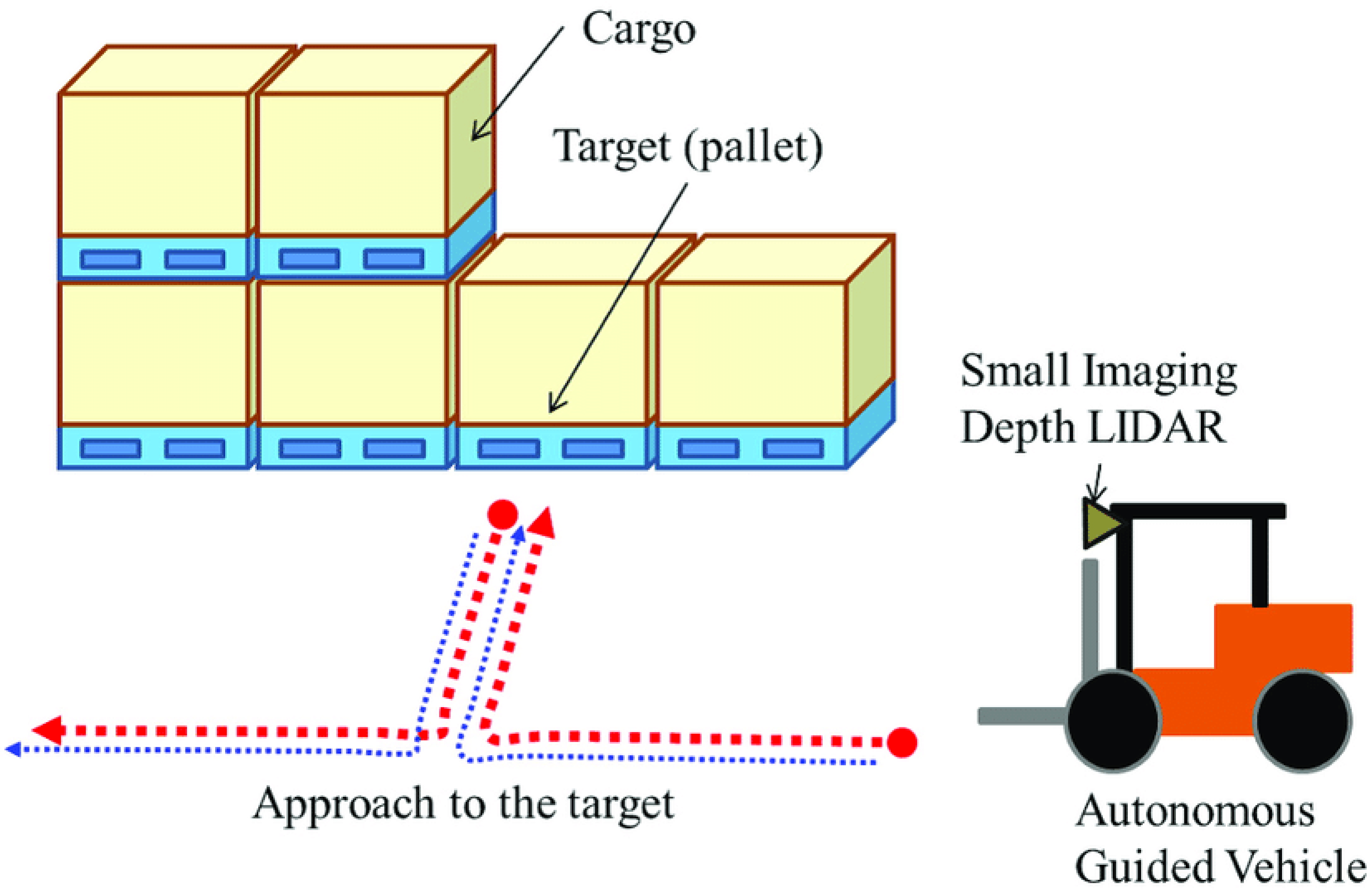
Cobot welding

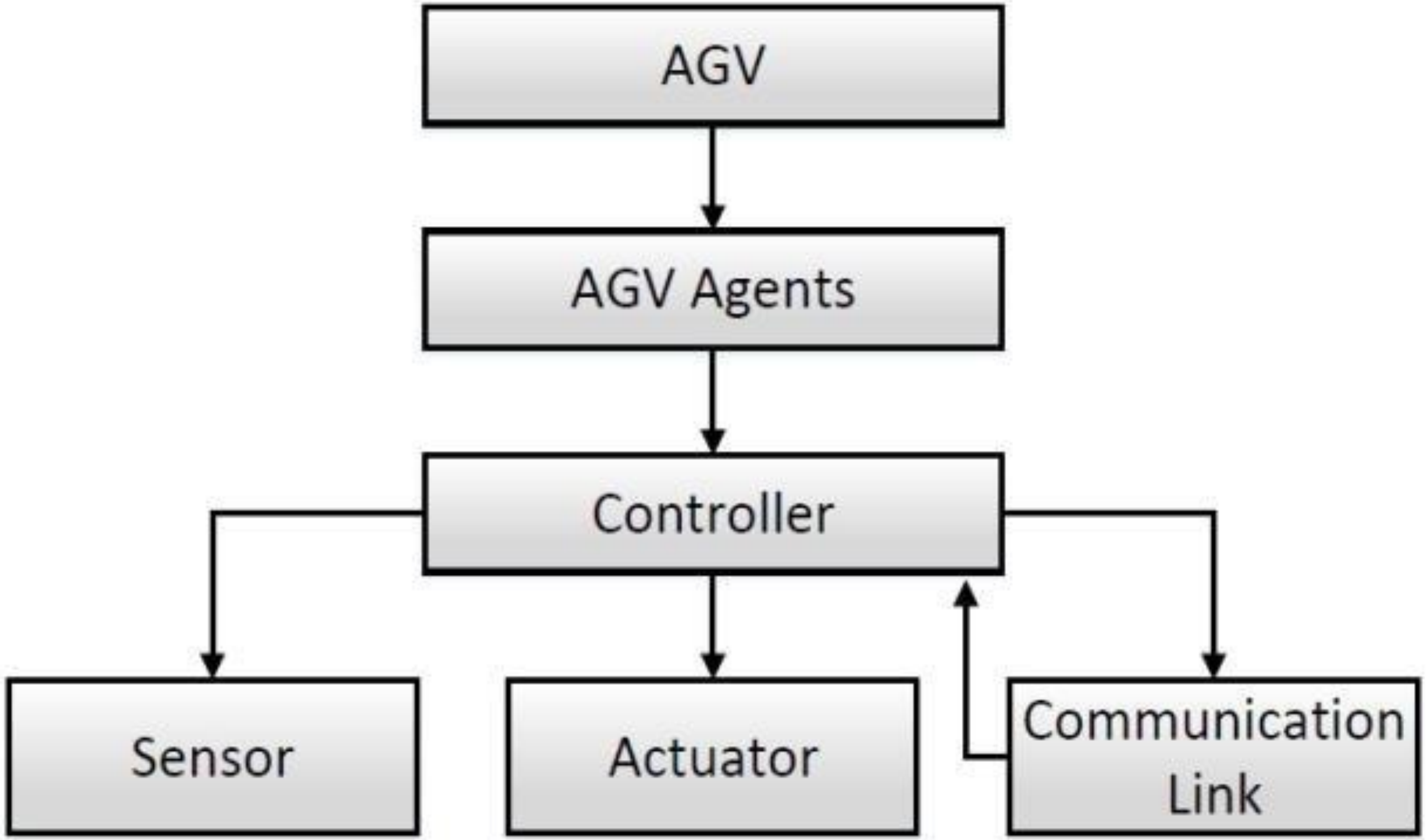
Advantages	Disadvantages
Productivity, Safety, Efficiency, Quality, Repeatability, Accuracy	Initial cost for equipment, installation, integration into the manufacturing process
Energy savings: illumination, air conditioning, ventilation	Environmental disturbance affecting cobot dynamics
Robust control on welding speed	Need for peripherals
Sensors can go beyond human capabilities	Need for programming or softwares
Continuous work	Need for training

Manual welding

Advantages	Disadvantages
Operators' adaptive intelligence	Years of training for operators to get proper skills
Dexterity	Exposure to dangerous fumes, gas, arc radiation
Flexibility	Shortage of skilled workers
	Lack of reliable repeatability

Automated guided vehicles


Cargo
Target (pallet)
Small Imaging
Depth LIDAR
Approach to the target
Autonomous
Guided Vehicle


AGV
AGV Agents
Controller
Sensor
Actuator
Communication Link

Definition

Automated guided vehicle system is a material handling system that uses independently operated, self-propelled vehicles guided along defined pathways. The vehicles are powered by on-board batteries.

https://www.youtube.com/watch?v=mEzCMS50mtE

INTRODUCTION

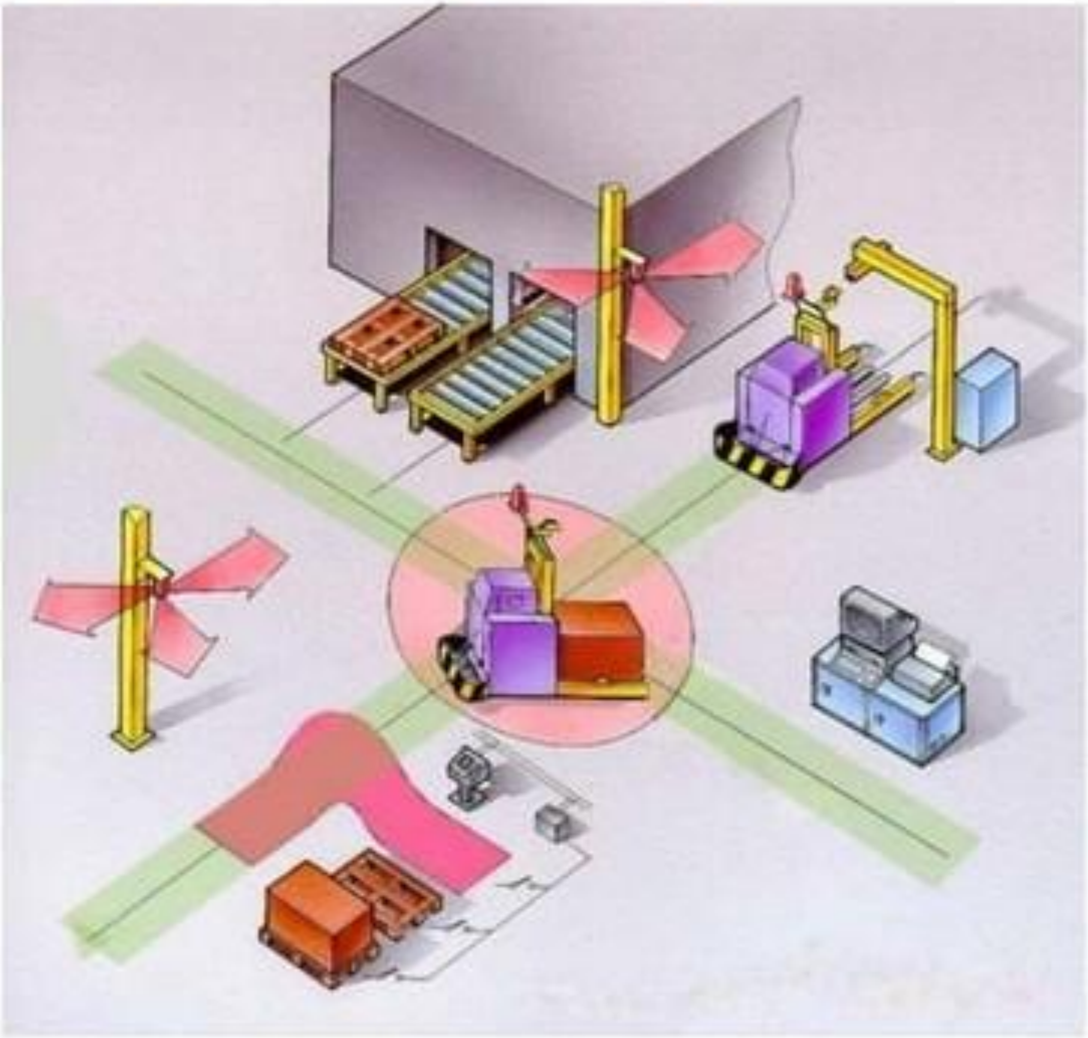
- Automated guided vehicles (AGVs) are self-driven vehicles.
- Early types of AGVS were introduced around 1954.

They are used to transport material from one location on the facility floor to another without any accompanying operator, and are widely used in material handling systems, flexible manufacturing systems, and container handling applications.

AGV System

1. Automated guided vehicle (AGV)
2. Load transfer positions
3. Load handling equipment
4. Load devices
5. Guide track

   (laser, inductive, optical)
6. Data transmission
7. Management system



Types of AGV

- Types Of AGV
  - Driverless Trains
  - AGV's Pallet Trucks
  - Unit Load Carrier

https://www.youtube.com/watch?v=WIlS3vNSuQ4

- Flexible material handling systems are required to perform an efficient routing of material with random handling capability.
- The use of AGVs increases flexibility.

Advantages of an automated guided vehicle system

1. Reduced Labor Costs.
2. Increased Accuracy and Productivity.
3. High availability/reliability.
4. Random material handling capability due to programmability.
5. Integrated operation of all AGVs.

Application:

- Efficient, cost effective movement of materials is an important and common element in improving operations in many manufacturing plants and warehouses.

Industries Application:

1. Manufacturing.
2. Chemical.
3. Pharmaceutical.
4. Paper and print.
5. Food and beverage.
6. Hospital.
7. Warehousing.
8. Theme parks

https://www.youtube.com/watch?v=k5iBfky6430

Featured Industries

Automotive - The leading supplier of Self Guided Vehicles (SGVs) for the automotive industry...

Printing - AGVs for the **Newsprint** and **Commercial Print** Industry...

Chemicals / Plastics - AGVs for handling raw materials and finished goods...

Hospitals - Automated Transport Systems (ATS) for healthcare facilities...

Food / Beverage - AGVs for movement of materials in the process or in the warehouse...

Pharmaceutical - AGVs support cGMP and validation requirements...

Warehouse / Distribution Center - AGVs support movements between palletizer, stretch wrapper, and storage areas...

Paper - AGVs move rolls and pallets between the paper machine, converting lines and the warehouse...

Manufacturing - AGVs deliver raw materials, move WIP and remove finished goods from the manufacturing floor...

Special Applications - AGVs handle many simple or complex repetitive tasks such as automatic trailer loading...

Vehicle Functions

Man / vehicle functions
- Inputs made via operator panel with its keyboard and display
- Destination input to the vehicle
- Plug-in manual control and diagnosis module

Route (destination) finding
- High vehicle intelligence
- Travel route topology stored in the vehicle
- Destination code processing
- Load-sensing and empty location recognition

Guide track following

Guided movements using:
- optical track
- inductive track
- "free-flight" (partly guide-trackless)
- "free-navigation" (guide-trackless

Data exchange
- Infrared
- Radio

Special functions
- Battery reserve monitoring
- Control of battery charging
- Obstacle recognition

Load handling
- Load acceptance
- Load depositing
- Load monitoring
- Load transfer synchronization

Travel control
- Speed
- Safety gap maintenance
- Collision protection

Common applications:

- Transport many different types of material including pallets, rolls, racks, carts, and containers. AGVs excel in applications with the following characteristics:

1. Repetitive movement of materials over a distance.
2. Regular delivery of stable loads.
3. Medium throughout/volume.
4. When on-time delivery is critical and late deliveries are causing inefficiency.
5. Operations with at least two shifts.
6. Processes where tracking material is important.

Handling raw materials, Work-in-process movement, Pallet handling, Finished product handling, Trailer loading, Roll handling, Container handling.

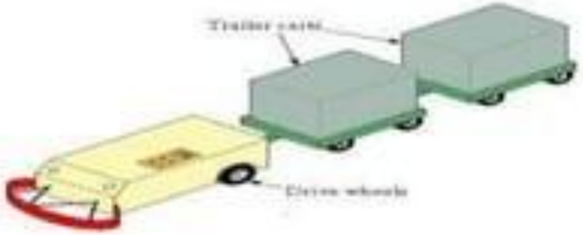
https://www.youtube.com/watch?v=dBCEx5kHYeE

Different Types of AGVS

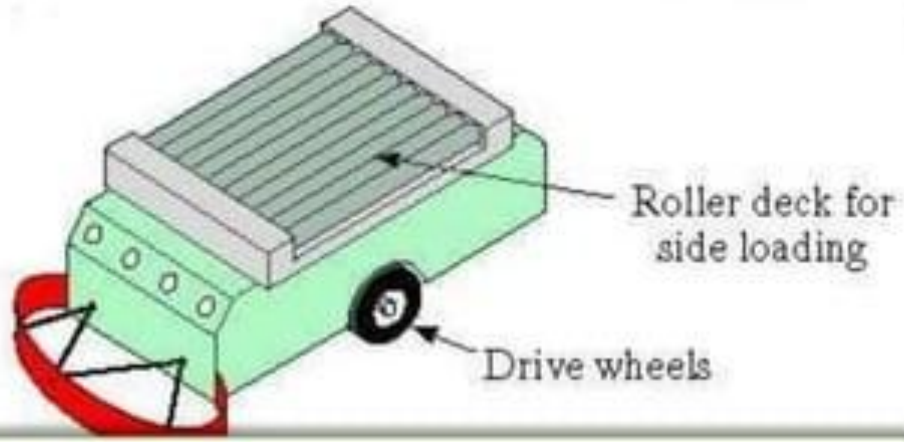
1.Fork Lifts.

2. Tow/Tugger. (Driverless train)

3. Unit Load.



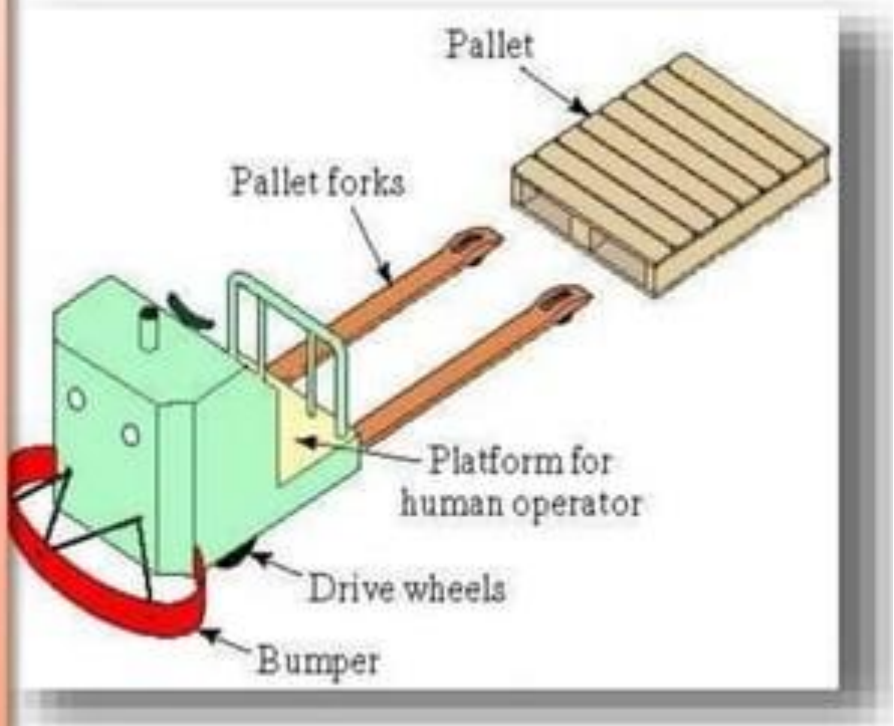
Unit Load Carriers



- These are used to move unit loads from one station to another.
- It is also used for automatic loading and unloading of pallets by means of rollers.
- Load capacity ranges up to 250 kg or less.
- Especially these vehicles are designed to move small loads.

AGV Pallet Trucks

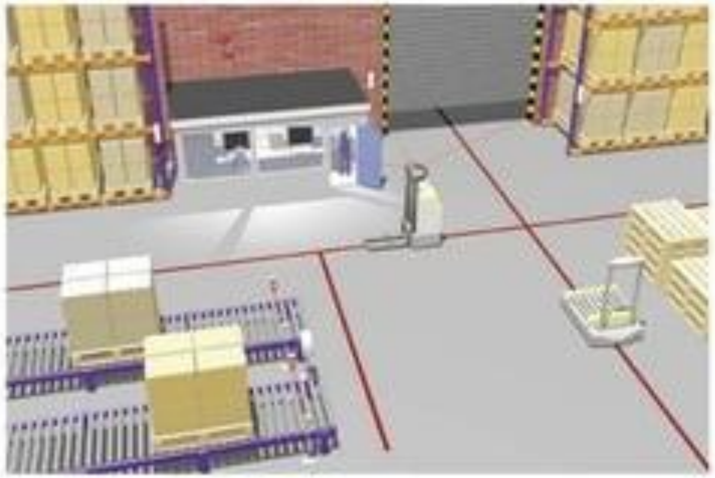
- Pallet trucks are used to move palletized loads along predetermined routes.
- The capacity of an AGV pallet truck ranges up to several thousand kilograms and some are capable of handling two pallets.
- It is achieved for vertical movement to reach loads on racks and shelves.

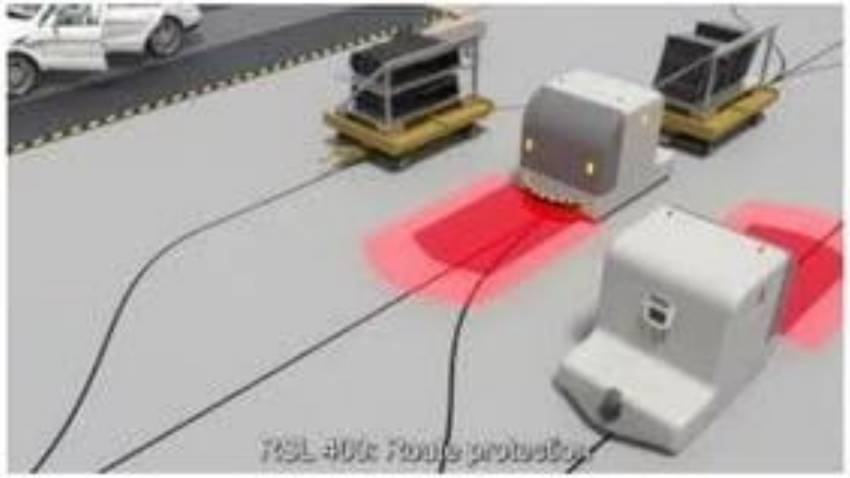


Vehicle Guidance System

1. Fixed-route guidance method, and

2. Free-route guidance method.

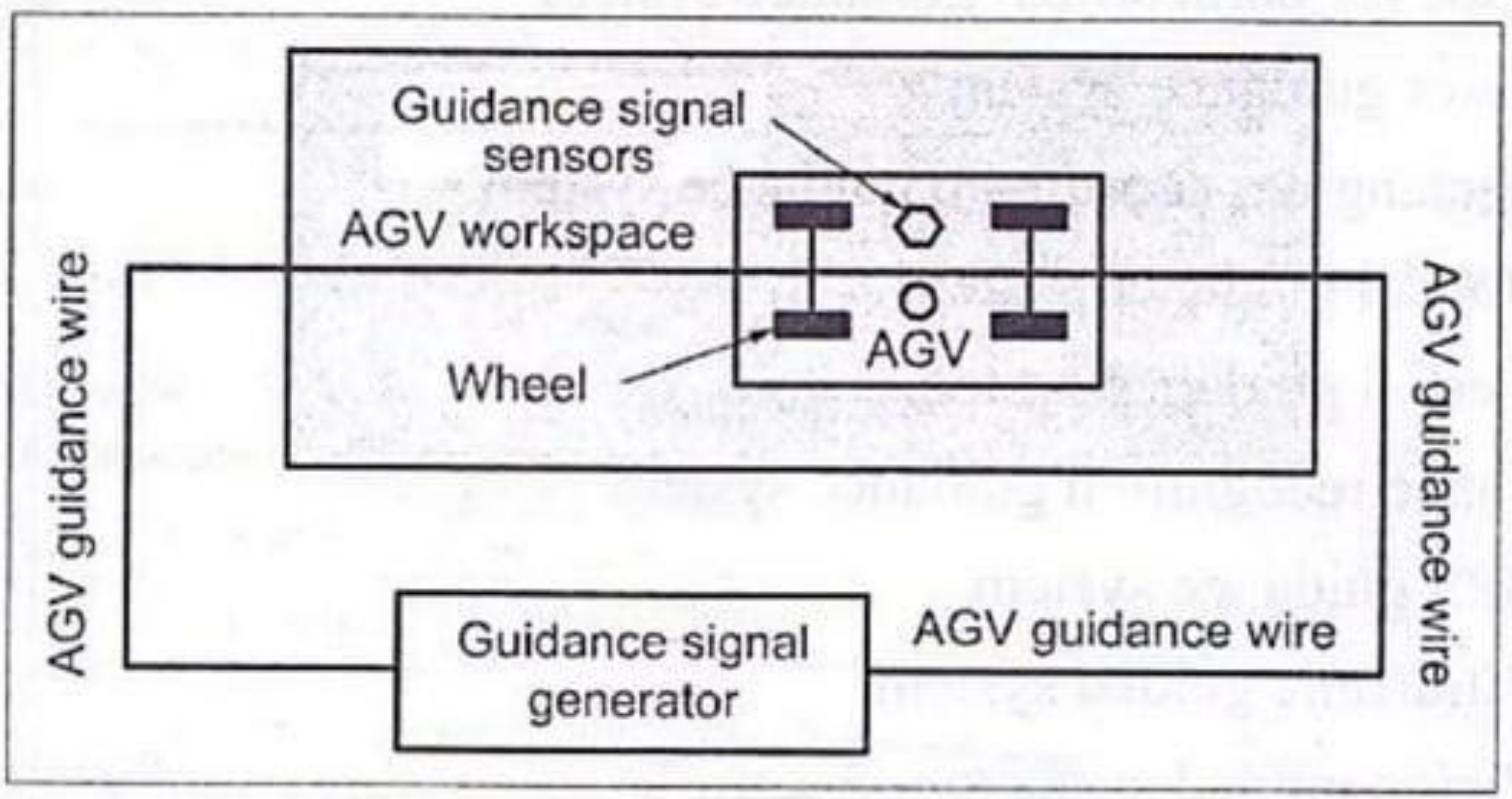




Fixed-Route Guidance Method

Fixed route guidance is to set medium guidance information in the path, AGV can drive with it, such as electromagnetic guidance, tape guidance, etc.

Fig. depicts a typical underlying principle of fixed-route guidance method.

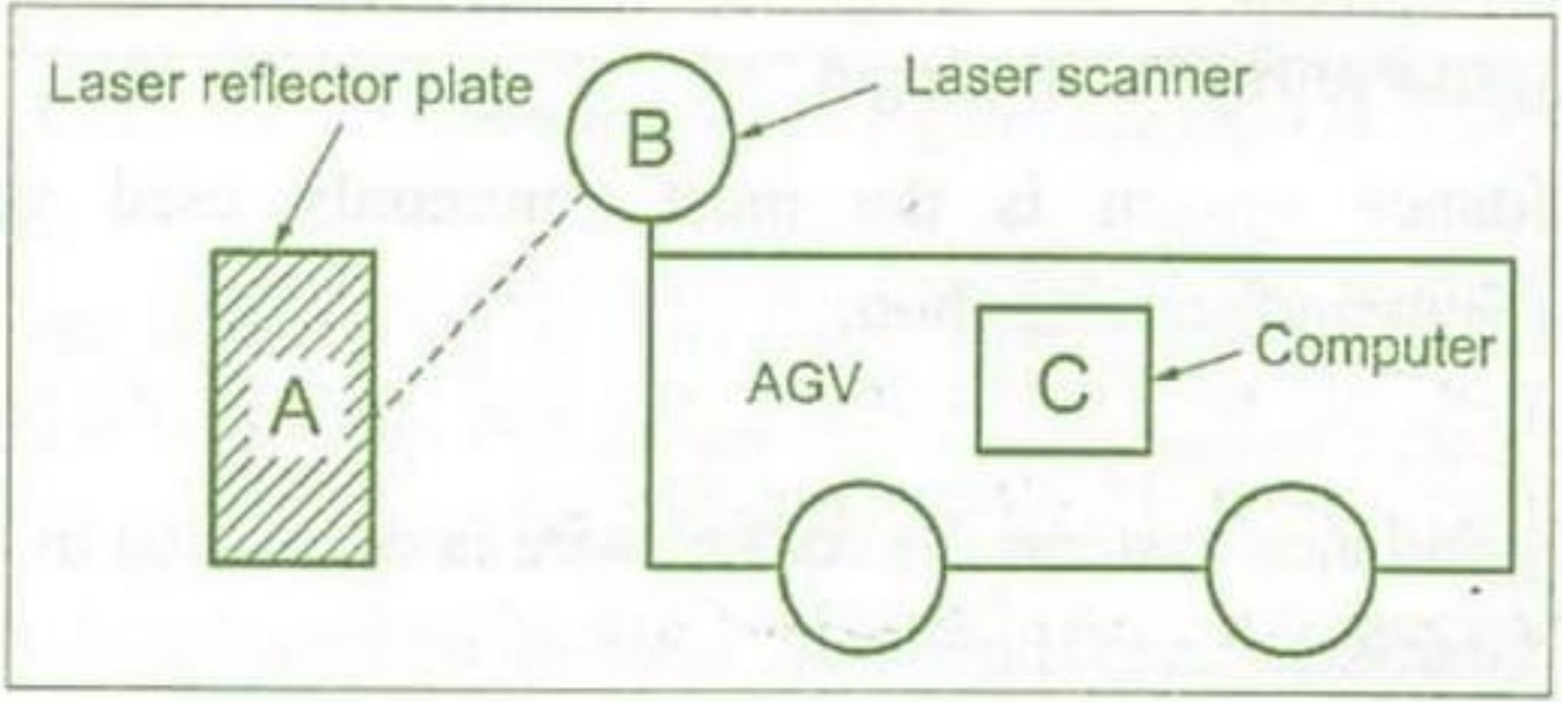


Fixed-route guidance method (electromagnetic guidance)

Free-Route Guidance Method

Free-route guidance stores the size of the coordinates, AGV can identify current position and decide driving path, such as laser-guidance and image recognition guidance.

Fig. depicts a typical underlying principle of free-route guidance method.



Free route guidance method (laser guidance)

Types of Vehicle Guidance Technologies (Types of AGV Guidance System)

There are many AGV guidance technologies/methods available and their selection will depend on need, application, and environmental constraints.

The-various types of vehicle guidance technologies/methods are:

1. Electromagnetic guidance (or wire guided) system
2. Tape (or paint strips) guidance system
3. Laser guidance system
4. Rectangular coordinate guidance system
5. Optical guidance system
6. Inertial guidance system
7. Image recognition guidance system
8. GPS guidance system
9. Ultrasonic guided system
10. Vision guided system

Automated Guided Vehicle Variants

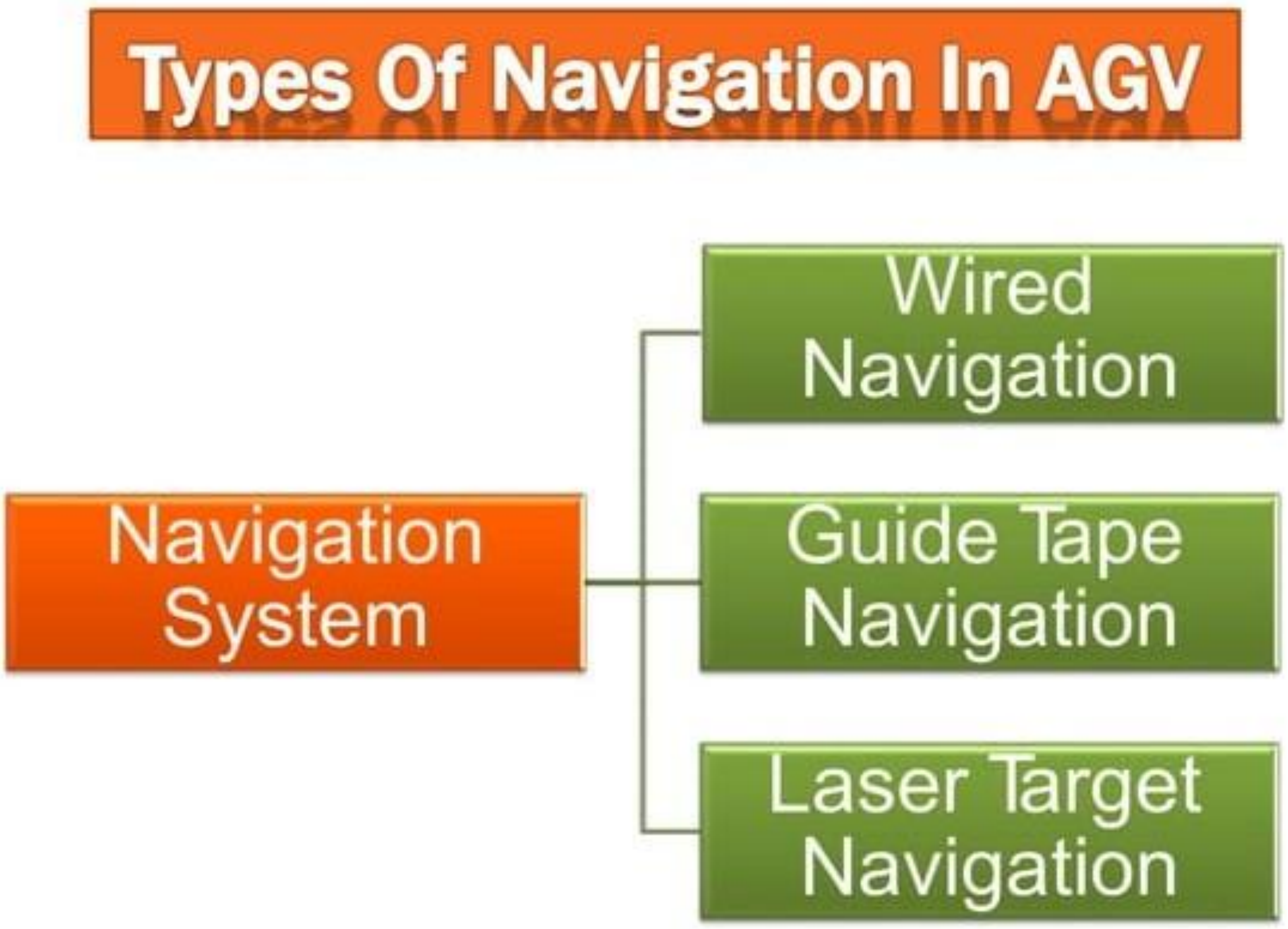
Machine Vision, Geoguidance (Natural) Guidance

Inertial (Gyroscopic) Guidance

Laser Target Guidance

Magnetic or Colored Tape Guidance

Wired Guidance


Types Of Navigation In AGV
Navigation System
Wired Navigation
Guide Tape Navigation
Laser Target Navigation

1. Wire guidance system,
2. Paint strips system, and
3. Self-guided (or autonomous) vehicles.

I. Wire Guidance System (Imbedded Guide Wires Technology)

Thé wire guidance system is the most commonly used vehicle guided technology in the manufacturing shop.

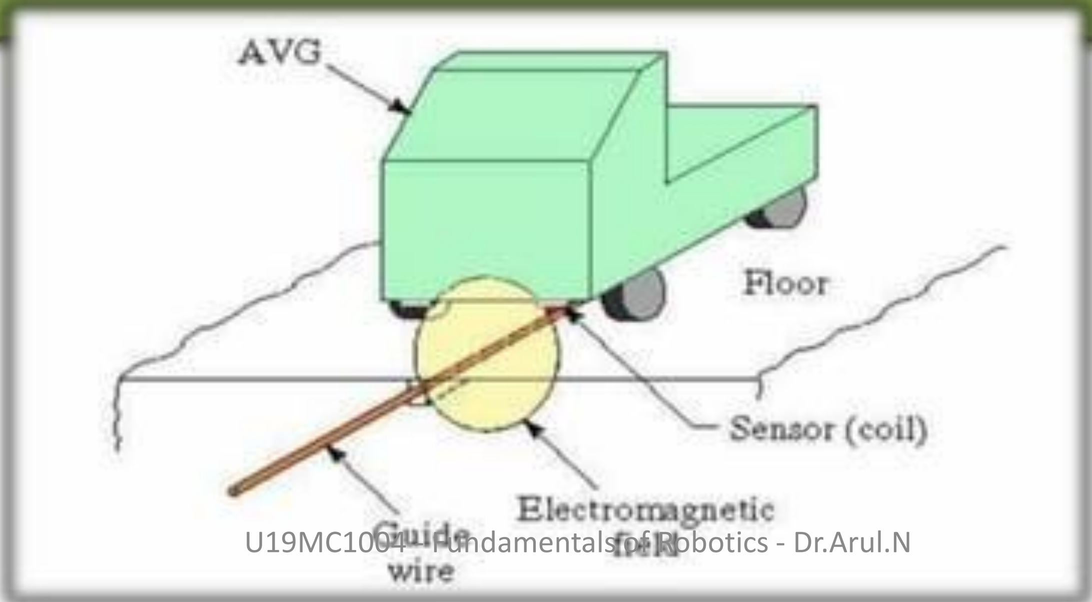
Construction:

- In this wire guidance system, the control wire is embedded in the factory floor along which the AGV is to transverse.
- For this purpose, a rectangular slot is cut into the concrete floor and the wire is placed in position with the rest of the slot being filled with epoxy, as shown in Fig.

https://www.youtube.com/watch?v=6HFK8MZF2_M

Wired Navigation

- The wired sensor is placed on bottom of the AGV'S and is placed facing the ground.
- A slot is cut in the ground and a wire is placed approximately 1 inch below the ground.
- The sensors detects the radio frequency being transmitted from the wire and follows it.



Working principle:

- Wire guidance is based on the fact that an electrical conductor through which an AC current is flowing will create an electromagnetic field around itself as shown in Fig. Since the field is stronger closer to the wire, the AGV is able to steer itself using an antenna that detects the strength of the field.
- More than one AGV can be located on a single wire, and different guide wires can carry electricity at different frequencies, which enables a single system to control AGVs on different paths.

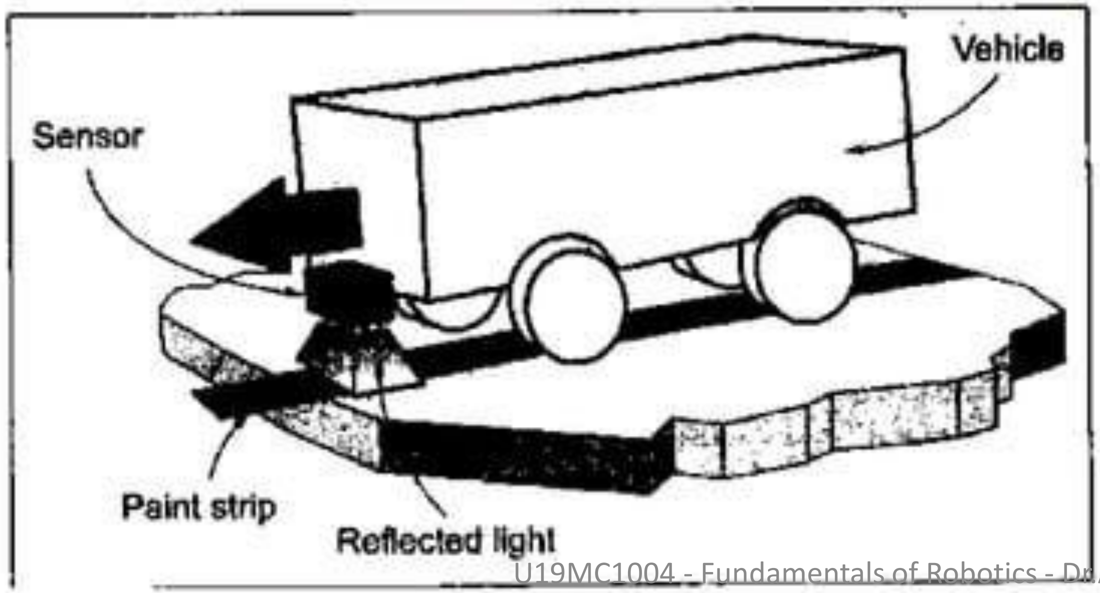
2. Paint Strips Guidance System

In this method, the paint strips are used to define the pathway and the AGV uses optical sensors to follow the painted strip.

✓ The strips can be painted, taped or sprayed onto the floor.

Working principle:

- This type of system uses a line of fluorescent particles or dye to indicate the path for the vehicle to follow.
- Sensors on the vehicle are used to detect reflected light to indicate to the vehicle its position in relation to the specified path, as shown in Fig.4.20.

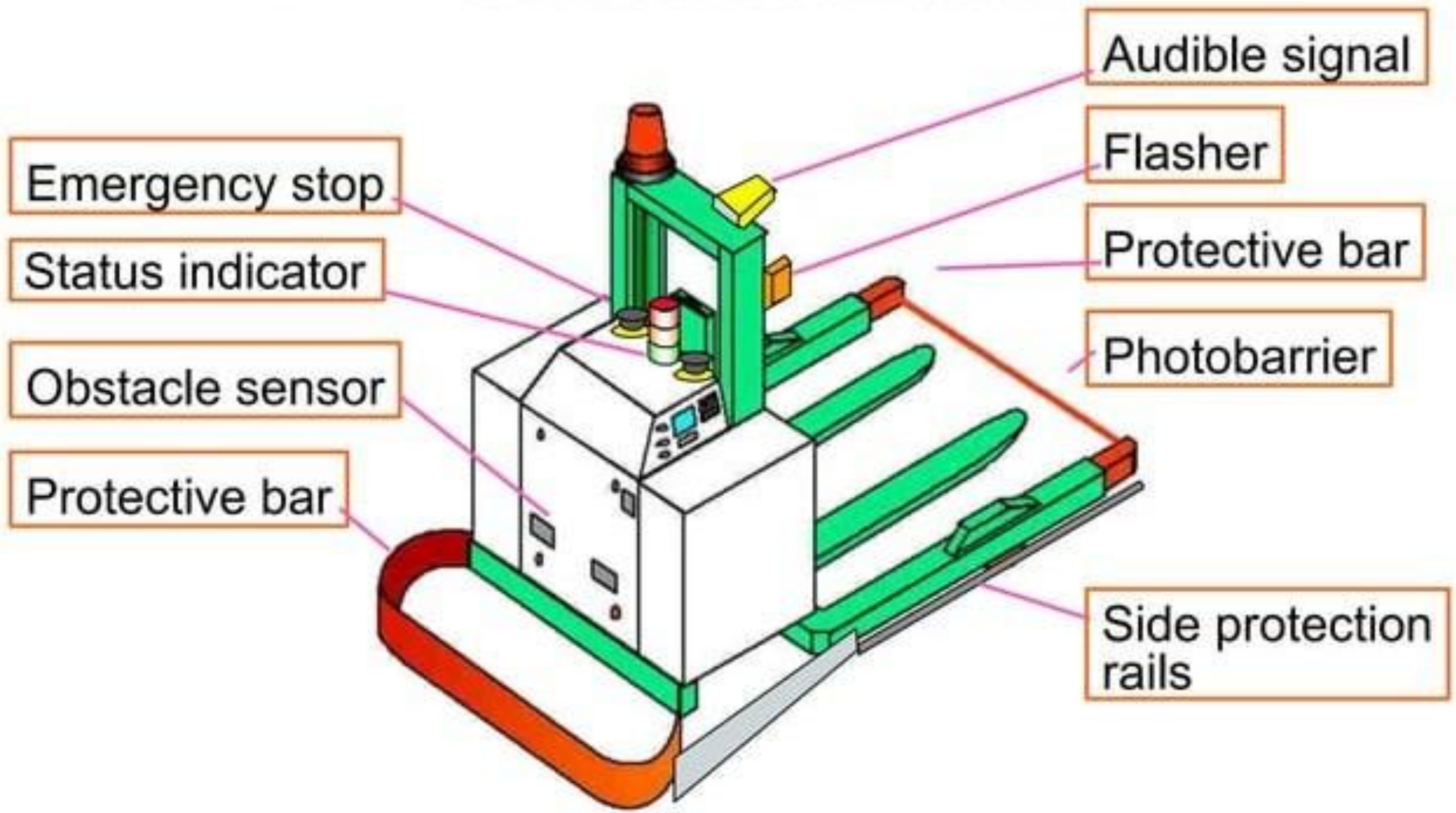


Typical paint strip guidance system

Guide Tape Navigation

- The AGV'S use Optical / Chemical / magnetic tape for the guide path.
- The AGC'S is fitted with the appropriate guide sensors to follow the path of the tape.
- It is considered a "passive" system since it does not require the guide medium to be energized as wire does.

Safety Elements



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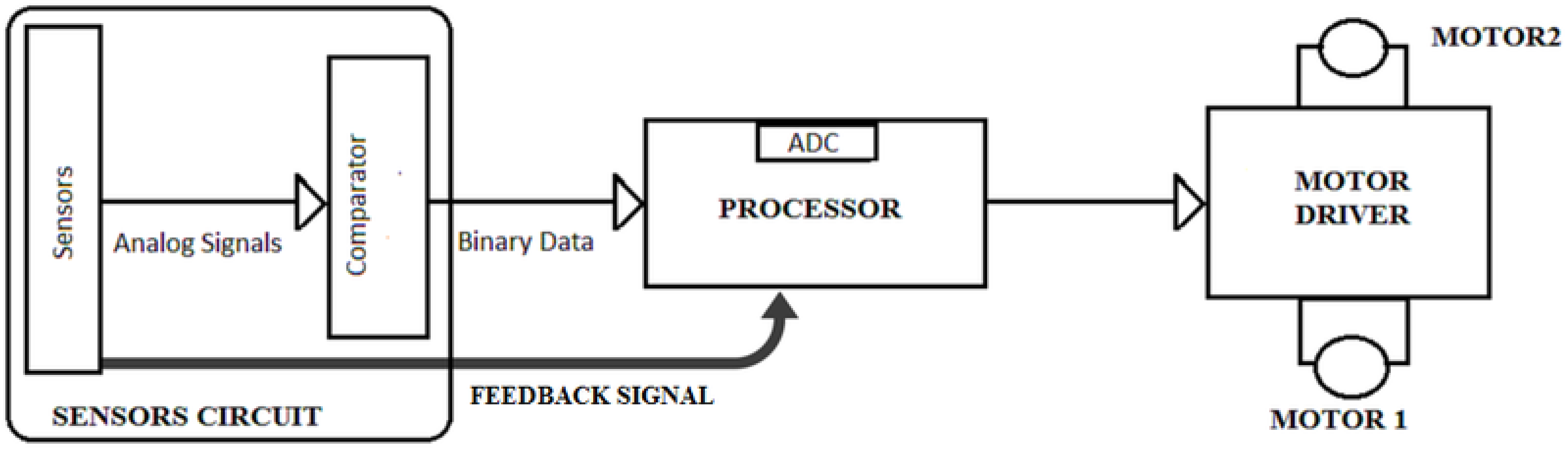
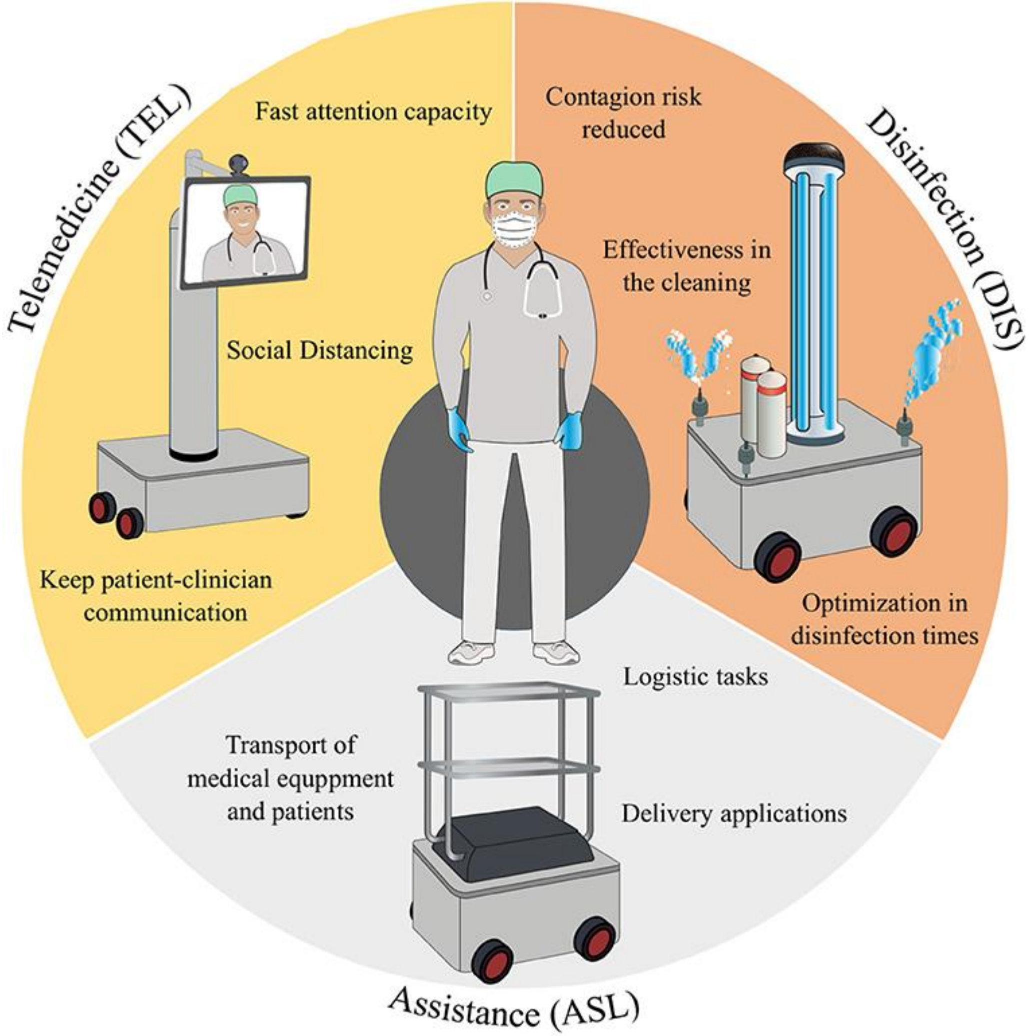
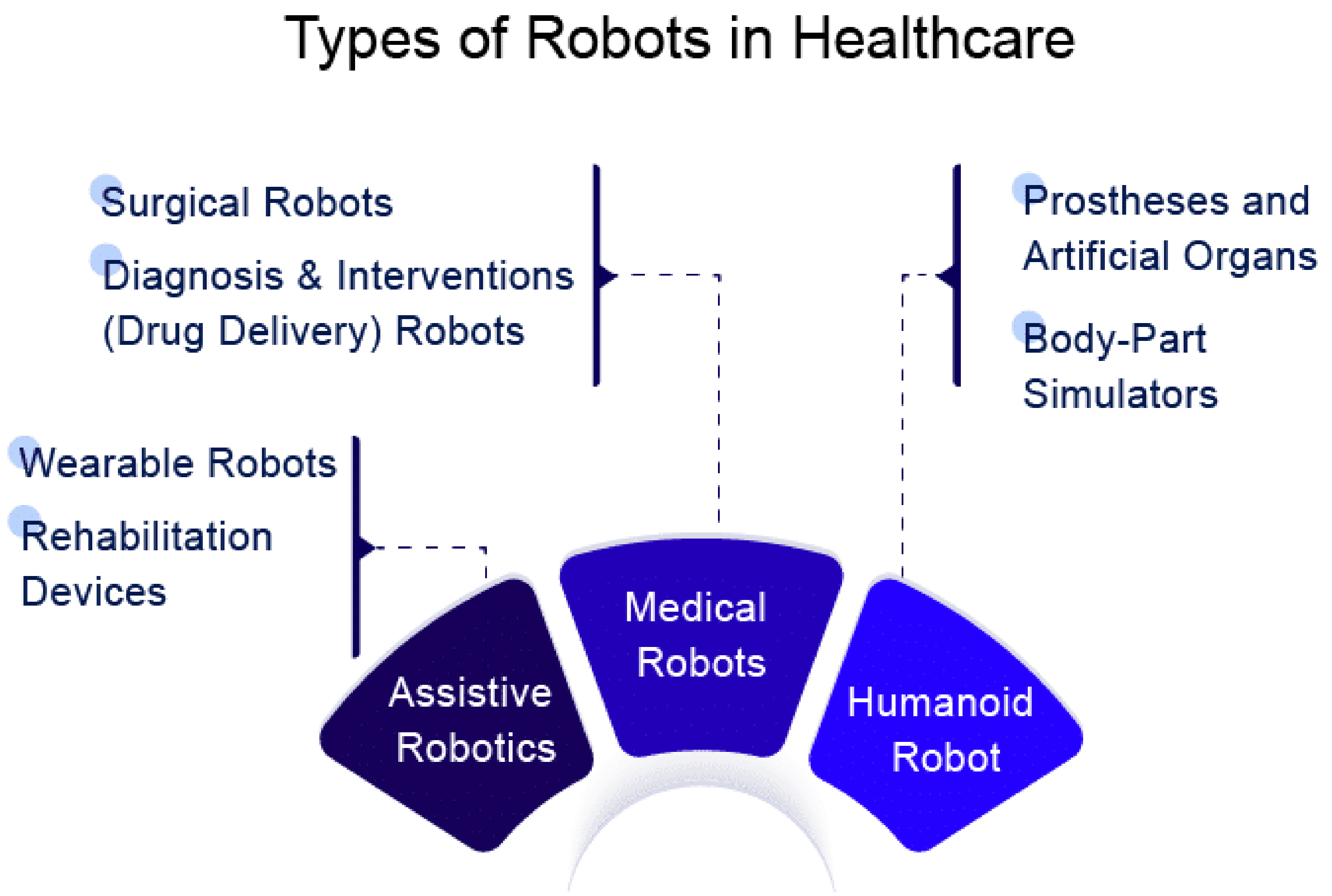
Block Diagram of Line follower AGV



Robots in Health care Industries

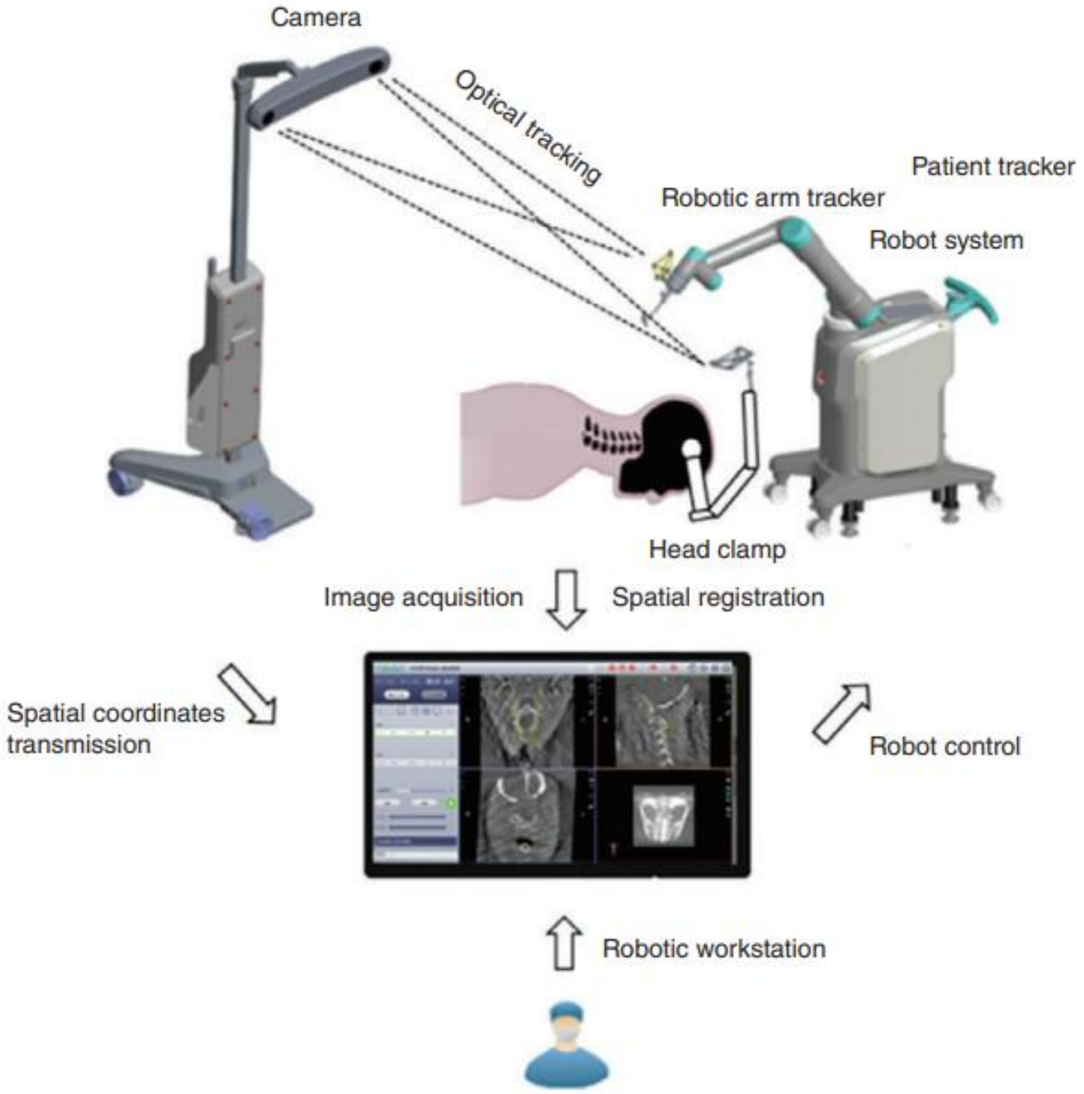




- https://www.delveinsight.com/blog/medical-robots-market

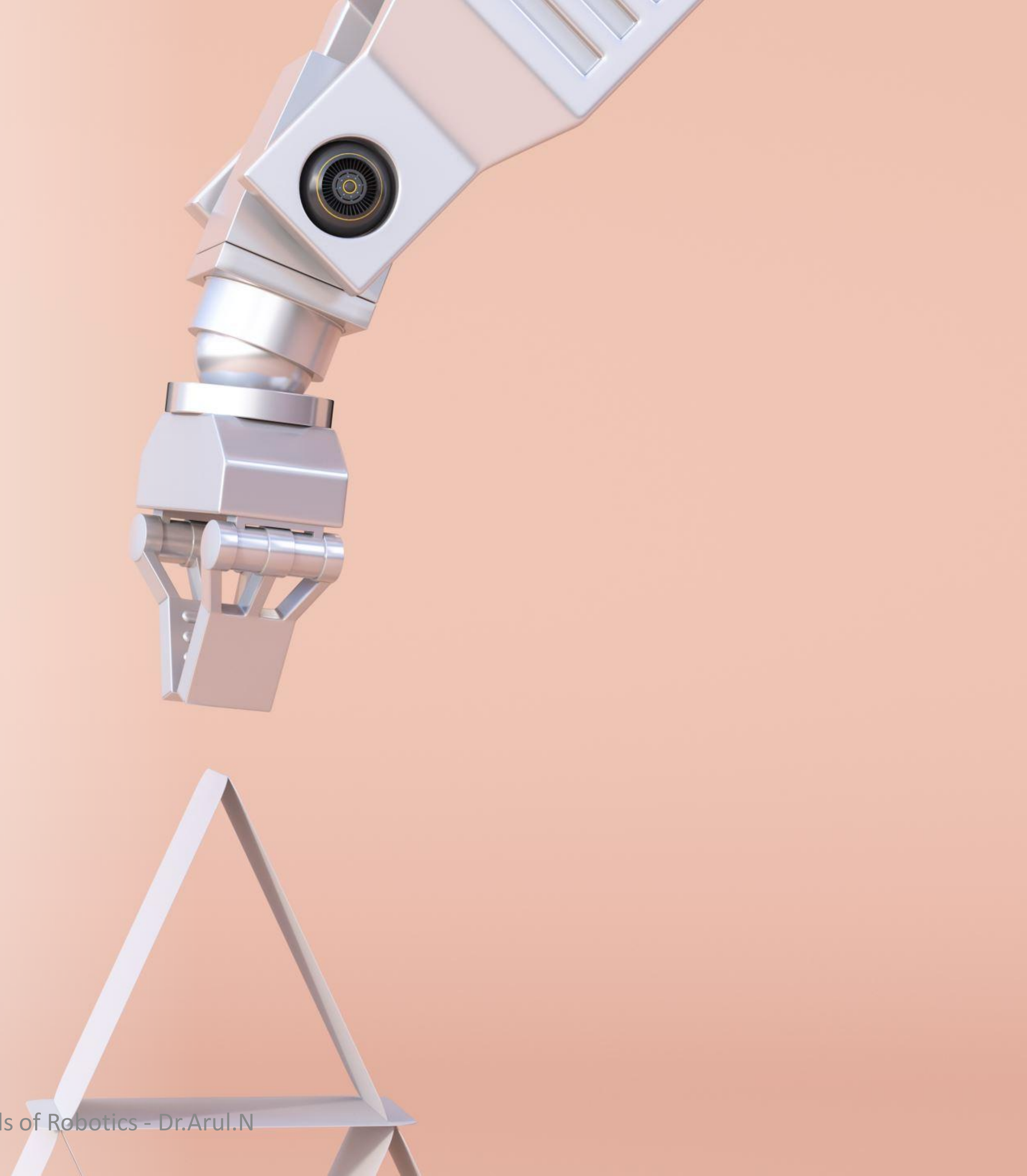
TianJi Robot system.

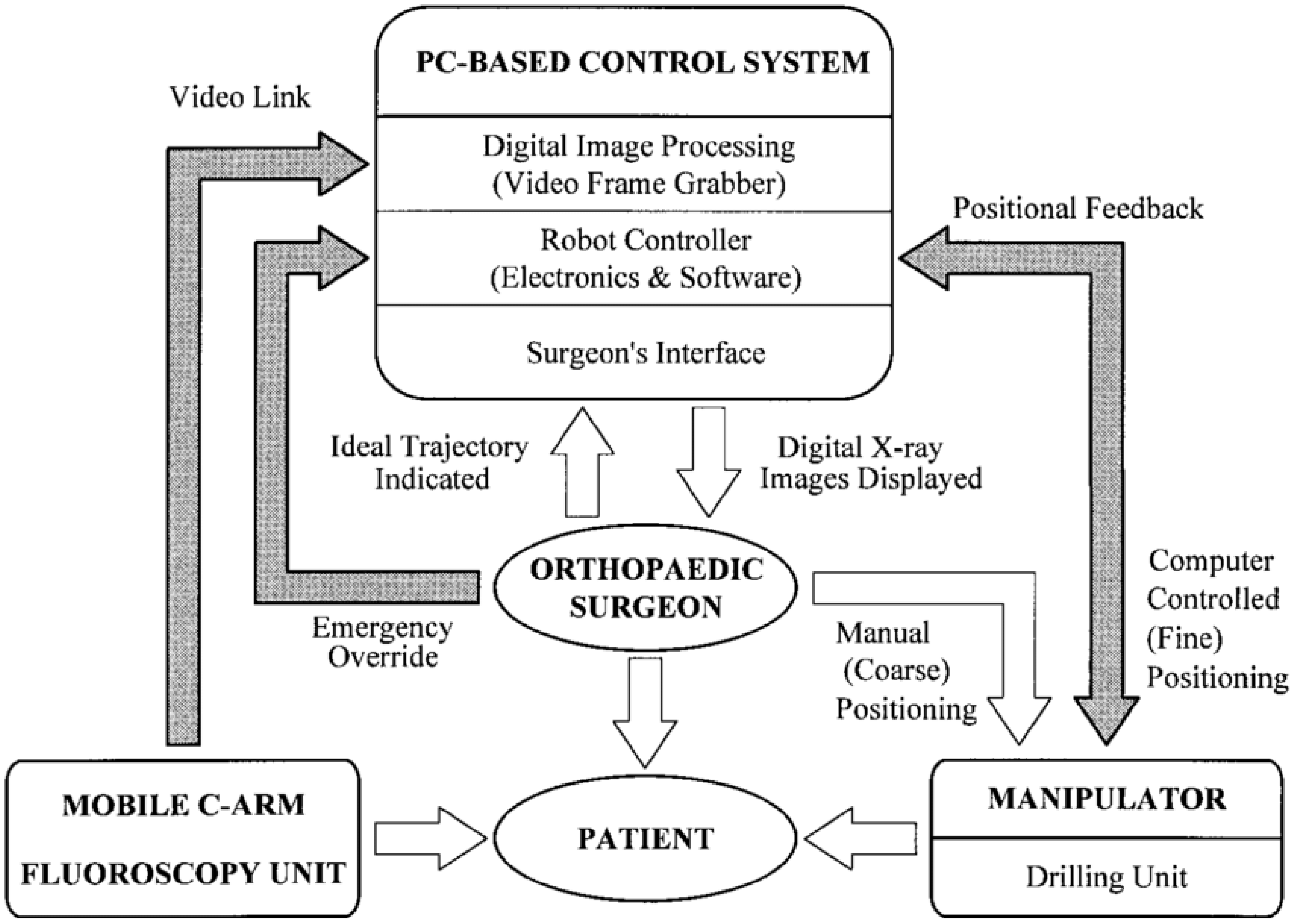
- Orthopaedic Surgical Robot



Orthopaedic Surgical Robot

- An orthopaedic surgical robotic system mainly uses preoperative or intraoperative images for surgical planning, providing accurate positioning of surgical tools or implants through robotic arm movement and rigid guidance, assisting the surgeon to complete surgical operations.




PC-BASED CONTROL SYSTEM
Digital Image Processing (Video Frame Grabber)
Robot Controller (Electronics & Software)
Surgeon's Interface
Video Link
Positional Feedback
Ideal Trajectory Indicated
Digital X-ray Images Displayed
ORTHOPAEDIC SURGEON
Emergency Override
Manual (Coarse) Positioning
Computer Controlled (Fine) Positioning
MOBILE C-ARM
FLUOROSCOPY UNIT
PATIENT
MANIPULATOR
Drilling Unit

Component	Function
PC-Based Control System	Central unit that processes images, controls robot, and interfaces with surgeon.
Digital Image Processing	Captures and processes real-time X-ray/video images.
Robot Controller	Executes precise control of the manipulator using software.
Surgeon’s Interface	Allows the surgeon to input commands and monitor the system.
Orthopaedic Surgeon	Plans the trajectory, monitors progress, and can manually intervene.
Patient	Receives treatment; positioned between imaging and robotic units.
Mobile C-Arm Fluoroscopy Unit	Provides real-time X-ray images to assist in navigation.
Manipulator (Drilling Unit)	Performs fine, computer-controlled bone drilling as per instructions.
Positional Feedback	Sends real-time position data back to the control system for accuracy.

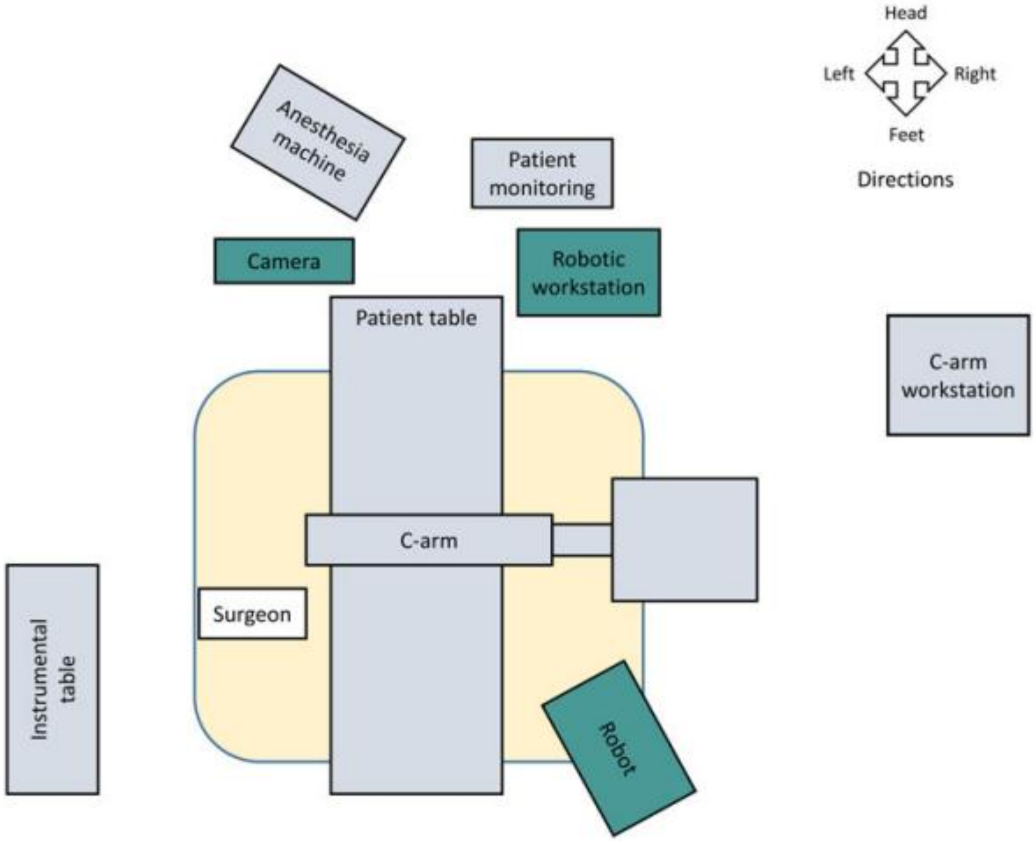


Fig. 4 Schematic diagram of operation room. When performing robotic surgery, it is recommended that the operation room be arranged as shown.

Component	Function / Placement
Patient Table	Center of the setup; patient lies here during surgery.
C-arm	Positioned horizontally over the patient; provides intraoperative imaging (X-ray).
Surgeon	Stands beside the patient table for direct manual access if needed.
Robot	Positioned at the foot-right side; performs robotic-assisted tasks near the patient.
Robotic Workstation	Right side; controls robotic arm via surgeon interface and imaging data.
C-arm Workstation	controls imaging and fluoroscopy functions.
Anesthesia Machine	manages anesthesia for the patient during surgery.
Patient Monitoring	displays real-time vitals and physiological parameters.
Camera	used for visual tracking and documentation.
Instrumental Table	holds surgical instruments for easy access.

- Ref : file:///C:/Users/student/Downloads/Guideline_for_Posterior_Atlantoaxial_Internal_Fixa.pdf

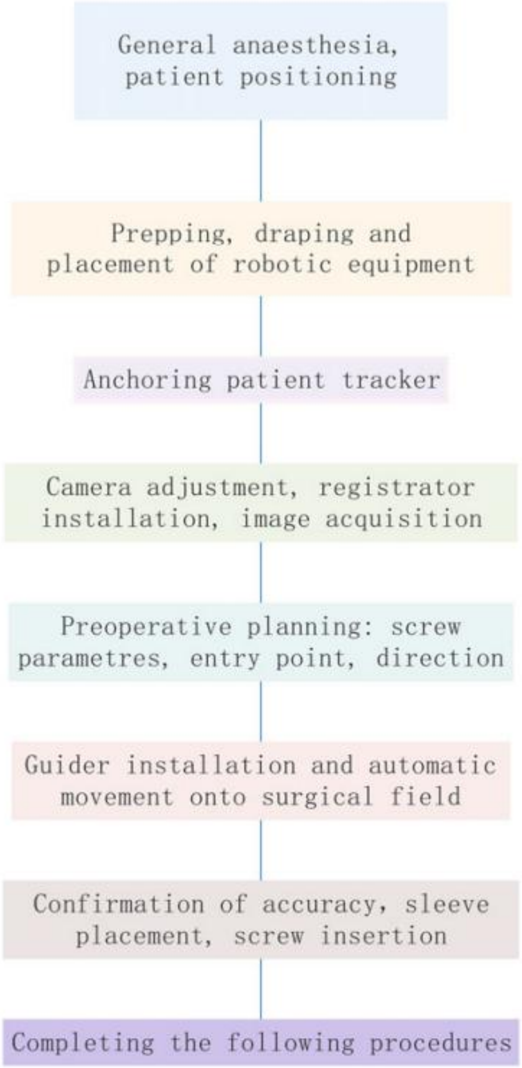


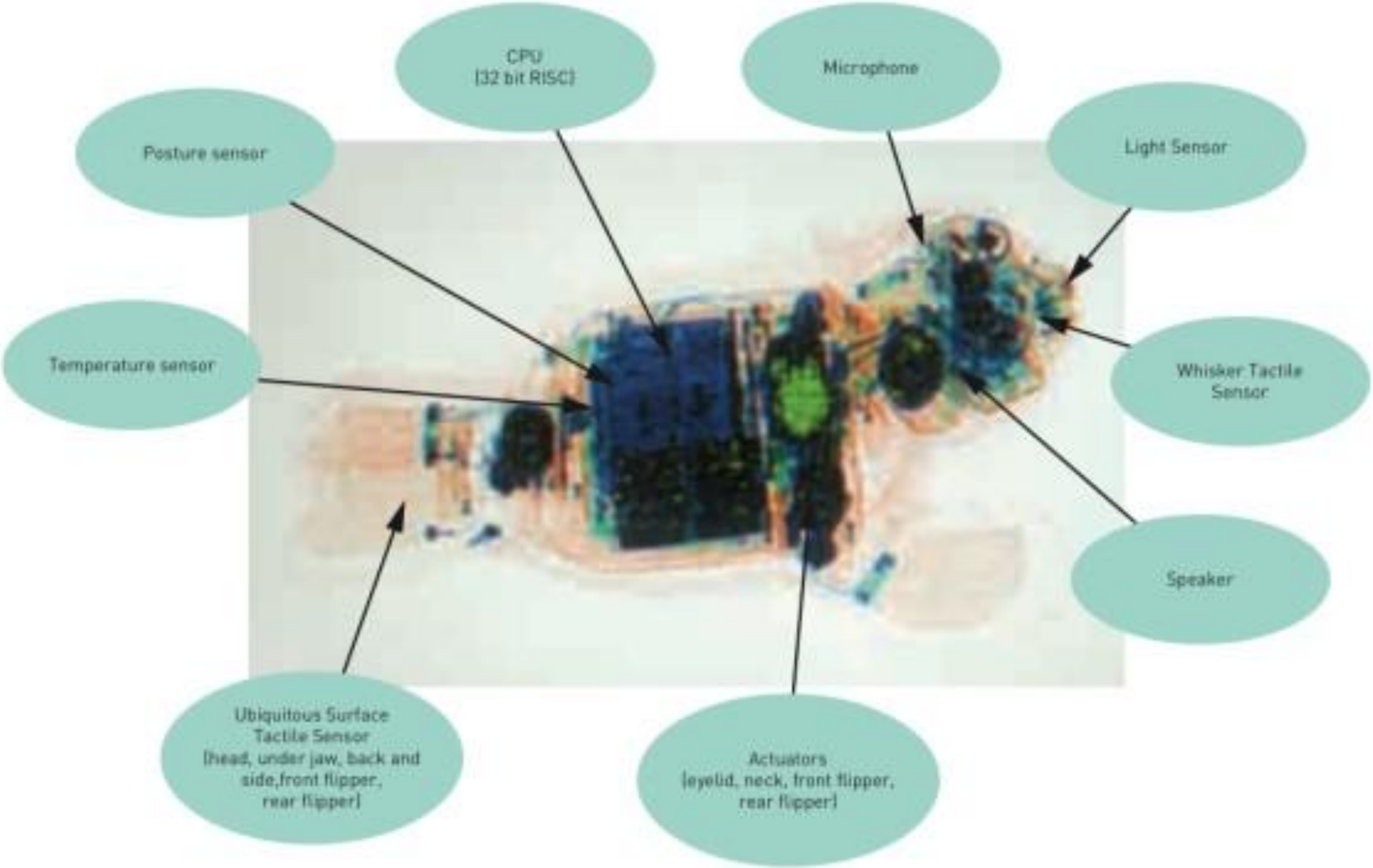
Fig. 5 Workflow of robot-assisted procedures.

Therapeutic Robot (PARO)

- PARO is an advanced interactive robot developed by AIST, a leading Japanese industrial automation pioneer.
- It allows the documented benefits of animal therapy to be administered to patients in environments such as hospitals and extended care facilities where live animals present treatment or logistical difficulties.
- PARO has been found to reduce patient stress and their caregivers
- PARO stimulates interaction between patients and caregivers
- PARO has been shown to have a Psychological effect on patients, improving thier relaxation and motivation
- PARO improves the socialiazation of patients with each other and with caregivers
- World's Most Therapeutic Robot certified by Guinness World Records

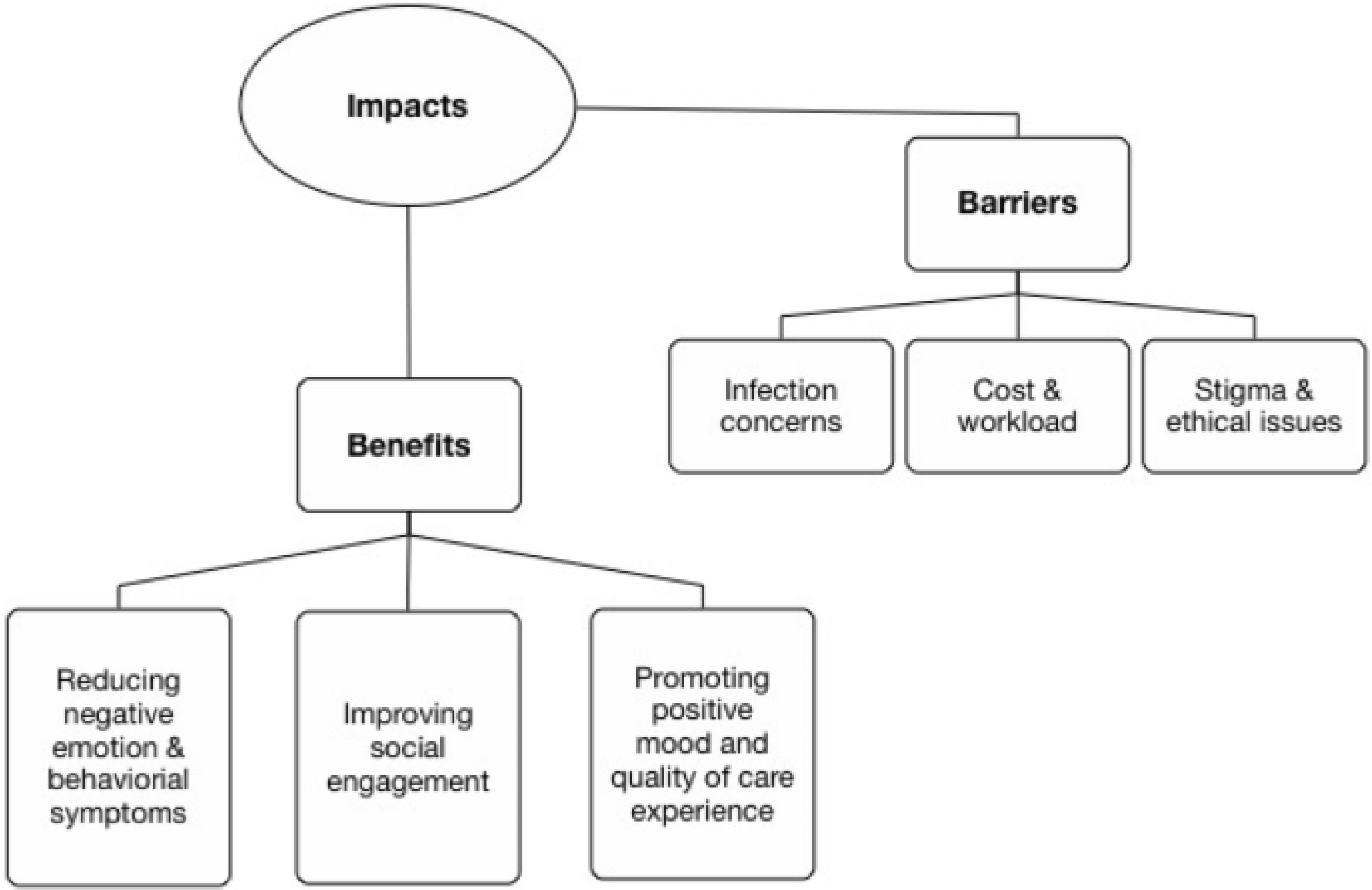
PARO

Components of PARO



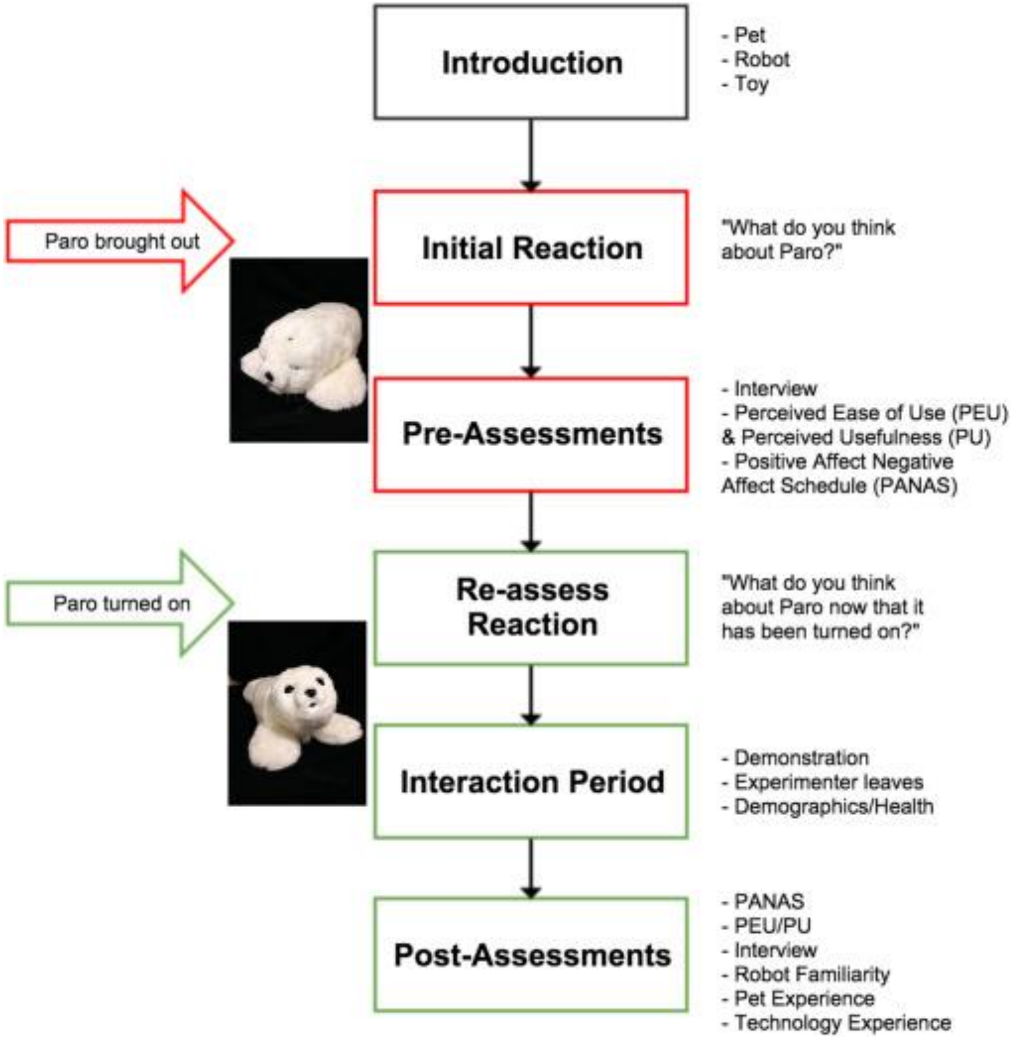
https://www.bbvaopenmind.com/en/articles/life-innovation-with-therapeutic-robot-paro/

Impact and Barriers



Interaction Process with PARO

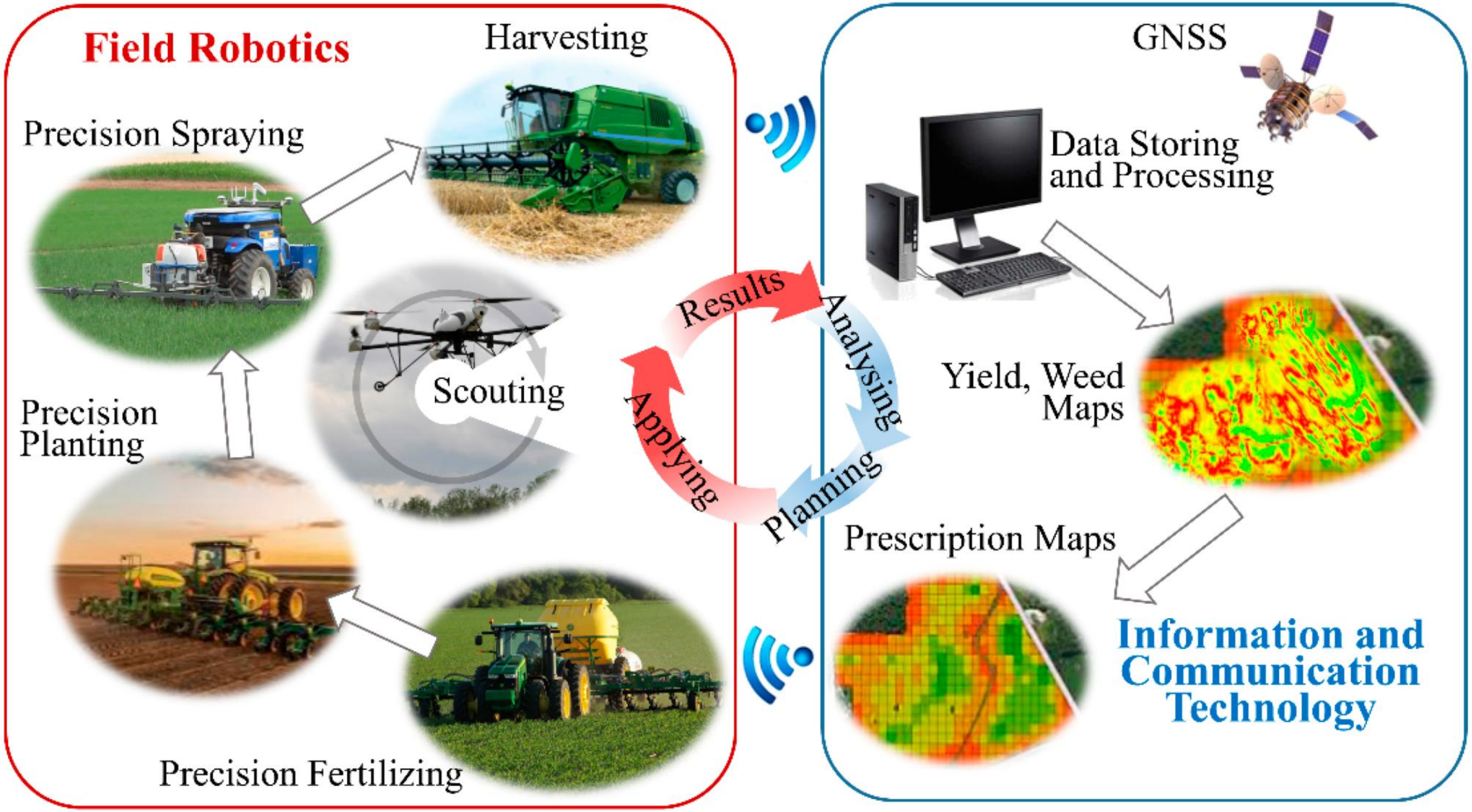
Introduction – The user is introduced to PARO (as a pet, robot, or toy).
Initial Reaction – First impressions are recorded.
Pre-Assessments – Interviews and surveys
PARO is Turned On – The robot begins interacting.
Re-assessment – The user reacts again after PARO is active.
Interaction Period – User interacts freely while being observed.
Post-Assessments – Final feedback and experiences are recorded.



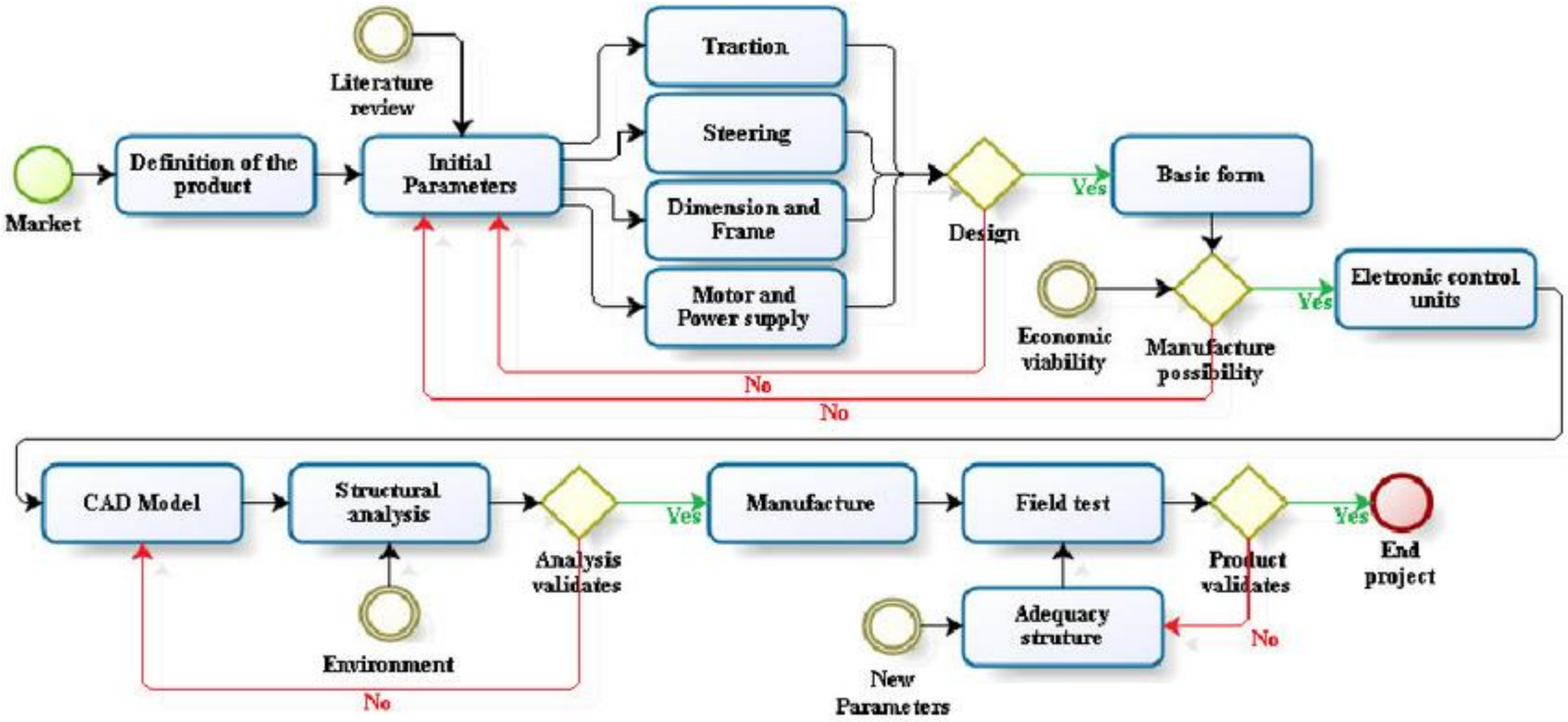
Robots in Agriculture

Agricultural Robots, commonly known as Agribots or Agbots, serve as artificial intelligence sources in the agriculture industry. They assist farmers in improving productivity and reducing the dependency on manual field tasks.

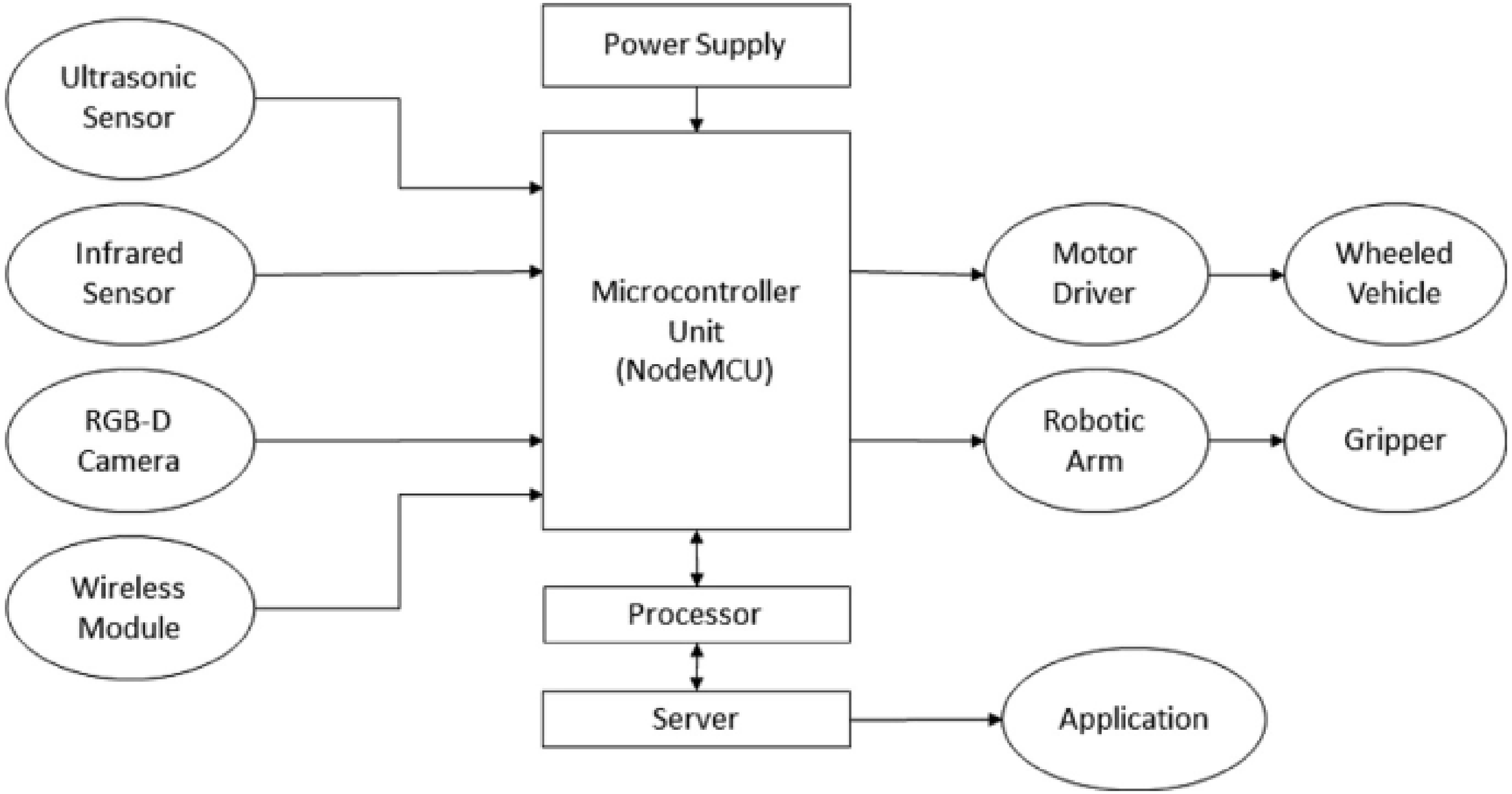
- **Harvesting** – This is among the most common functions performed by an Agribot. These robots work with increased speed and accuracy to improve crop yield size and reduce wastage.
- **Weed Control** – Agbots help distinguish weeds from useful crops and remove them by causing artificial soil disturbances using laser technologies.
- **Mowing** – Agbots use smart sensors to determine plant density and cut farmlands with precision.
- **Seeding** – Agribots also act as seeder attachments where they accurately predict the soil tendency and help in planting seeds at the right places.
- **Spraying** – Agbots help identify weeds and crops that require pesticides and fertilizers, thereby leading to a reduction in wastage of resources.
- **Sorting and Packaging** – Agbots assist in detecting, sorting and packing agricultural products.
- **Livestock Monitoring** – Agbots help in tracking livestock and navigating them through rugged terrains.
- **Irrigation** – Artificial intelligence assists in accessing water volumes and helps farmers use water in a controlled manner only on plants in need of water.


Field Robotics
Harvesting
Precision Spraying
Scouting
Precision Planting
Precision Fertilizing
Results
Analysing
Planning
Applying
GNSS
Data Storing and Processing
Yield, Weed Maps
Prescription Maps
Information and Communication Technology

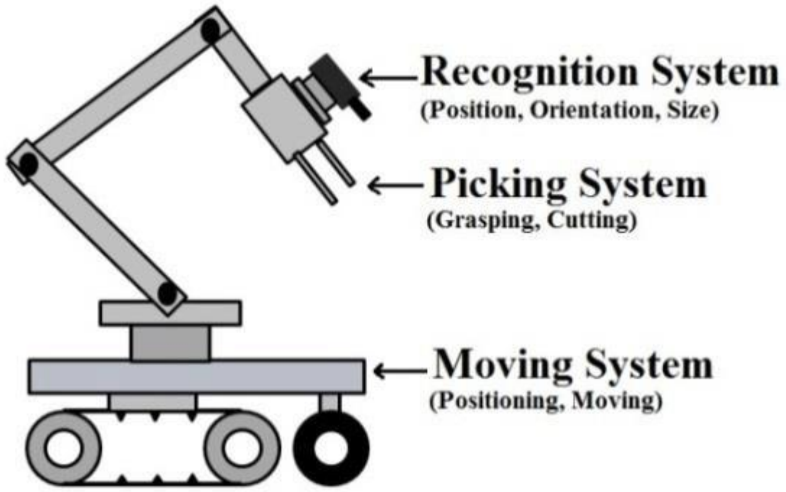
Flow chart for agricultural mobile robot Design

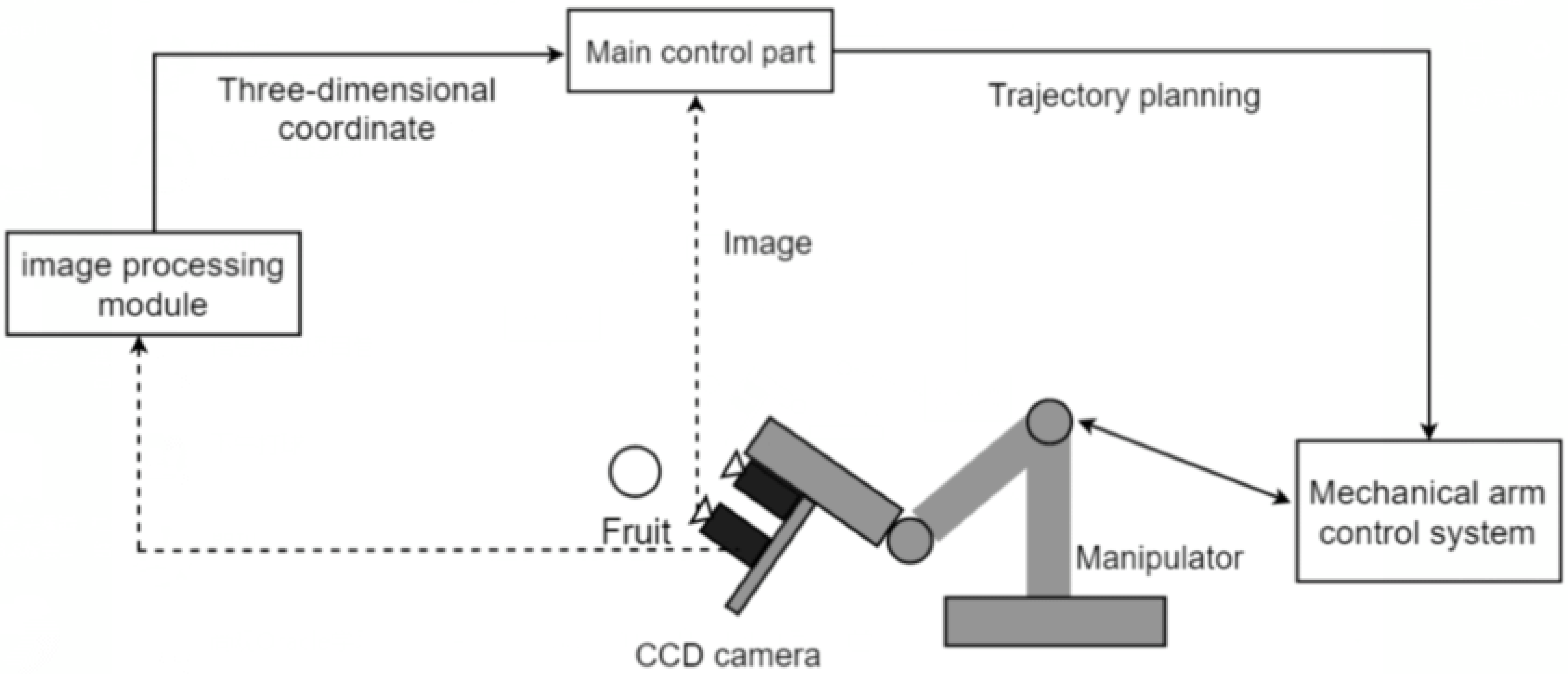


Crop Harvesting System- Block Diagram (Smart Agriculture)



Fruit Picking Robot





Fruit Picking Robot

The whole picking robot consists of two parts including a platform with mechanical components, and the most significant control system.

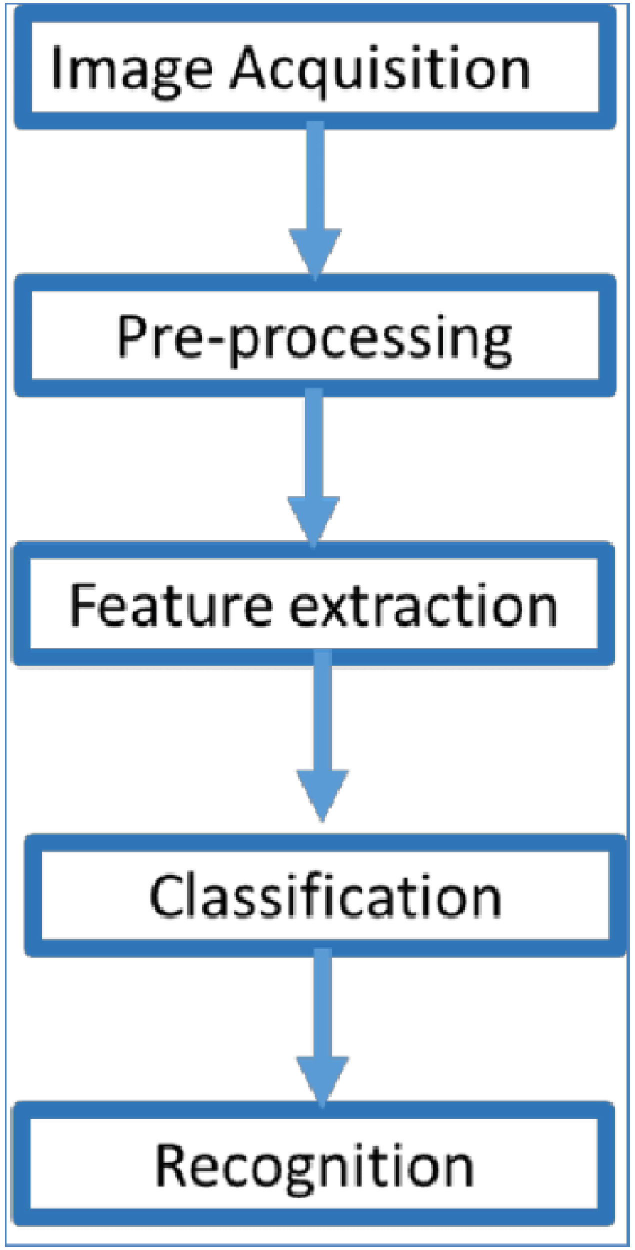
In the system hardware, the acquisition of objects is accomplished through visual sensors.

After that, image analysis and processing the coordinate information of the acquired objects, which through the professional software that collocated in the system.

In this way, to complete the identification and positioning work, which lays the foundation for picking.

Image Processing Steps

- In the picking robot system, the end-effector is responsible for picking. It completes the picking of objects by working with the manipulator control system. The whole picking process is combined with the main controller and the servo drive



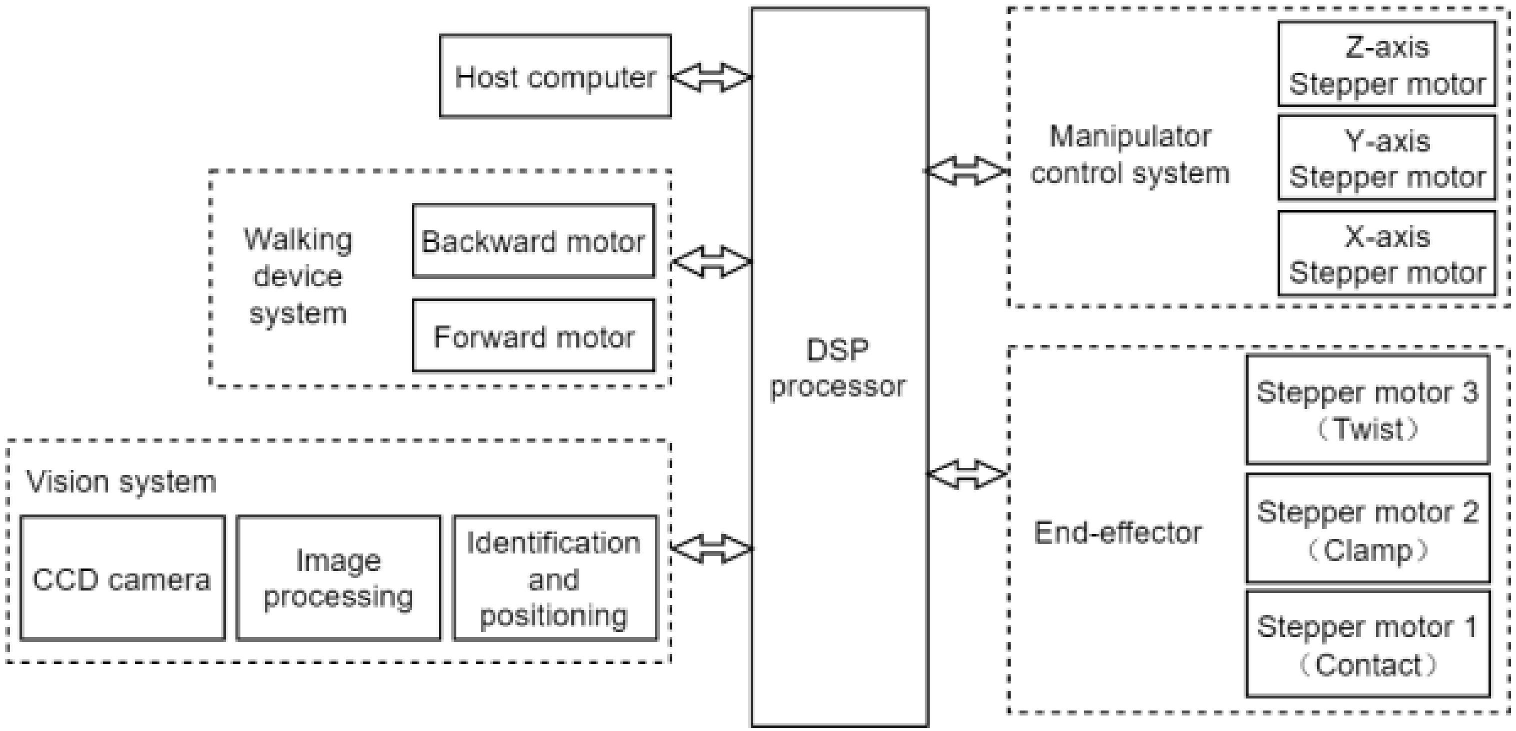


Fig. 3. The circuit control frame diagram of target fruit recognition system

- Ref : file:///C:/Users/student/Downloads/Research_on_Picking_Identification_and_Positioning.pdf

Robots in Space & Defence

SPACE ROBOTICS

Evolution of robots

- SHAKEY (1966-1972):
- It is based on the SPA (sense, plan and action) algorithm. It is used in built world modules to match and worked accordingly.
- FLOW CHART:

key technologies used:

- Mapping and navigation
- One of the basic functions of a space robot is to navigate its way cleverly through all obstacles that come in its way. Mapping and navigation comprise of three more technologies
- Obstacle avoidance
- Mapping
- Path planning

- Planning: It is a feature by which a robot understands the situation and decides a strategy to tackle it.
- Sequencing: Selection of a particular skill set which would result in perfect execution of a plan.
- Control: Performing the selected skill set to perfection.

Types of Robots in space:

- There are 3 basic types of robots in space and all the robots sent to space come under these types only.
- Planetary Rovers:
- It is the most advanced form of robotics technology used in space research. They are the robots, which explore, navigate and research themselves with the least human intervention; they analyze the data collected and send the results back to earth.

- IN-orbit Operators:
- They are the robots, which assist an astronaut during his space mission. For example a robot can be designed specially to refuel a shuttle thus helping the astronaut to remain in his shuttle and accomplish various tasks without any risk to their lives

Mineralogy and robots:

- Presently humans are facing a huge challenge of exhaustion minerals due to which space exploration is being used specifically for mineralogical purposes
- It allows the robot to detect rocks and get precise spectral measurements and validate the data without any human intervention.

MILITARY ROBOTS

Why Military Robots?

- Job of Soldier is no walk in the PARK
- Difficult Tasks
  - Walking through minefields
  - deactivating unexploded bombs
  - clearing out hostile buildings
- Robots to do these jobs instead of humans
- To operate in a relatively unstructured, natural environment
- Replacing human in dangerous, dirty, or dull missions
- Bear cost to build the robot instead of losing a human life

http://science.howstuffworks.com/military-robot.htm

TYPES

- Today's military robots don't do a whole lot on their own.
- Computer brains aren't very sophisticated in terms of artificial intelligence (AI).
- Instead of independent AI, most military robots are **remote-controlled** by human operators. Hence the term **Unmanned Vehicles**
- **UAV – Unmanned Aerial Vehicle**
- **UUV – Unmanned Underwater Vehicle**
- **UGV – Unmanned Ground Vehicles**

Examples

MQ1-Predator

Talisman

TALON

MULE

AUTONOMOUS ROBOTS

BIGDOG

CRUSHER

Basic Idea

- The basic idea is to program the robot to respond a certain way to outside stimuli.
- Most of them use **stereo vision** to see the world around them. Several Cameras give these robots depth perception, and image-recognition software gives them the ability to locate and classify various objects.
- More advanced robots can **analyze and adapt** to unfamiliar environments, even to areas with rough terrain. These robots may associate certain terrain patterns with certain actions. A rover robot, for example, might construct a map of the land in front of it based on its visual sensors. If the map shows a very bumpy terrain pattern, the robot knows to travel another way.

B I G D O G

- Developed by Boston Dynamics
- Quadruped robot
  - Walk
  - Run
  - Climbs on rough terrain
  - Carries heavy loads.
- Legs contain sensors, including joint position and ground contact.
- BigDog also features a laser gyroscope and a stereo vision system.
- On-board computer controls locomotion, servos the legs and handles a wide variety of sensors.
- Big Dog's control system manages the dynamics of its behavior to keep it balanced, steer and navigate

CRUSHER

- UGV Funded by **DARPA** and designed by Carnegie Mellon's National Robotics Engineering Center **(NREC).**

- Designed primarily for - **Reconnaissance and Support .**
- Key Features :- Rugged, flexible vehicle that can carry **huge payloads.**
  Navigate autonomously over **extreme terrain.**
  Runs on battery power alone - **silent operation.**
  Can carry weapons - **Combat roles** down the line.

WORKING

- 78hp turbo-diesel engine – GENERATOR.
- Output - continuous 58 kW power.
- Charges Crusher's 300-volt, 18.7-kW, lithium-ion battery pack.
- The batteries in turn run **six** 210-kW electric motors(Each produces 282 hp).
- Regenerative Braking.

Vision

- **8 LADAR units(4h,4v)** - scan area and measures 't' for the REFLECTED beam.

  6 pairs of **stereo-vision cameras** - depth perception .

  4 **color cameras** - apply a color pixel to each point of distance determined by the LADAR sensor.

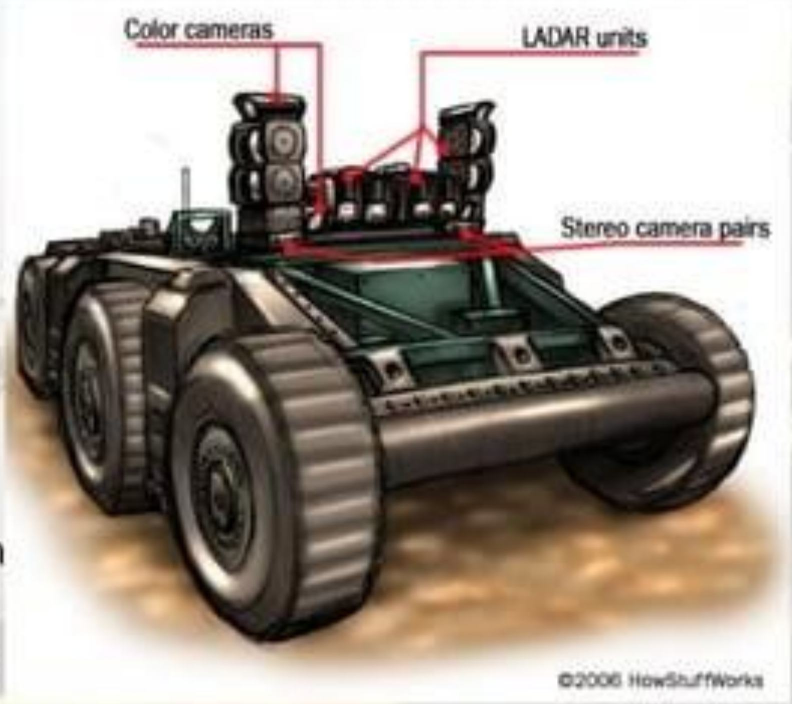
ON-BOARD CPU(700-MHz Pentium 3)

- ✓ Creates a 3-D picture of the landscape in which Crusher is traveling.
- ✓ controls mechanical activities and runs the navigation software .

INERTIAL MEASUREMENT UNIT (IMU)

- ➢ Detects **Crusher's altitude**, position and direction of movement.
- ➢ Combination of accelerometers (tilt sensors) and gyroscopes.

So Crusher is always aware of its own motion and position relative to the landscape.



SPECIFICATIONS

- **Empty vehicle weight**: 13,200 lbs (5,990 kg)
- **Maximum payload**: 8,000 lbs (3,600 kg)
- **Length**: 201 inches (510 cm)
- **Width**: 102 inches (260 cm)
- **Height** :60 inches (152 cm)
- **Ground clearance**: 0 to 30 inches (76 cm
- **Tire diameter**: 49.5 inches (125.7 cm)
- **Top speed**: 26 mph (42 kph) in 7 sec
- **Possible control modes**:
  - Remote control
  - Waypoint-based navigation
  - Full autonomy

Research Challenges

- Reliance on **centrally derived information** may lead to significant problems.
- **Objects in the environment** should be **basic building blocks** of the robot operator for world
- **Time for robotic planning** (path planning, task planning, and mission planning)
- The **operator** has significant and well-defined roles to play even if the robots are highly autonomous, and the **robot and user interfaces** must support these roles.
- **Avoid lethal crossfire situation**
- Utilize **local information** and not rely on a global source
- To navigate in complex indoor or outdoor environments and **build three-dimensional models for manipulation**.

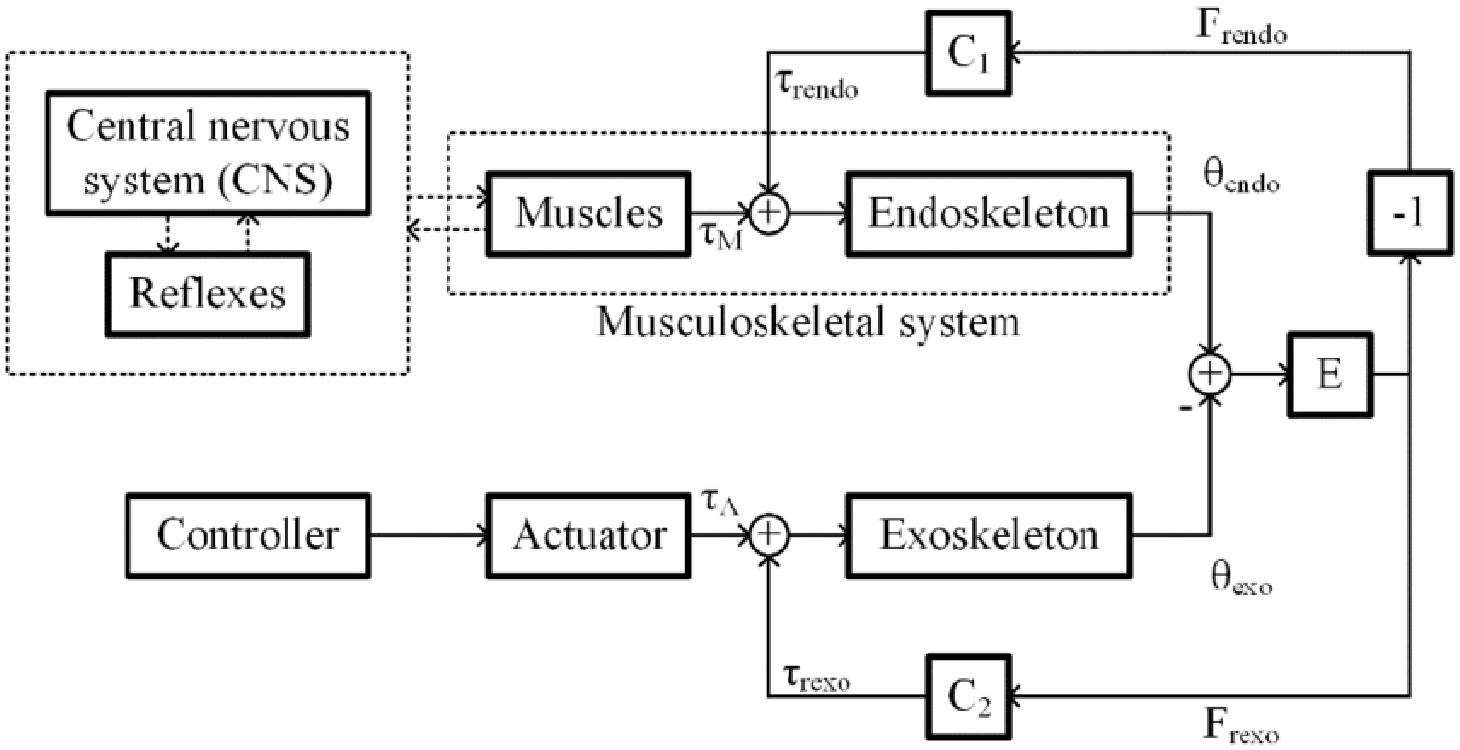
Research Challenges

- **Robust, secure** communication links
- **Safe, long duration, lightweight, power storage**
- **Perception for real-world** navigation and for mission operations
- Approach the performance of a human in performing **dexterous manipulation** of tools, weapons.
- Performing **real-time diagnosis** and **recovery** from anomalous conditions
- Keeping the system **safe**

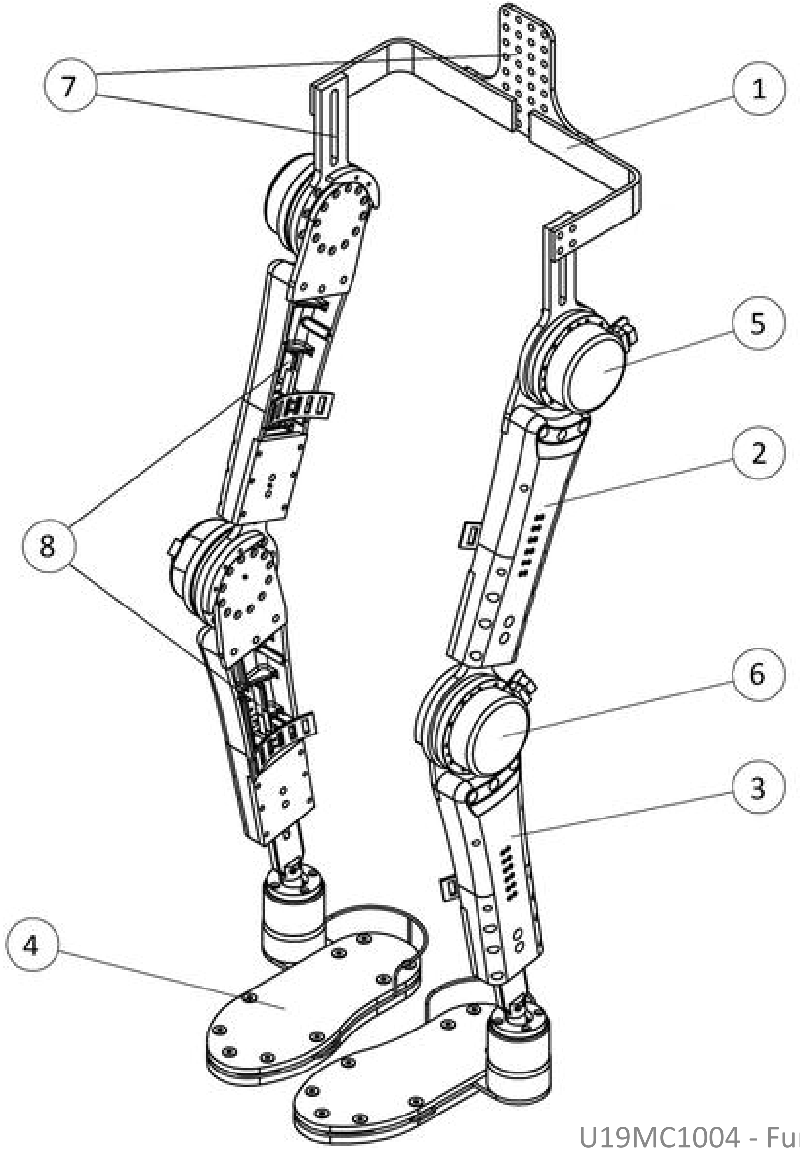
Exoskeleton Robot

Reference : Block Diagram

- https://www.researchgate.net/publication/332044978_Comparison_of_Control_Algorithms_Using_a_Generalized_Model_for_a_Human_with_an_Exoskeleton

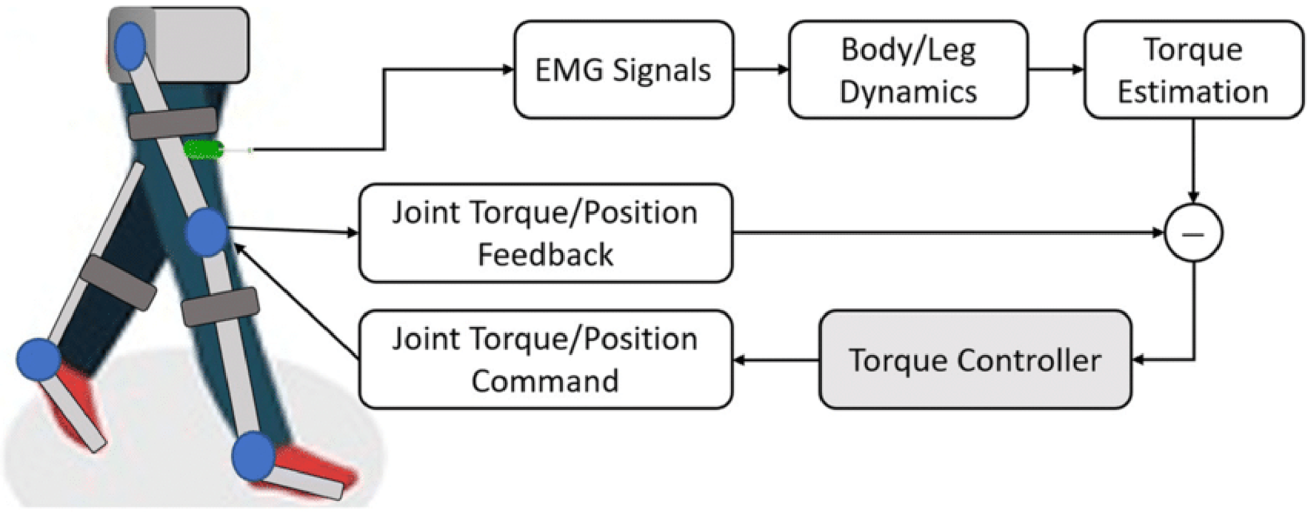


Lower Limb Exoskeleton

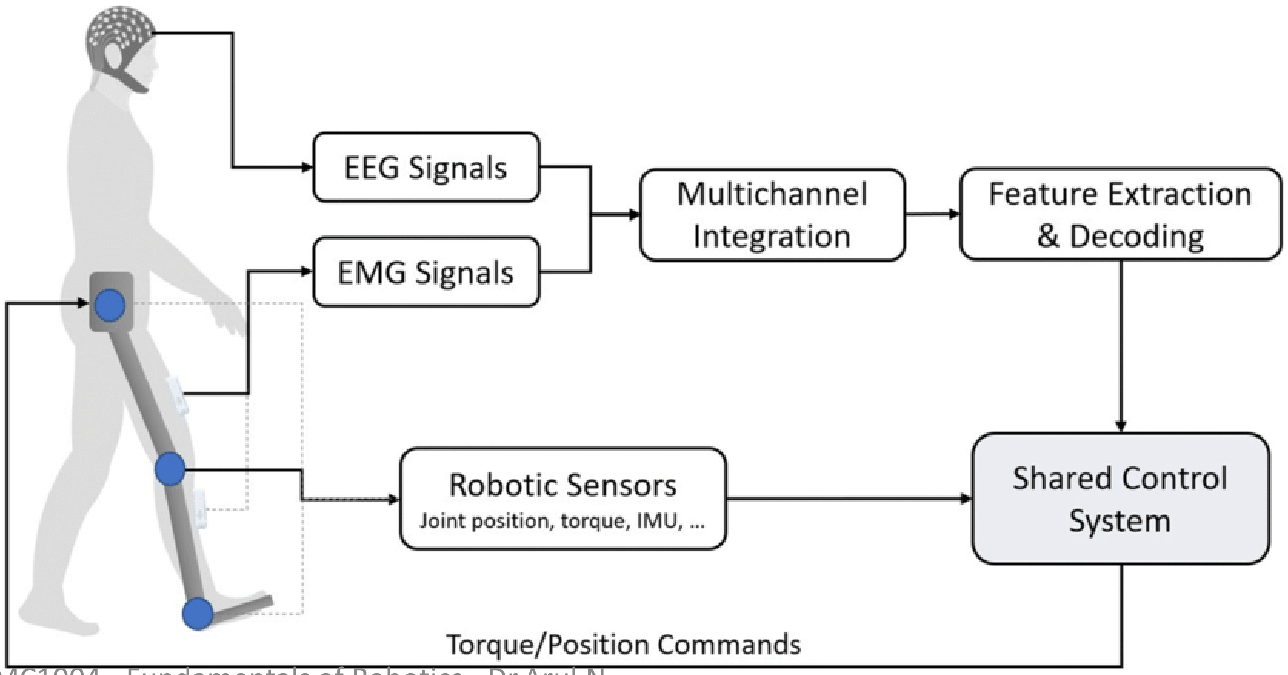


1. Waist
2. Upper Leg
3. Lower Leg
4. Foot
5. Hip Actuator
6. Knee Actuator
7. Waist Adjustment Mechanisms
8. Leg Adjustment Mechanisms

https://www.researchgate.net/figure/Lower-limb-exoskeleton-control-scheme-a-Joint-torque-contro
system-based-on-cognitive_fig5_343577783



(a)



(b)

Telerobotics

- Telerobotic devices are typically developed for situations or environments that are too dangerous, uncomfortable, limiting, repetitive, or costly for humans to perform.

- Academies Press. https://doi.org/10.17226/4761.

Underwater: inspection, maintenance, construction, mining, exploration, search and recovery, science, surveying.

Space: assembly, maintenance, exploration, manufacturing, science.Resource industry: forestry, farming, mining, power line maintenance.

Process control plants: nuclear, chemical, etc., involving operation, maintenance, decommissioning, emergency.

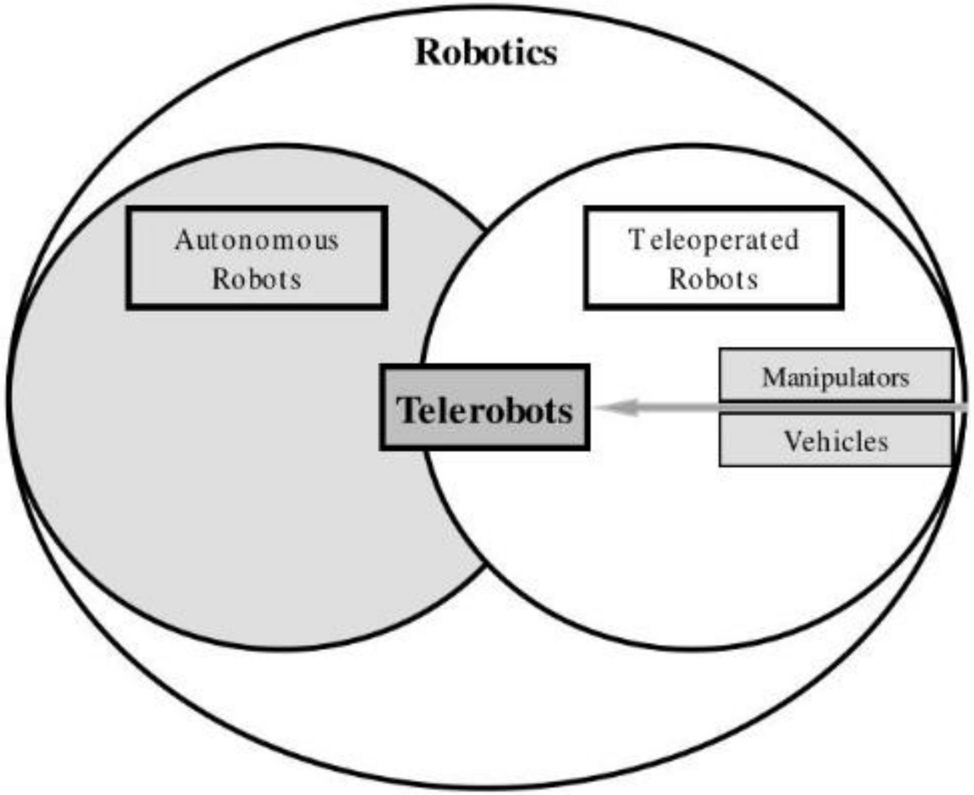
Reality: Scientific and Technological Challenges.

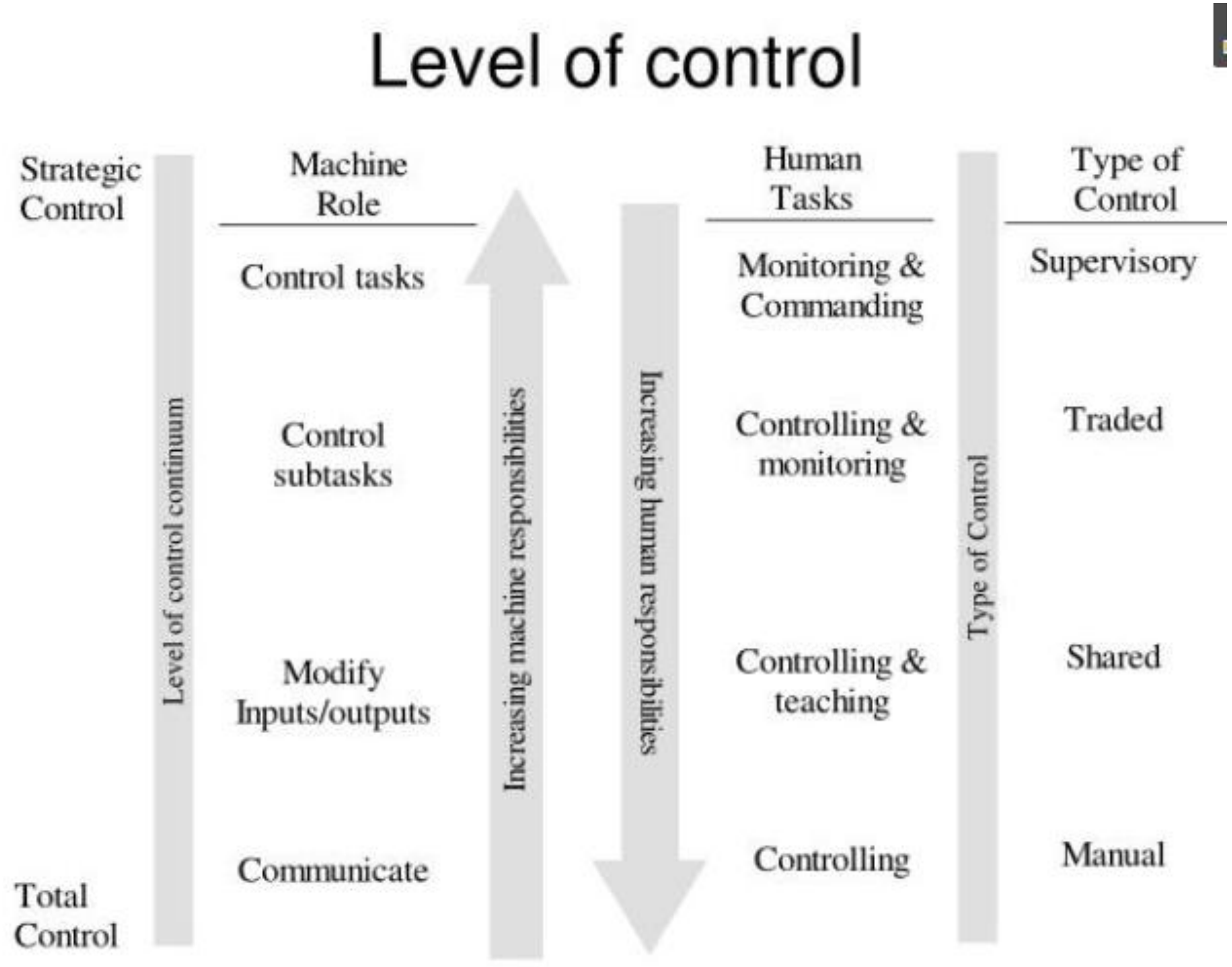
Military: operations in the air, undersea, and on land.

Medical: patient transport, disability aids, surgery, monitoring, remote treatment.

Construction: earth moving, building construction, building and structure inspection, cleaning and maintenance.

Civil security: protection and security, firefighting, police work, bomb


Robotics
Autonomous
Robots
Teleoperated
Robots
Manipulators
Telerobots
Vehicles



As we want machines to do more complex things and have more control, the human role changes from directly doing the work to teaching, monitoring, and guiding the machines.

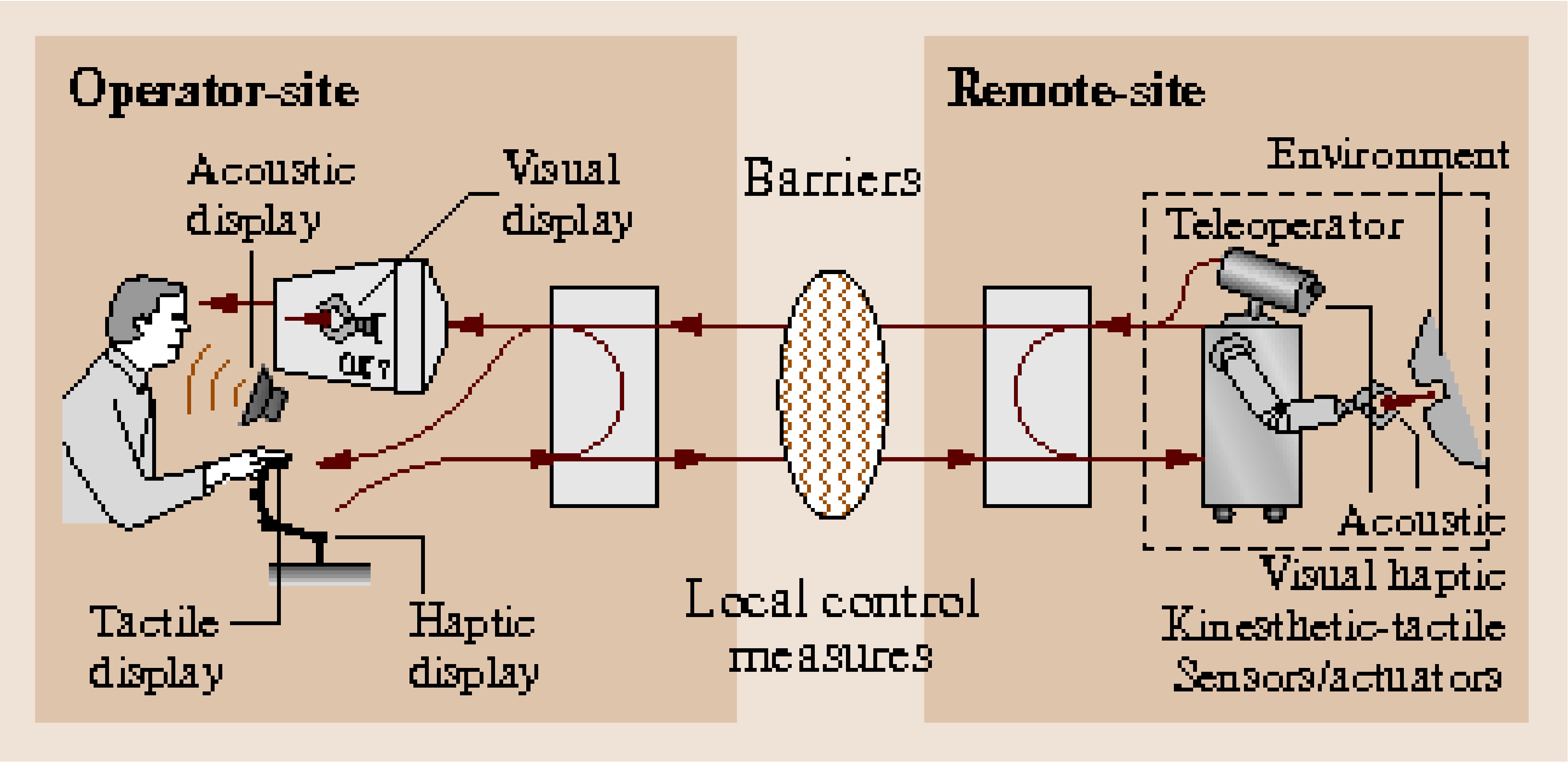
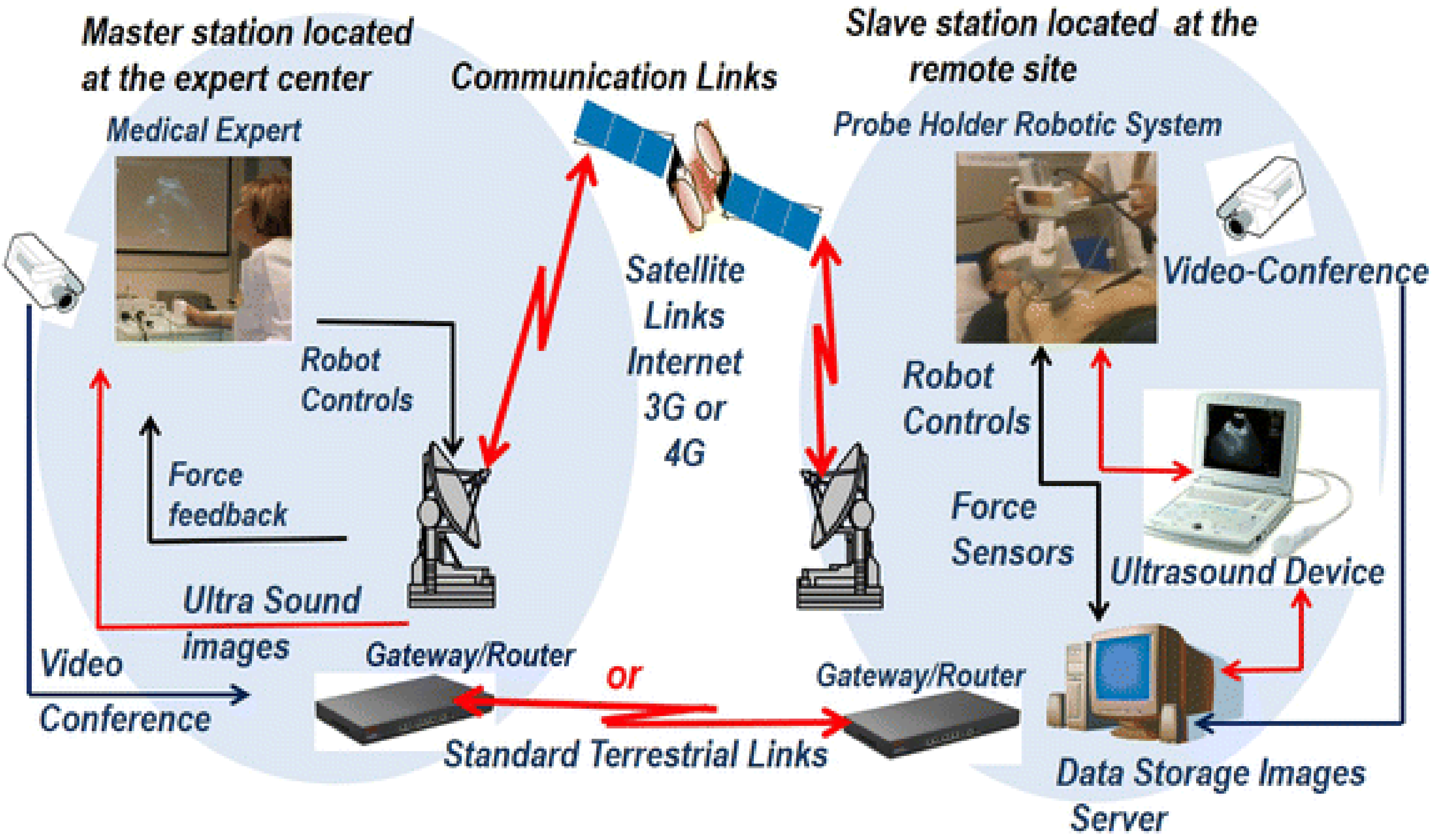

Operator-site
Acoustic display
Visual display
Barriers
Remote-site
Environment
Teleoperator
Acoustic
Visual haptic
Kinesthetic-tactile
Sensors/actuators
Tactile display
Haptic display
Local control measures

Illustration of a Medical telerobot



- https://www.researchgate.net/publication/239784016_ROBOT_TASK_SPACE_ANALYZER_INTEGRATION_AND_TESTING