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# The Research Overview of Mobile Robot Core Technology

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## Abstract

**As an important branch of robotics, mobile robot is a comprehensive system, which can perceive the environment and has the functions of decision-making, planning, behavior control, execution, etc. With the continuous progress of science and technology, the performance of mobile robots has gradually improved, and they have been widely used in military, industrial, exploration, medical and other fields. The research on mobile robots has also developed to a new stage, and has become one of the largest research focuses in the robot field. In this paper, the core technologies and future prospects of mobile robots are comprehensively discussed, focusing on mobile robot computing architecture, environment awareness, map creation and path technology.**

## Keywords

**Mobile Robot; Path Planning; End-edge-cloud Coordination; Map Building; Environment Awareness; Machine Vision.**

## 1. Introduction

Robotics is a multidisciplinary technology, involving machinery, information, materials, automatic control, artificial intelligence, biomedicine, bionics and other disciplines. Since entering the 21st century, with the great progress of artificial intelligence, mobile robots will become more intelligent and personalized. Mobile robots have rapidly expanded from traditional industrial manufacturing fields to medical services, home services, education and entertainment, exploration and exploration, bioengineering, disaster relief and rescue, deep space and deep-sea exploration, intelligent transportation, intelligent factories and other fields [1-2].

## 2. The Overview of Mobile Robots

Mobile robots, which represent the highest achievement of mechatronics, are one of the most active fields of science and technology development at present. They have concentrated the research achievements of many disciplines such as sensor technology, information processing, electronic engineering, computer engineering, automatic control engineering and artificial intelligence.

### 2.1. Application Scenarios

With the rapid development of computer technology, artificial intelligence and network technology, robot technology is expanding rapidly from the traditional industrial manufacturing field to social services, medical health, leisure and entertainment, transportation, military defense, space exploration and other fields, and robot systems that meet the needs of different fields are deeply researched and developed. In the field of transportation, autonomous vehicles are approaching the real application with unprecedented

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momentum. When autonomous vehicles are applied on a large scale, it will bring a tremendous change to the entire industry. In the field of logistics, mobile robots have achieved accurate packaging, transportation and sorting of goods, helping the circulation and logistics industry to improve efficiency. In the military field, such as unmanned aerial vehicles (UAVs) and unmanned ships (UAVs) have become conventional weapons, which can complete reconnaissance, jamming, strike, rescue and other tasks, and play an important role. In the field of home service, the sweeping robot has been able to take the place of human beings for long-term cleaning work.

## 2.2. Classification

As shown in Figure 1, according to the working environment, mobile robots are divided into indoor robots and outdoor robots. According to functions and uses, mobile robots are divided into service mobile robots, military mobile robots, industrial production mobile robots and entertainment mobile robots. According to the mobile mode, mobile robots are divided into crawling mobile robots, swimming mobile robots, wheeled mobile robots, leg foot mobile robots and humanoid mobile robots. According to the working space, mobile robots are divided into land mobile robots, underwater mobile robots, flying mobile robots and extraterrestrial exploration mobile robots.

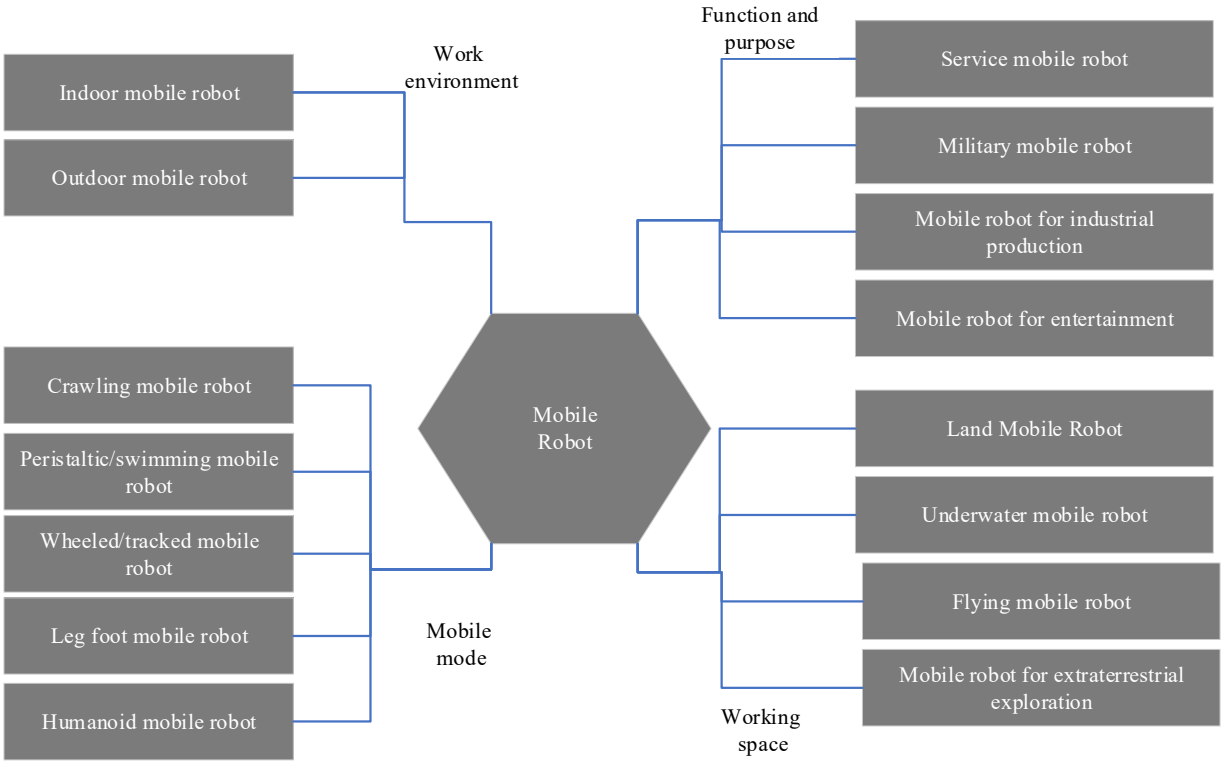


**Fig. 1** The mobile classification

## 2.3. Development Trend

In order to adapt to more complex dynamic working environment, stronger environmental adaptability and more accurate computing requirements, mobile robot positioning and navigation technology and environment awareness technology are constantly changing.

(1) Application of Cloud Brain

The brain of a mobile robot is composed of a computer or multiple microprocessors. As an agent, if this agent is used as the foreground and combines cloud computing, cloud storage and Internet technology as the background to assist mobile robot perception and decision-making,

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the performance of the robot will be greatly improved [3]. At the same time, cloud computing has also been listed as one of the twelve disruptive technologies by McKinsey. The combination of advanced robot technology will bring greater technological change to the whole society. By adding an intelligent interface to the cloud, mobile robots can perform machine learning, deep learning and other intelligent commands through the artificial intelligence interface, further improving the accuracy, speed, stability and security of operation. Through cloud based deep learning, it will be widely used to enhance the robot's understanding of the surrounding environment.

(2) Application of Bionics

The combination of mobile robot technology and bionics is to apply similar motion principles to robots by studying the mechanism of muscle and joint motion of humans or other creatures, so that their motion flexibility is equivalent to that of humans and other creatures [4]. The increasing improvement of bionics technology can not only promote the research of high adaptability of mobile robots, but also provide strong support for the research of perception, control and decision-making methods of mobile robots.

(3) Application of neuroscience

The combination of mobile robotics with neuroscience and brain science is to combine the research results of brain science to make mobile robots imitate people from the perspective of mechanism and structure. The deep cross integration of neuroscience and information science is expected to bring new breakthroughs to the research of mobile robot theory and application. In the future, it will be possible to control the movement of intelligent robots through neural signals and use biological cells to improve the intelligence of robots [5].

## 3. The Overview of Core Technology Development

### 3.1. The Computing Architecture of Mobile Robot

The traditional mobile robot computing completely relies on the local computing resources of the mobile robot to solve the problem in real time, and the execution speed is slow, which cannot meet the increasingly complex computing requirements of mobile robots.

Benefiting from the rapid growth of network data transmission rate, cloud computing technology has begun to be applied in the robot field. After the concept of cloud robot was proposed in 2010, it has aroused the interest of researchers at home and abroad, and has become a new important direction in the robot field [6]. Cloud robot is the combination of cloud computing technology and robotics. It uses the powerful storage and computing capabilities of the cloud to improve robot capabilities and reduce the cost of robot local resources. At present, there are roughly three types of cloud-based robot service platforms: network-based cloud robot platform, sensor network-based cloud robot platform and robot service network protocol (RSNP) based cloud robot platform. Network based cloud robot platforms mainly include DAvinCi, Rapyuta, RoboEarth, etc. Based on the idea of platform as a service, DAvinCi moves tasks executed on the robot ontology to the cloud for execution [7]. Japanese intelligent robot start-ups combine the Rapyuta robot with the cloud platform, and put the robot brain into the cloud, which not only saves the robot production cost, but also improves the computing power required for robot operation [8]. RoboEarth uses cloud computing resources as data storage and integrates web services in the cloud environment [9]. Bouziane et al. use NAO humanoid robots to perform interactive tasks such as voice recognition, face detection, video capture and so on, relying on cloud infrastructure [10]. Cloud robot platforms based on sensor networks mainly include Sensor cloud, sensor cloud platform, etc. These cloud platforms are used to process huge data. Data is collected from sensor devices through the platform, and robot applications are deployed in the cloud environment.

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If only relying on the cloud and are subject to the network environment, the reliability of the autonomous navigation of mobile robots cannnot be ensured. Edge computing is a new concept put forward in recent years. It refers to an open platform integrating network, computing, storage, and application core capabilities to provide the nearest service on the side close to the object or data source. Edge computing is very suitable for scenes with high real-time requirements, and mobile robots are really such applications. Edge real-time computing combined with the unlimited processing capacity of cloud computing can greatly improve the human-computer interaction and scene adaptation capabilities of the robot ontology, as well as enhance the ability of autonomous movement and perception [11]. Cloud-edge-end computing architecture is an important direction for the future development of mobile robot computing architecture, which can solve the problem of insufficient computing power through computing power in the cloud or edge according to different scenarios [12].

## 3.2. The Perception Technology of Mobile Robot

Mobile robots can locate, avoid obstacles and navigate by recognizing the environment. With the progress of robot technology, the concept of robot environment is also expanding. In addition to its moving space environment, it also includes other natural environmental factors, such as gas environment, climate parameters, etc. It can be divided into internal sensors and external sensors according to the perceived environment. The internal sensors mainly include odometer, gyroscope and magnetic compass, which are used for mobile robot positioning. External sensors are used to sense the external environment information. Ultrasonic sensors, infrared sensors, cameras and laser rangefinders, air environment sensors are all external environment sensors.

The advantages of visual sensors are wide detection range and rich information acquisition. In practical applications, multiple visual sensors are often used or used together with other sensors. Through a certain algorithm, many information such as object shape, distance and speed can be obtained [13]. The multi vision system uses three or more cameras, most of which are used to solve the problem of matching ambiguity in the binocular stereo vision system and improve the matching accuracy. Panoramic vision system is a multi-directional imaging system with a large horizontal field of view. Panoramic camera can be realized by image stitching or catadioptric optical elements. The method of image mosaic uses single or multiple camera rotations to scan the scene at a large angle to obtain continuous multi frame images in different directions, and then the mosaic technology is used to obtain the panorama. The data acquired by the depth camera can accurately know the distance from each point in the image to the camera. Real scenes can be restored through 3D coordinates to realize scene modeling and other applications.

A single sensor has functional limitations, so robots often equip multiple sensors at the same time, and use sensor information fusion technology to play the advantages of each sensor to obtain more extensive and reliable environmental information [14].

## 3.3. The Path Planning of Mobile Robot

The research of path planning began in the 1970s, and heuristic and approximate methods were applied to path planning in the 1980s. Since the 1990s, various intelligent algorithms have been widely used in path planning, and a lot of research results have been achieved. Up to now, path planning plays a very important role in industrial production, computer games, mobile robots and logistics.

(1) Integration of path planning technologies

Global path planning technology has been widely used, and the theoretical research has also become mature. However, global path planning is suitable for unstructured complex environments on the basis of known environments. Local path planning is suitable for real-time

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path planning with unknown environment, but it is slow and time-consuming. Combined with global path planning and local path planning, better planning results can be achieved.

(2) Research on path planning for multiple mobile robots

Multi mobile robot cooperative work has become an active and challenging research field. Multi mobile robot path planning is one of the key technologies of multi mobile robot system. Many scholars at home and abroad are very active in the research of multi mobile robot path planning. Compared with the path planning of a single robot, the path planning of multiple robots is significantly more difficult [15]. Scholars have conducted extensive research and achieved some results, but there is still no satisfactory solution.

(3) Research on path planning of mobile robot in high-dimensional environment

The current global path planning technology is mainly aimed at two-dimensional space, and the research on global path planning in three-dimensional space is relatively less. Compared with the path planning of land mobile robots, the path planning of aerial robots and underwater robots is more difficult and faces more uncertainties due to the harsh environment. Strengthening the research of path planning technology of 3d space mobile robot is the need of the current practical application of mobile robot, and also becomes the hotspot of mobile robot navigation research.

### 3.4. The Map Creation of Mobile Robot

(1) Multi robot map creation

Multi robot map creation refers to that multiple robots start from different places in the same environment, use their own sensors to sense the environment, and at the same time, robots exchange data information with each other, gradually merge into a global map, and correct their respective positioning. In addition to all the problems of single robot map creation, map creation based on multi robot system should also solve the problems brought by multi robot system, such as mutual positioning, local map fusion into global map, etc.

(2) Semantic Map Creation

Semantic map creation refers to that the map creation system can not only obtain the geometric structure information in the environment, but also identify the independent individuals in the environment, obtain their position, posture, functional attributes and other semantic information during the mapping process, so as to deal with complex scenes and complete more intelligent service tasks [16]. The knowledge representation of similar objects in semantic map creation can be shared, and the scalability and storage efficiency of the map creation system can be improved by maintaining the shared knowledge base.

(3) Multi source fusion map creation

The current map creation technology generally uses a single observation sensor to observe the environment, and combines the inertial measurement unit to achieve mobile robot positioning and map creation. Map creation based on a single observation source has problems such as low accuracy, vulnerability to interference, and lack of reliability. In recent years, with the continuous reduction of sensor cost and the continuous development of multi-sensor data fusion technology, research on application and algorithm of map creation based on multi-sensor data fusion has become one of the hot research fields, promoting the development of map construction, positioning, autonomous navigation and other research [17].

## 4. Conclusion

The demand for improving the working performance of industrial robots in traditional industrial fields, as well as the demand for promoting and applying robots in other fields, leads the new direction and trend of mobile robots in the new era. Nowadays, mobile robots are widely used, covering the ground, air, underwater and even outer space. Mobile robot has

become an important research field of robot technology, involving interdisciplinary integration, integration of information, materials, automatic control and other disciplines.

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