AUTONOMOUS MOBILE ROBOT (AGV) / AUTONOMOUS GUIDED VEHICLE (AMR)

Muhammad Faqiihuddin bin Nasary

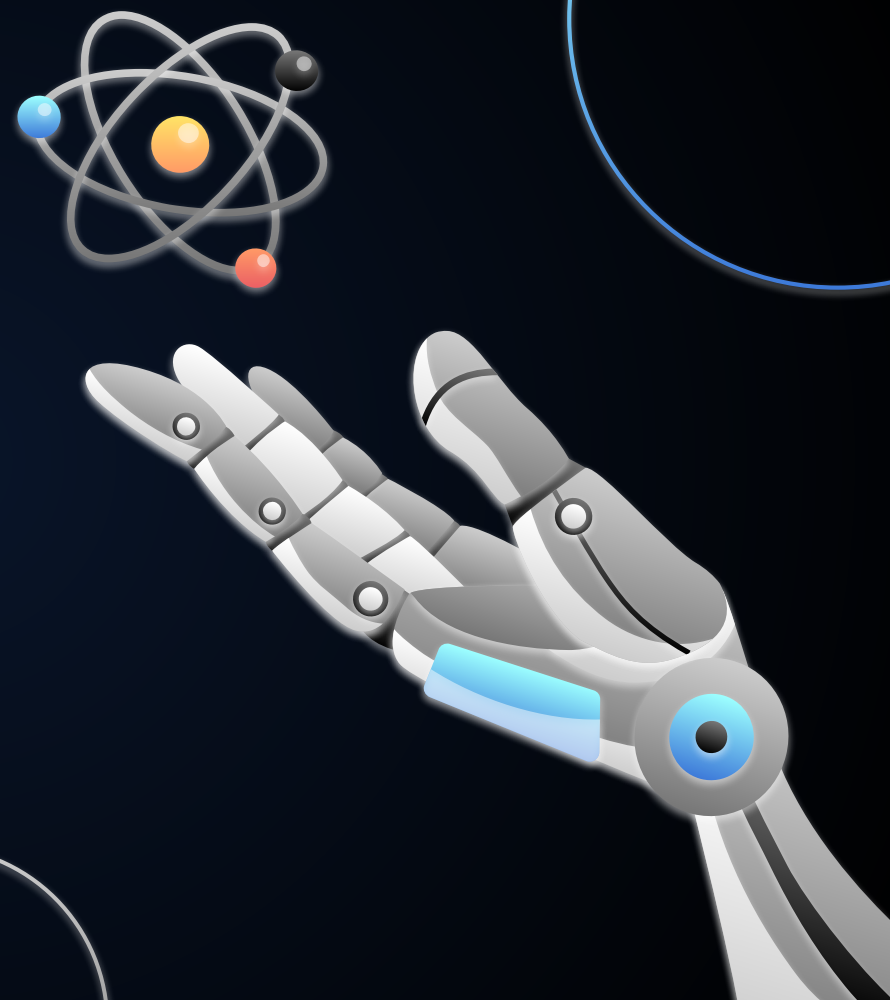
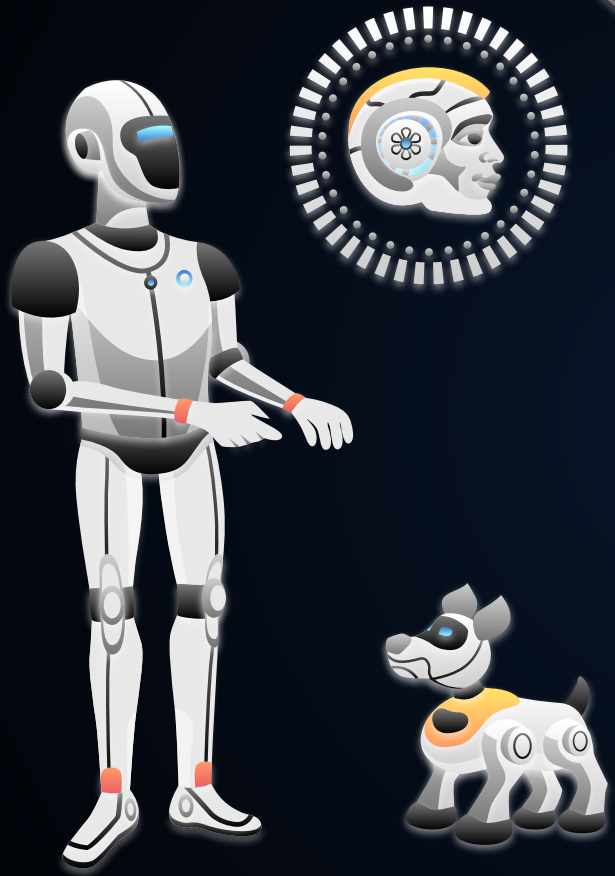


TABLE OF CONTENTS



INTRODUCTION

AGVs and AMRs are advanced robotic systems that operate autonomously to navigate, transport materials, and perform tasks without human intervention. AGVs focus on guided vehicle movements, while AMRs excel in mobile autonomy, collectively revolutionizing industries by providing efficient and automated solutions for material handling and logistics operations.

AUTONOMOUS GUIDED VEHICLES (AGV)

- Autonomous Guided Vehicles (AGVs) are advanced robotic systems designed to navigate and transport materials or goods without human intervention.
- AGVs are equipped with sensors, control systems, and onboard computers that enable them to perceive their environment and make intelligent decisions regarding their path, speed, and actions.
- These vehicles are widely used in industries such as manufacturing, logistics, warehousing, and healthcare to automate material handling tasks and improve efficiency.
- AGVs are capable of navigating through predefined routes, avoiding obstacles, and interacting with their surroundings using various technologies like vision systems, laser scanners, and proximity sensors.

AUTONOMOUS MOBILE ROBOT (AMR)

- Autonomous Mobile Robots (AMRs) are sophisticated robotic systems that can independently navigate and perform tasks in dynamic environments without human guidance.
- AMRs utilize a combination of sensors, algorithms, and onboard computing to perceive their surroundings, plan their paths, and execute various tasks.
- These robots are employed in industries such as manufacturing, logistics, and healthcare to automate material handling, transportation, and other repetitive tasks.
- AMRs are equipped with sensors like lidar, cameras, and proximity sensors to accurately detect and avoid obstacles, ensuring safe and efficient navigation.

02

HISTORY
OF AGV & AMR

HISTORY OF AGV & AMR

1953	1987
In 1953, the first AGV, named "Magnetohydrodynamic AGV," was developed by Ralph R. Mosher at the Oak Ridge National Laboratory in the United States. It utilized magnetic fields to propel and guide the vehicle along a predetermined track. This marked the beginning of AGV technology.	In 1987, the Stanford Cart, a pioneering autonomous mobile robot, was introduced by the Stanford Artificial Intelligence Laboratory. This self-navigating robot utilized laser range finders and computer vision to perceive its environment and autonomously plan its path, paving the way for future developments in AMR technology.

HISTORY OF AGV & AMR

1990	2003
The year 1990 witnessed the introduction of the FROG (Free Roaming On Grid) system developed by Frog AGV Systems in Germany. FROG was the first commercial AGV system that combined computer-controlled vehicles with an automated traffic control system, enabling efficient and safe material transportation in industrial settings.	In 2003, Kiva Systems (now known as Amazon Robotics) was founded, bringing a significant advancement in AMR technology. Kiva's innovative robots were designed for warehouse automation, capable of autonomously navigating, retrieving, and delivering inventory,

HISTORY OF AGV & AMR

2012	2016
The launch of the Autonomous Transport System (ATS) by Swisslog in 2012 marked a milestone in AGV technology. ATS introduced fleet management software and advanced navigation capabilities, allowing AGVs to dynamically plan routes, optimize workflows, and adapt to changing production environments.	In 2016, Boston Dynamics introduced "Handle," a highly agile and mobile robot with wheels and legs, showcasing the versatility of AMRs. Handle demonstrated the capability to maneuver through various terrains and environments, highlighting the potential for agile and adaptable robotic systems.

02

APPLICATION OF AGV & AMR

APPLICATION

Manufacturing Industry

AGVs and AMRs are extensively used in manufacturing facilities for material handling, assembly line operations, and inventory management, improving efficiency and reducing human intervention.

Logistics and Warehousing

AGVs and AMRs streamline the movement of goods within warehouses and distribution centers, optimizing picking, sorting, and transportation processes, leading to enhanced productivity and accuracy.

APPLICATION

Healthcare Facilities

AGVs and AMRs play a crucial role in healthcare settings by autonomously delivering medications, supplies, and medical equipment, ensuring timely and efficient delivery while minimizing human contact.

Retail and E-commerce

AGVs and AMRs are utilized in retail and e-commerce warehouses for order fulfillment, inventory management, and stock replenishment, enabling faster and more accurate order processing.

APPLICATION

Airport Operations

AGVs and AMR are employed in airports for baggage handling, luggage transportation, and aircraft maintenance, improving operational efficiency and reducing manual labor requirements.

Food and Beverage Industry

AGVs and AMR automates material handling and logistics processes in food processing and beverage production facilities, ensuring safe and efficient movement of ingredients and finished products.

04

MAIN COMPONENTS

MAIN COMPONENTS

AGV
DESIGN

LOCOMOTION
SYSTEM

NAVIGATION &
CONTROL SYSTEM

DATA
COLLECTION

DATA
TRANSMISSION

POWER
MANAGEMENT

01 AGV DESIGN

UNIT LOAD AGVS

Designed to transport individual items or loads within a facility autonomously, enhancing material handling efficiency.

TUGGER AGV

Used for towing or pulling multiple carts or trailers, facilitating the movement of heavy loads across the facility.

ASSEMBLY LINE AGV

Operates within assembly lines to deliver components and materials to specific workstations, ensuring a smooth and efficient production process.

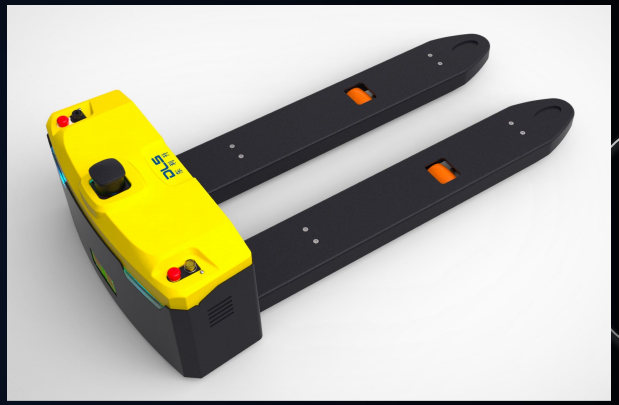
01 AGV DESIGN

FORKLIFT AGVS

Equipped with forklift mechanisms, these AGVs handle palletized loads, autonomously picking up, transporting, and placing them in designated locations.

CONVEYOR AGV

Works in conjunction with conveyor systems to transfer goods between different areas of a facility, optimizing material flow and reducing manual handling.



PALLET HANDLING AGV

Specialized in handling palletized loads, these AGVs autonomously transport and stack pallets, enhancing warehouse and distribution operations.

02 LOCOMOTION SYSTEM

Wheel-based

AGVs that utilize wheels for locomotion, providing versatile movement and enabling efficient navigation in a variety of environments.

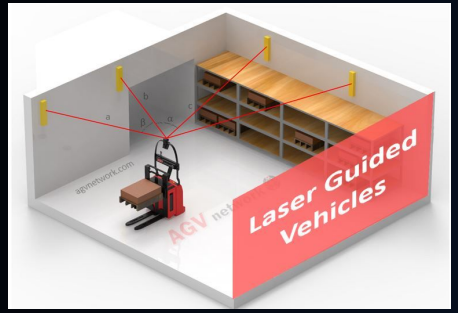
Track-based

Equipped with tracks for locomotion, offering enhanced stability and traction in rugged or uneven terrains.

Magnetic-guided

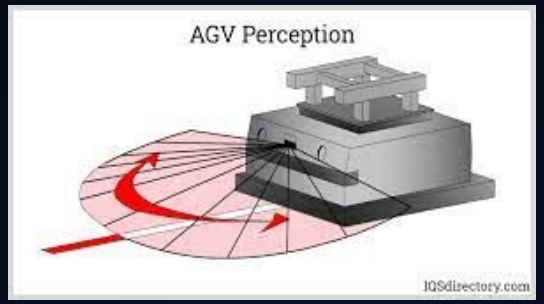
Rely on magnetic markers embedded in the floor for navigation, ensuring precise and repeatable movement along predetermined paths.

02 LOCOMOTION SYSTEM



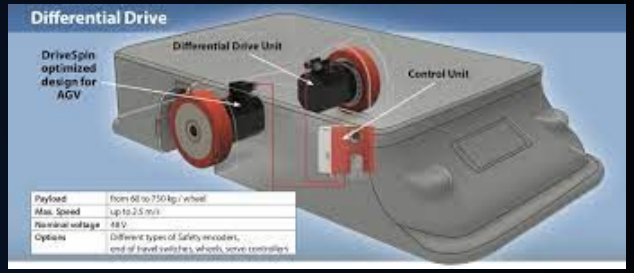
Laser-guided

Employ laser sensors to detect and navigate within their surroundings, allowing for accurate positioning and obstacle avoidance.



Vision-guided

Utilize advanced vision systems, such as cameras and image processing algorithms, to perceive their environment and navigate autonomously based on visual cues.



Differential Drive

Enabling agile and efficient maneuverability by controlling the speed and direction of individual wheels or tracks.

02 LOCOMOTION SYSTEM

Omnidirectional Drive

Equipped with omnidirectional wheels or holonomic drive systems, granting them the ability to move in any direction and perform precise maneuvers.

Legs Locomotion

Designed with legged locomotion systems, mimicking human or animal movements, enabling them to traverse challenging terrain and navigate complex environments.

Hybrid

Combine multiple locomotion systems, such as wheeled and legged or tracked and wheeled, for increased flexibility and adaptability in various operating conditions.

03 NAVIGATION & CONTROL SYSTEM

MAGNETIC TAPE

Follow a predefined path marked by magnetic tape on the floor, providing reliable and accurate navigation for repetitive tasks.

NATURAL FEATURE

Utilize natural features in the environment, such as walls or landmarks, to navigate and determine their position autonomously.

03 NAVIGATION & CONTROL SYSTEM

RFID

Equipped with RFID tags and readers, enabling precise localization and tracking of the AGV within the facility for efficient navigation and coordination.

OPTICAL GUIDANCE

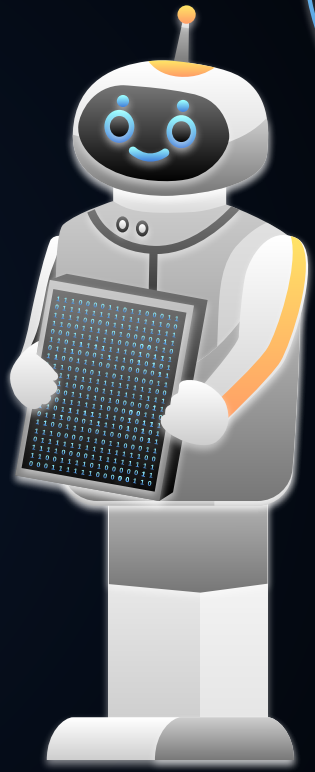
Utilize optical sensors and markers, such as barcode or QR code readers, to navigate and follow designated paths or instructions within the environment.

MAP-BASED

Use prebuilt maps or digital representations of the environment, combining sensor data and algorithms to navigate and plan optimal routes for efficient and safe movement.

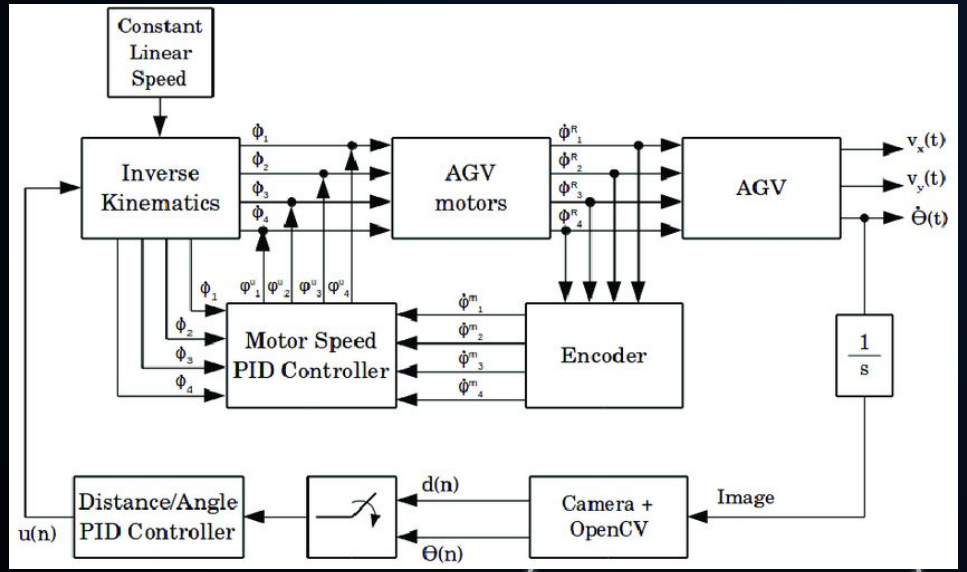
CONTROL THEORY

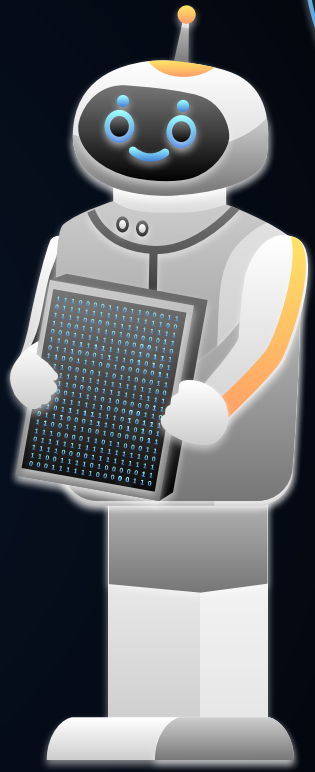
- Control theory in AGV and AMR involves designing algorithms and systems that govern the behavior and movement of these robotic vehicles.
- It encompasses aspects such as trajectory planning, path following, obstacle avoidance, and coordination with other vehicles or systems.
- The control theory aims to optimize performance, efficiency, safety, and adaptability of AGVs and AMRs, ensuring reliable and precise operation in diverse environments and tasks.



CONTROL SYSTEM

- The control system in AGV and AMR encompasses the hardware and software components that govern the vehicle's motion, perception, decision-making, and communication.

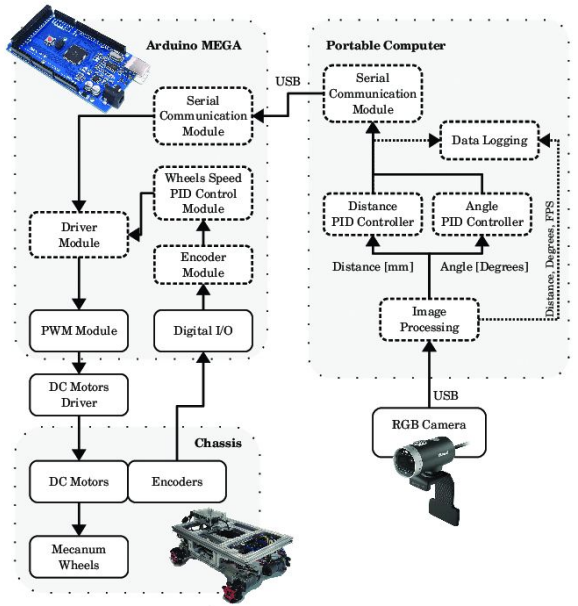




SYSTEM ARCHITECTURE

- The system architecture involves the arrangement and integration of sensors, actuators, controllers, and communication interfaces, enabling seamless coordination and operation of the AGV or AMR within its environment.

ication protocol. Figure 6 summarizes the architecture.



04 DATA COLLECTION

GPS

Utilizes satellite signals to provide precise positioning and navigation information for accurate localization and route planning.

1

LIDAR

Uses laser beams to create detailed 3D maps of the surrounding environment, allowing for accurate obstacle detection, localization, and mapping.

2

3

ULTRASONIC

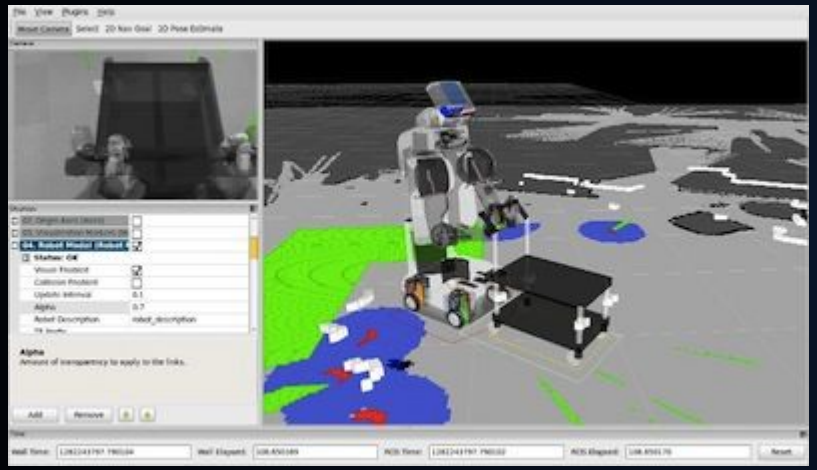
Emits sound waves and measures the time it takes for the waves to bounce back, enabling proximity sensing and obstacle detection for safe navigation.

4

INFRARED

Detects infrared radiation emitted or reflected by objects, enabling proximity sensing, object detection, and ambient light level measurement in various operating conditions.

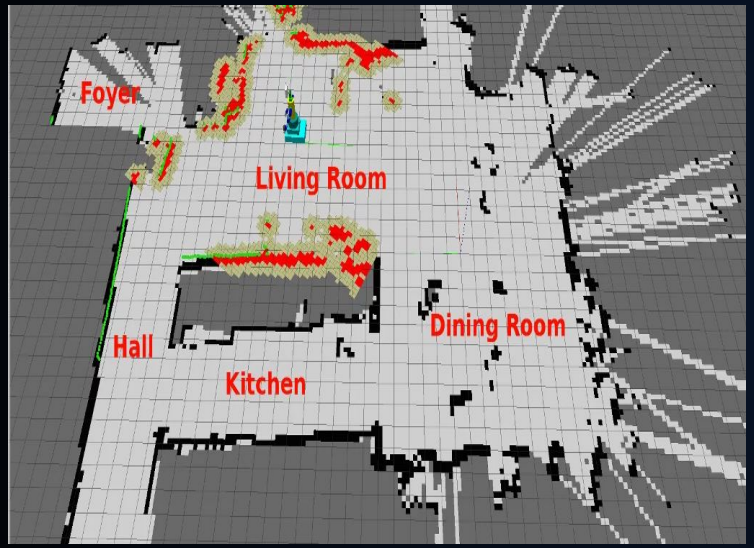
04 DATA COLLECTION (SOFTWARE)



ROS (ROBOT OPERATING SYSTEM)

Open-source software framework that provides a set of tools and libraries for AGV communication, control, and integration, allowing for interoperability and collaboration among different robotic systems.

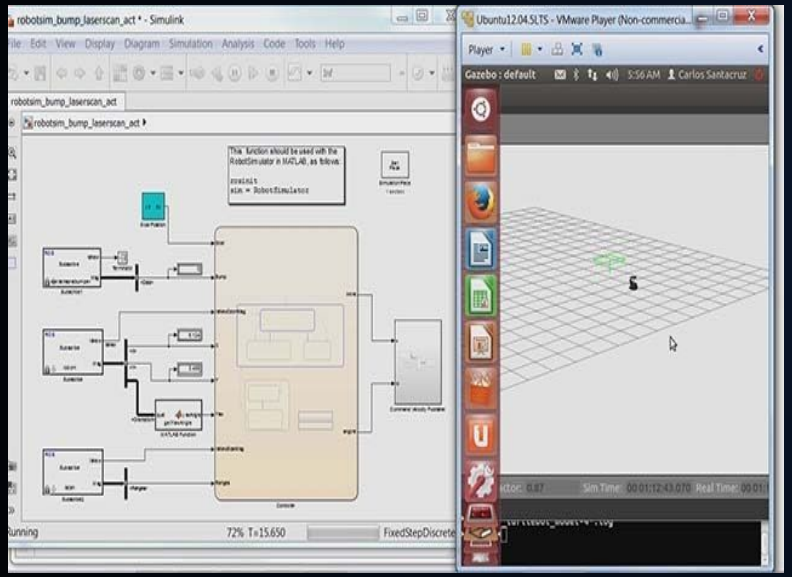
04 DATA COLLECTION (SOFTWARE)



SLAM (Simultaneous Localization and Mapping)

Algorithmic technique used by AGVs to create maps of their environment while simultaneously localizing themselves within the map, enabling autonomous navigation and exploration.

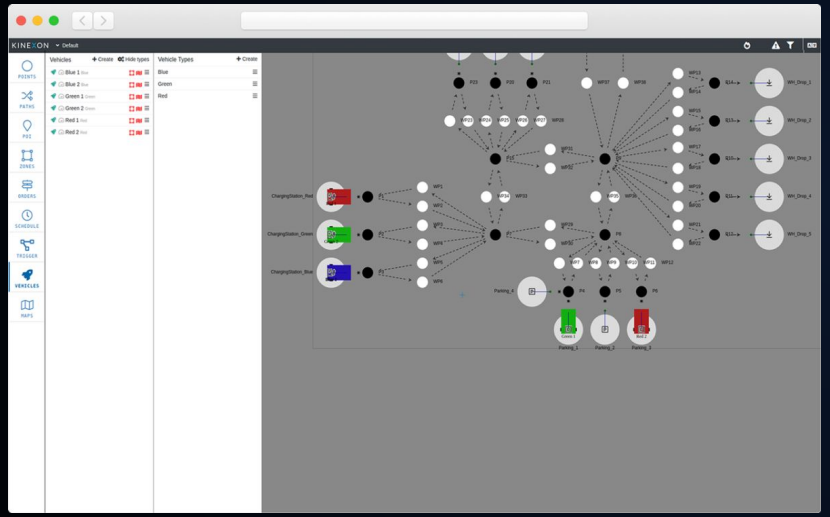
04 DATA COLLECTION (SOFTWARE)



MATLAB

Data collection software that enables advanced data analysis, modeling, and simulation for AGVs, facilitating algorithm development and system optimization.

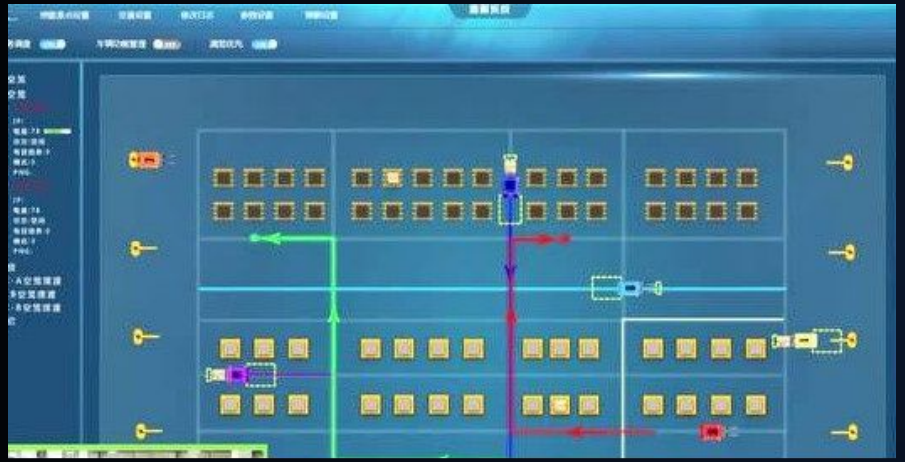
04 DATA COLLECTION (SOFTWARE)



AGV FLEET MANAGEMENT

Software system that manages and coordinates a fleet of AGVs, optimizing task allocation, route planning, and resource utilization for efficient and synchronized operation.

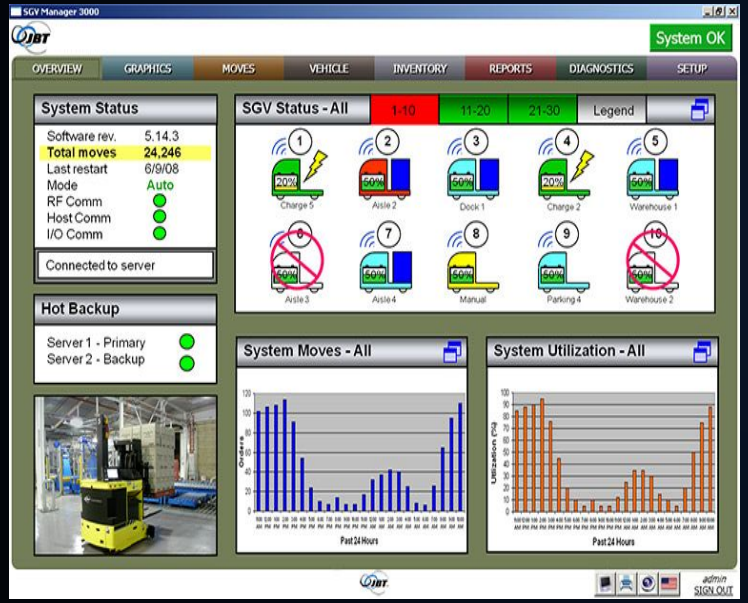
04 DATA COLLECTION (SOFTWARE)



PERFORMANCE MONITORING

Software mechanism that collects, analyzes, and presents real-time data about AGV performance metrics, such as speed, efficiency, and error rates, allowing for continuous monitoring and optimization of operations.

04 DATA COLLECTION (SOFTWARE)



INTEGRATION SOFTWARE

Software tools and frameworks that facilitate the seamless integration and communication between AGVs and other systems, such as warehouse management systems or automation control systems, ensuring efficient interoperability and coordination.

05 DATA TRANSMISSION

WIRELESS

- Utilizes wireless communication protocols, such as Wi-Fi or Bluetooth, for seamless and flexible connectivity between the AGV and other systems.

WIRED

- Relies on physical wired connections, such as Ethernet cables or USB connections, ensuring reliable and high-speed data transfer between the AGV and external devices.

ETHERNET

- Utilizes Ethernet protocol for fast and reliable communication, enabling real-time data exchange and control commands between the AGV and the network infrastructure.

CAN BUS

- Utilizes Controller Area Network (CAN) protocol for robust and efficient communication between various devices within the AGV system, allowing for synchronized data exchange and control signals.

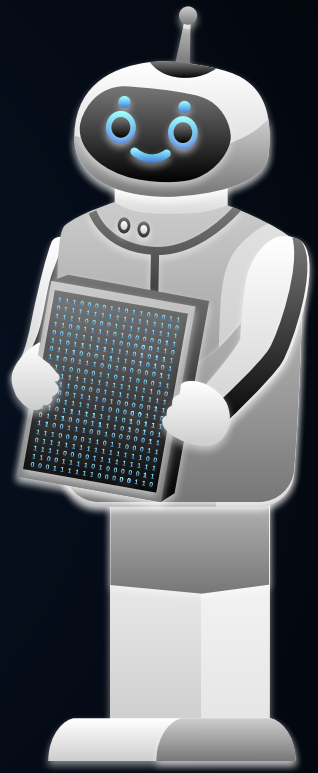
06 POWER MANAGEMENT

1) BATTERY

Utilizes rechargeable batteries as a primary energy source, providing mobility and flexibility while requiring periodic recharging.

2) FUEL CELL

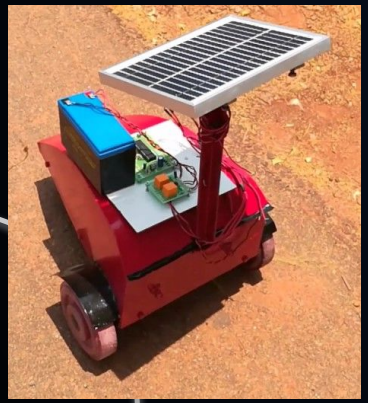
Employs fuel cells to convert hydrogen or other fuels into electricity, offering longer operating durations and quick refueling capabilities.



06 POWER MANAGEMENT

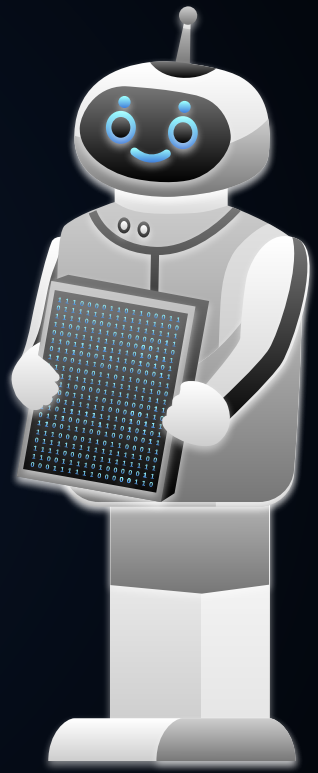
3) PLUG-IN

Relies on plugging into external power sources, allowing for continuous operation without the need for onboard energy storage.



4) SOLAR

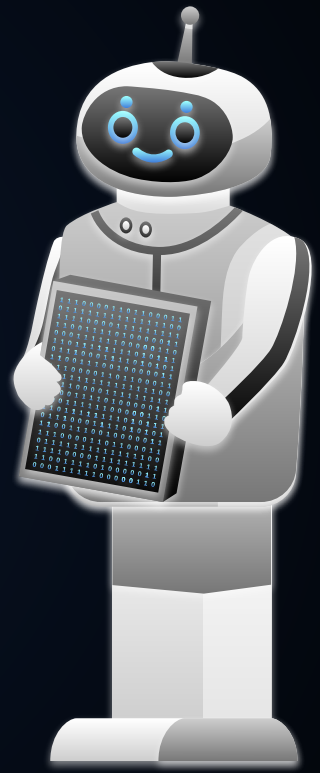
Harnesses solar energy through photovoltaic panels, providing sustainable and renewable power to supplement or recharge the onboard energy storage.



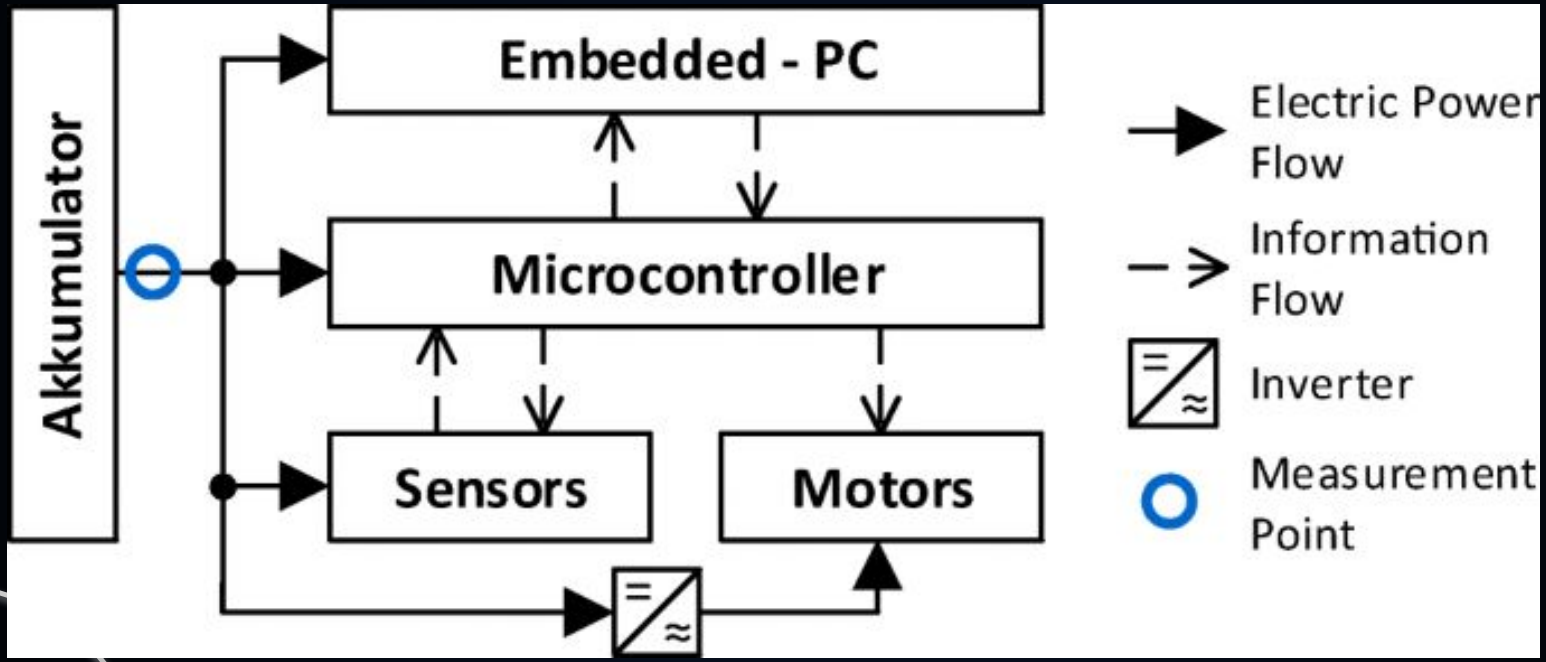
06 POWER MANAGEMENT

5) HYBRID

Combines multiple power sources, such as batteries and fuel cells, to optimize energy utilization, enhance performance, and extend operating durations.



06 POWER MANAGEMENT



06 POWER MANAGEMENT