Mobile robots

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Abstract: *This work focuses on mobile robots,which are in many intralogistics operations like manufacturing, warehousing, cross-docks, terminals and hospital. Big attention is dedicated to wheeled mobile robots, which help human on daily tasks and work autonomously.*

Keywords: *Mobile robots, Wheeled mobile robots, Types of robot control, Wheels types, Distribution of robots*

1 Introduction

Mobile robots are devices, which move from one place to another to complete their goals autonomously (without external human help). Mobile robots are used in a wide range of applications including in factories (automated guided vehicles or AGVs), for military operations (unmanned ground reconnaissance vehicles), in healthcare (pharmaceutical delivery), for search and rescue, as security guards, and in homes (floor cleaning and lawn mowing). Their advanced hardware and control software allow autonomous operations in dynamic environments. Compared to an automated guided vehicle (AGV) system in which a central unit takes control of scheduling, routing, and dispatching decisions for all AGVs, AMRs can communicate and negotiate independently with other resources like machines and systems and thus decentralize the decision-making process. AGVs are most often used in industrial applications to move materials around a manufacturing facility or a warehouse. Typical AGV types, as shown on a picture 1, are tuggers (AGVs that pull carts), unit loaders (AGVs with onboard roller tables for parts-tray transfers), and fork trucks (robots similar to manual fork trucks)[1, 2, 3].

Picture 1: tugger on the left and unit load on the right [1]

2 Distribution

Robots can mainly walk, roll, jump, run, slide, skate, swim, and fly. According to their locomotion system, mobile robots can be classified into the following major categories:

- Stationary (arm/manipulator)
- Land-based
- Wheeled mobile robot (WMR)
- Walking (or legged) mobile robot
- Tracked slip/skid locomotion
- Hybrid
- Air-based
- Water-based
- Other

Each system has its own advantages and disadvantages. In next part is dedicated to wheeled mobile robots[4].

2.1 Wheeled mobile robot

Is a robot, which uses wheels for travelling to specific location. Wheels are one of the most important systems for robot locomotion, and autonomous intelligent vehicles (AIVs) are part of a challenging research field in mobile robotics in transport, logistics, and distribution. The use of wheels is simpler than using treads or legs and is easier to design, build, and program when the robot is moving on flat, nonrugged terrain. Some of advantages are that its cheaper,less complex and they cause less wear and tear on the surface, no problem with balance issues. The main disadvantage of wheels is that they are not very good at navigating over obstacles, such as rocky terrain, sharp surfaces, or areas with low friction. Existing four wheel types[2, 5]:

- Standard wheel: two degrees of freedom; rotation around the (motorized) wheel axle and the contact point.
- castor wheel: two degrees of freedom; rotation around an offset steering joint.
- Swedish wheel: three degrees of freedom; rotation around the (motorized) wheel axle, around the rollers, and around the contact point.
- Ball or spherical wheel: realization technically difficult

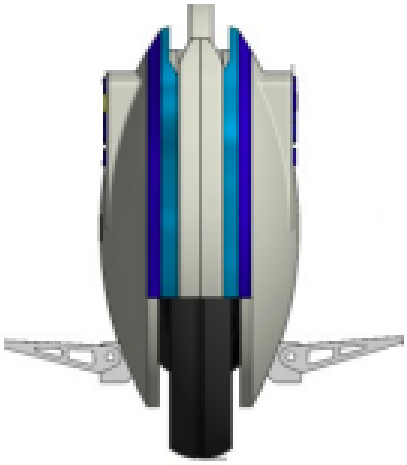
Wheeled mobile robots has different drive type to get to their location. The most common for wheeled mobile robots are[4, 6, 7, 8]:

- Differential drive which is consisted of two fixed wheels on both sides of the robot. one or two passive castor wheels are used for balance and stability. It is the simplest mechanical drive which doesnt rotation. it turns only if one wheel is faster than other one and go straight if both have same speed
- Synchro drive has three or four wheels and all of them rotate in the same direction with same speed. This type cannot drive and rotate at the same time.

- Tricycle or car-like drive has one wheel. For stability got 2 fixed wheels. This type cannot turn on the spot but it can take position of 90° and rotate.
- Omnidirectional steering is obtained of three + wheels. WMR with three wheels can do 90° roller angle with universal wheels. Four wheels are seperated on 2 left handed wheels and 2 right handed wheels and one of them can do 45° and other -45°.

Wheeled mobile robots can be classified as:

- Single-wheeled robots Single-wheeled robots which is Unicycle robot with one fixed or conventional wheel. The unicycle system is an inherently unstable system. Both longitudinal and lateral stability controls are needed simultaneously to maintain the unicycle's posture. Segways can also be considered a self-balancing, one-wheeled robot [4, 9].

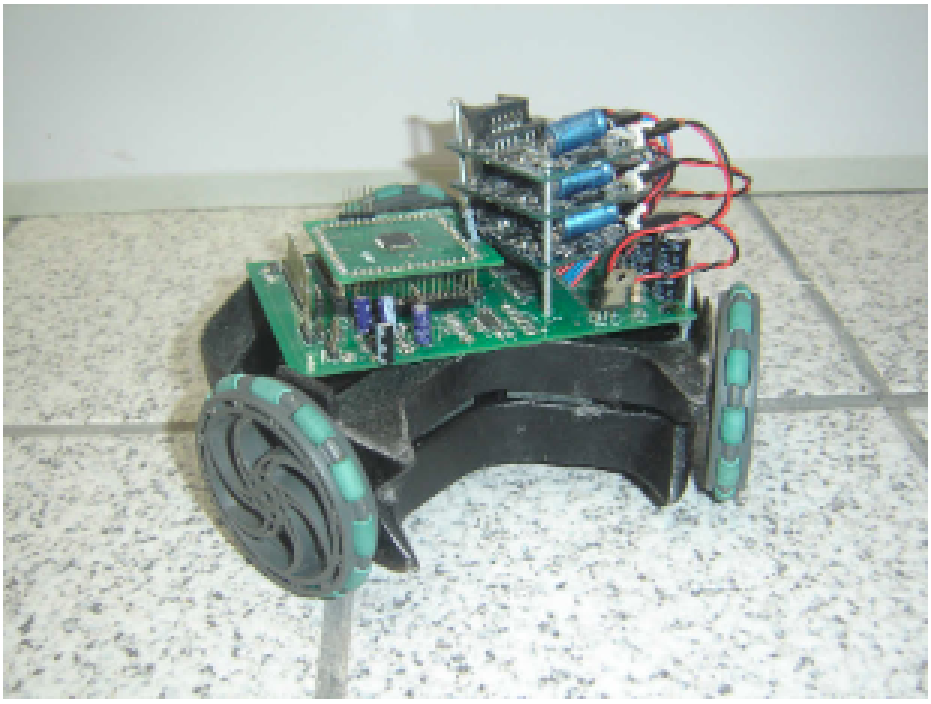


Picture 2: Self balancing one-wheel vehicle(Segway)[9]

- Two-wheeled robots have parallel and conventional wheels controlled by two independent actuators It is also considered that every wheel is perpendicular to the ground and the contact between the wheels and the ground is nonslipping and pure rolling. The Roomba vacuum cleaner is a two-wheeled robot. It utilizes a contact sensor at the front and an infrared sensor on top [4, 10].

Picture 3: Roomba vacuum[10]

- Three-wheeled robots can be seperated into two types. First one is differentially steered (two driven wheels with an additional free turning wheel to maintain the vehicle in balance) and second is two wheels driven by a single actuator and a driven steering for the third wheel [4, 11].



Picture 4: a Three Wheeled Omnidirectional Robot[11]

- Four-wheeled robots are more stable than the three-wheeled counterpart, because the center of gravity (COG) is located inside the rectangle formed by the four wheels rather than a triangle. The wheels can be differentially steered two-by-two powered wheels or can have car-like steering. They are acquiring a great importance in transports, logistics, food industry, and food processing. Interesting example is Centaur which combines the sophisticated upper body dexterity of NASA's humanoid, Robonaut, with a rugged and versatile four-wheeled base. This combination allows for robotic use of human tools and interfaces in remote locations by incorporating design improvements to the existing Robonaut that target the challenges of planetary field work[4, 12].

Picture 5: Centaur: NASA's Mobile Humanoid Designed for Field Work[12]

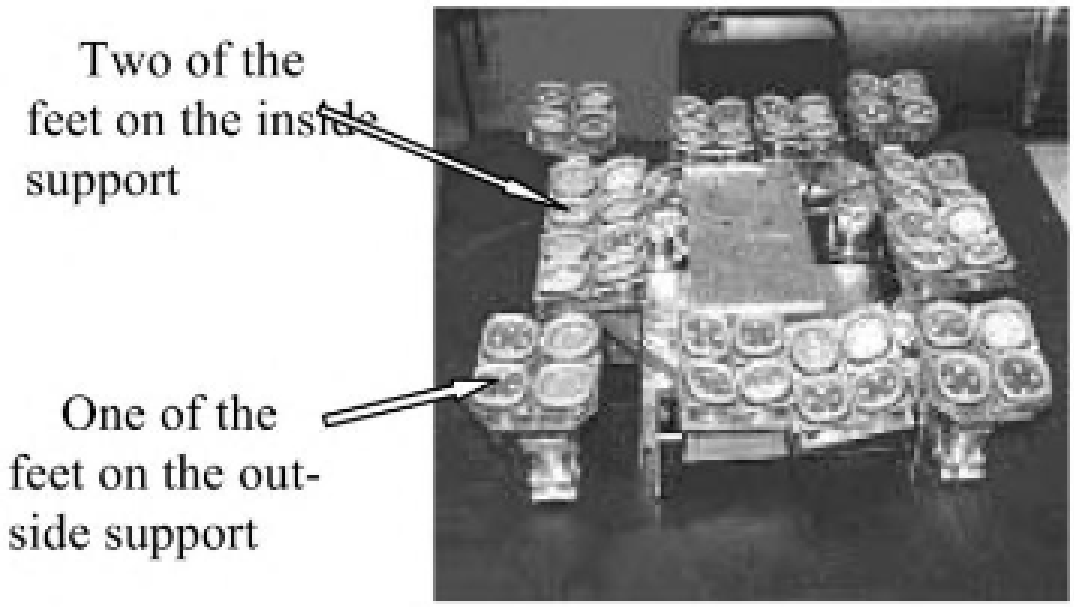
- Five-wheeled robots are designed to move through outdoor rough terrains since they improve the contact and stability. LNAI 6424 is first proposed an innovative asymmetrical prototype of a five-wheeled robot(WMR) with reconfiguration features which can overcross the obstacles and climb on slope[4, 13].

Picture 6: Prototype of a Five-Wheeled Robot[13]

- Six-wheeled robots are steered by synchronizing the speed difference of the bogie wheels and the steering of the front and rear wheels. This fact enables for high-precision maneuvers and revolving instantly with minimum skid/slip of the four center wheels. The utilization of parallel revolute joints for the front wheel and the bogies produces a virtual center of rotation (COR) at the level of the wheel axis. This guaranties climbing abilities and maximum stability, even for very low friction coefficients between the ground and the wheel. Example of Six-wheeled robot is Curiosity which has a suspension system which keeps all six wheels in contact with the surface and helps them go over slopes and sandy terrain. Good control is needed to avoid slipping[4, 14].

Picture 7: Curiosity[14]

- More than six wheels is for example The Octopus robot which is a WMR that is able to deal with obstacles autonomously on rough terrain without getting stuck. It is equipped with tilt sensors and tactile wheels[4, 15].



Picture 8: The Octopus robot[15]

3 Conclusion

Main goal was familiarization with mobile robots and their distribution. Major attention was paid to wheeled mobile robots which are used in industrial applications for example to move materials around a manufacturing facility or a warehouse. Split of the wheeled mobile robots was discussed and their type of drives. At the end was talked about n numbers of wheels and some examples of them.

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