Design and Implementation of the Robot for Serving Tea and Water

Baoyi Liao, Han Chen*
Oceanography Institute, Shanwei Institute of Technology, Shanwei, Guangdong, China
**Corresponding Author*

Abstract: With the continuous progress of science and technology, robot technology is playing an increasingly important role in the field of service. The research focuses on the design and implementation of a tea delivery robot, which aims to provide efficient service experience while reducing service costs. The robot has successfully realized the functions of autonomous navigation, path planning and obstacle avoidance in indoor environment through the integrated use of mechanical design, automatic control, navigation and positioning technology, as well as the design of human-computer interface. The robot is also equipped with an intelligent robotic arm, which can complete the task of pouring and serving tea. This study will discuss the design concept, key technical modules and the performance of the robot in practical applications in detail.

Keywords: Service Robot; Human-computer Interaction; Automatic Control; Mechanical Design

1. Introduction

The fast-paced life of modern society and the increasing cost of labor have prompted the wide application of robot technology in the field of service.As one of the innovative applications, the tea delivery robot aims to provide users with efficient and convenient tea service.The design and implementation of robots are not only related to technological breakthroughs, but also related to the improvement of user experience and the improvement of service quality.The goal of this research is to build a multi-functional tea delivery robot that can intelligently navigate in the indoor environment, quickly find the target location, and complete the pouring and delivery of tea.To achieve this goal, a range of advanced technologies can be employed, including environmental awareness, map construction, path planning, obstacle avoidance strategies, robotic arm control, and more.At the same time, a user-friendly human-machine interface is also designed to enable users to easily interact with the robot.[1]

2. Design Concept and Demand Analysis

2.1 Establishment of Design Concept

The research and development goal of the tea delivery robot is to improve the efficiency and customer experience of the modern service industry.In the process of designing robots, ensuring efficient operation of core functions and stable load bearing is a key goal.Create a robot design concept, highlighting the two key functions of efficient movement and stable bearing.Priority is given to the realization of robot motion efficiency and cargo stability.The core of robot design concept lies in the realization of efficient movement and stable bearing function.Given that robots will play a role in public places, their appearance design should follow ergonomic principles and be easier for consumers to accept and put into use.At the same time, the operation interface must be simple and intuitive, so that users can quickly grasp and easily operate.Safety is very important in robot design.As artificial intelligence assistants in crowd activities, robots are dedicated to providing services and are designed to ensure human safety in all situations.Environmental sensing efficiency has become a core competitive advantage in the field of robotics, responding in time, containing collisions, and eliminating accidents.In robot design, sustainability becomes an integral consideration.In terms of material screening and energy use, environmentally friendly materials and efficient energy are used to reduce the burden on the earth.Simplicity should be a key element in the maintenance and upgrading of robots, and in order to ensure continuous application benefits, the exclusive name remains the same.The core design elements are as

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follows, which constitute the soul of the tea delivery robot: excellent and stable motion performance, efficient and convenient load capacity;Elegant appearance of ergonomics, the operation interface is simple and clear;Safety performance is strictly held to high standards, and environmental protection and sustainability factors must be paid attention to.[2]

Figure 1. Robotic Application Scenarios

2.2 User Demand and Market Analysis

The key is to analyze user needs to create the perfect model of the tea supply robot.First of all, the survey shows that the fast-paced work scene and the need for high-quality life, prompting automated service equipment is increasingly popular.Users' demand for tea delivery robots extends beyond basic water delivery functions to include service speed, accuracy, and additional services such as hot and cold beverage options.[3]According to the use needs of various environments, the robot design should ensure a certain degree of flexibility and adaptability.For example, robots need to accurately identify each office in an office environment and then quickly deliver drinks to their destination.In public places such as hotels or exhibitions, robots need to have excellent group control and guidance capabilities.Labor costs continue to rise, and market analysis shows that enterprises and public places are competing to pursue cost-effective automation service strategies.The application of tea delivery robots has effectively improved service efficiency, greatly reduced labor costs, and has unlimited market potential.At the same time, with the progress of technology and cost reduction, small and medium-sized enterprises should have the ability to cope with the expansion of the market.The design of the tea delivery robot must take full account of the diversified needs of users and the evolution of the market, integrate technology and market needs, and form a close interaction.

3. Mechanical Structure Design

3.1 Design of Motion Mechanism

In the design of tea delivery robot, the design of motion mechanism plays an important role.The performance of the robot and its adaptability to the environment depend on the strengths and weaknesses of the components.The motion mechanism of the core part is mainly composed of the chassis design, the drive system and the wheel structure.First of all, the design of the chassis must ensure sufficient stability and bearing capacity to cope with various ground environments and bearing requirements.The material selection and structural planning of the chassis require a balance of weight and strength, and it also has excellent durability and can maintain stable performance in a variety of environments.The drive system is called the core of the motion mechanism, and the motor, transmission mechanism and control unit are available.The key to improving the overall efficiency is to install efficient motors.Motor selection must pay attention to torque and speed attributes, in order to ensure the stable operation of the robot under load environment.The efficiency of power transmission and the smoothness of robot motion depend on the design of transmission mechanism.The common transmission methods include direct drive and reducer drive, etc.[4] The selection of the robot depends on the application scenario and performance requirements.Wheeled structure is the key link of robot interaction with the ground, and its mobility and balance are directly affected.Wheel design needs to consider many aspects such as size, material and tread shape to adapt to various ground environments.For example, choosing wheels with excellent grip and shock absorption can slow slip and reduce vibration, thus improving the smoothness of operation.The construction of the motion mechanism must be comprehensively considered in terms of stability, efficiency, adaptability and cost, in order to ensure that the tea delivery robot shows excellent performance and stable reliability in actual combat.

Table 1. Related Parameters of the Robot Design

parameter	magnitude
Mechanical arm length (m)	0.6
Mechanical arm degree of freedom	6
teacup capacity (ml)	300
Water tank capacity (ml)	1000
operating temperature range (℃)	-10 to 50

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Automatic charging function	yes
Sound cue function	yes
Appearance material	stainless steel
weight (kg)	25

3.2 Design and Optimization of the Payload Platform

The construction of the carrying platform is very important for the performance of the tea robot.It must have sufficient bearing capacity, focusing on the stability of the item and the convenience of user access is crucial.At the beginning of the construction of the load platform, it is necessary to clarify its size and shape, and comply with various tableware and container sizes.Surface materials need to be non-slip, easy to clean and wear resistant, reducing the chance of sliding items in transit and reducing maintenance costs.The planning of the platform height has an important impact on the overall look and feel.An appropriate height is not only easy for the user to access the item, it also helps to ensure the stability of the item.[5] Some additional functions may need to be added to the load platform, for example in areas such as temperature control and vibration mitigation, to ensure that the quality of items remains stable during transport.For example, the platform is equipped with heating devices designed to keep the tea water at a constant temperature.Further optimize the performance of the payload platform and consider adopting a controllable architecture.For example, the platform has the function of adjusting height and Angle to meet various user needs and various application scenarios.The intelligent identification system can be integrated into the cargo platform and the application of sensor technology to detect whether the object is present, locate its spatial coordinates, and ensure the safe and accurate transportation process.The design of the payload platform only focuses on physical attributes, which is obviously not comprehensive enough, stability and carrying capacity must be taken into account, user interaction convenience and the integration of additional functions must go hand in hand, and the performance and user experience of the tea robot are expected to be greatly optimized.

4. Control System Development

4.1 Automatic Control Policy

The core lies in the operation of the control system of the tea robot, which directly affects the operation efficiency and safety of the robot.In the process of automatic control strategy design, accuracy, response speed and ability to adapt to the environment should be comprehensively evaluated.The foundation of the control system is the precision of the task execution.The robot uses multi-sensor data fusion technology, using lidar, infrared sensors, cameras and other sensors to achieve the target, collect information about the surrounding environment, and ensure that the robot accurately identifies the target location and driving path.The high-precision positioning system enables the robot to navigate accurately with minimal error.Response speed is of significant importance in evaluating control systems.The robot control module relies on efficient algorithms, such as fast path planning technology and dynamic obstacle avoidance strategies, to cope with emergencies, and the ability to respond to changes must be maintained.Robots operate freely in busy restaurants with real-time data processing and quick decision making.

Figure 2. Robot Food Delivery Scene

The environment adaptability of service robot is one of its key properties.The robot must maintain stable operation in various indoor environments, ground texture, lighting conditions, and spatial planning.To this end, machine learning technology has penetrated into the field of robot control, and environmental adaptation and knowledge accumulation have been deepened, which has improved its stability and credibility in various scenarios.The automatic control strategy of the tea delivery robot focuses on improving the accuracy of task execution, reaction speed and environmental adaptability, improving the service level of the robot, and ensuring safety.

4.2 Design of Human-Computer Interaction Interface

The design of human-computer interaction interface is related to the advantages and

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disadvantages of robot user experience.An intuitive, easy-to-use interface can not only improve the efficiency of robot use, but also enhance customer satisfaction.The design of human-computer interaction interface of tea and water delivery robot involves the following aspects: The intuitive aspect of the interface.It is easy for the public to control and apply, and the interface layout style is simple and clear.Even using large ICONS and clear text guidance for the first time can help users quickly learn.At the same time, the goal of the interface color and graphic design is to give the visual aesthetic pleasure, so as to encourage them to use more enthusiasm.Interface features.In one place, multifunctional options converge, adjust the delivery location to change the delivery time, and also include real-time robot location.User controls include touch screens and voice commands to make interactions simpler and more productive.The interface includes fault identification and feedback modules to help users deal with problems encountered in the process of use.We have taken into account the needs of all users, and the human-computer interaction interface is highly customized.Users make appropriate adjustments to the interface layout and function Settings according to their personal preferences and needs.For example, you can customize your usual delivery location, and you can customize the interface language and font size to better suit your preferences.

Figure 3. Intelligent Food Delivery Robot

Table 2. Related Hardware Parameters of the Food Delivery Robot

parameter	magnitude
parameter (m/s)	0.5
maximum load (kg)	10
maximum load (Ah)	20
Working hours (hours)	8
navigation accuracy (cm)	2
Number of obstacle-avoidance sensors	5
Number of cameras	2
control system	ROS
communication mode	Wi-Fi

5. Navigation and Positioning Technology

5.1 Environment Perception and Map Construction

The design and implementation of tea delivery robot cannot be separated from the integration of navigation and positioning technology.In order to realize the autonomous navigation and accurate positioning of indoor environment, the robot must have the skills of environment perception and map construction, both of which are indispensable.The environment perception plays a key role in robot navigation, and the real-time acquisition of environment information benefits from the role of sensors throughout the robot.There are many kinds of sensors applied to the tea delivery robot, using lidar, cameras, ultrasonic sensors and other equipment to detect the surrounding environment.The position, shape, distance and other information of obstacles are fully covered by these sensors, so this action helps the robot to build awareness of the surrounding environment.The Lidar robot has the function of environmental scanning, the main function of the point cloud map camera is to identify markers and capture human body dynamics, and the core role of the ultrasonic sensor is distance measurement and obstacle identification.As an extension of environmental perception, environmental data is transformed into a map that the robot can recognize.On the design level of tea delivery robot, simultaneous localization and map construction (SLAM) technology has been applied.SLAM technology allows robots to explore unfamiliar environments, draw maps in real time and confirm their positioning simultaneously.This technology relies on the fusion of perceptual data and existing map resources to continuously refresh topographic maps and location estimates.In this way, the robot optimizes the map as it moves, and its orientation can be precisely controlled.

Table 3. Data Table of the Food Delivery Robot Algorithm

parameter	magnitude
Navigation algorithm	SLAM
Path planning algorithm	A*
Observer avoidance strategy	Dynamic obstacle avoidance
positioning accuracy (cm)	5
Map update frequency (Hz)	10
Remote control type	Wireless remote control

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Charging time (hours)	3
noise level (dB)	55
price (USD)	5000

5.2 Path Planning and Obstacle Avoidance Strategies

Once the robot has the ability to sense the environment and build maps, the key next step is to plan routes and avoid conflicts.Path planning and obstacle avoidance strategy design are the key to determine whether the robot can complete the task safely and efficiently.Discussion on the strategy of robot arriving at target location.Path planning needs to consider a variety of factors before it can be applied to the tea delivery robot, such as map data, target location, and obstruction distribution.Common path planning algorithms mainly include A*, Dijkstra and RRT.Various algorithms make corresponding adjustments according to different scenarios and needs, and the goal of selecting the optimal path is to ensure that the robot can reach the destination quickly and stably.Obstacle avoidance strategy is regarded as a supplement to path planning, the goal of which is to avoid collision with obstacles during travel.The development of obstacle avoidance strategy depends on the real-time perception of obstacle location and robot dynamics, avoiding collision and adjusting robot path and speed in time.Obstacle avoidance strategies can be divided into two categories: static obstacle avoidance and dynamic obstacle avoidance.Static obstacle avoidance means the strategy of cleverly avoiding static obstacles in path planning, while dynamic obstacle avoidance means avoiding the collision of moving objects in real time while driving.In the noisy indoor environment, the tea robot operates smoothly, so the formulation of obstacle avoidance strategy is particularly critical.Robots need to be able to adapt quickly to the environment to ensure the safe and steady progress of services.

6. Conclusion

This study comprehensively discusses the design and implementation of a tea delivery robot, and successfully builds an efficient and user-friendly service robot by integrating advanced mechanical design, automatic control technology and human-computer interaction concepts.Experimental tests and application cases fully demonstrate the remarkable effectiveness of the robot in improving service efficiency and improving user experience.The robot can intelligently navigate in the indoor environment and independently complete the task of pouring and serving tea, which not only provides high-quality services, but also reduces the service cost.In the future, such robots are expected to be applied in a wider range of service fields, such as catering, medical care, and hotels.The versatility and intelligence of the robot make the robot suitable for various scenarios and can meet the needs of different fields.With the further development of technology, it can be expected that the performance and function of robots will continue to improve, bringing more convenience and comfort to people's lives.The continued development of this field will promote scientific and technological innovation, promote the wide application of robotics in the field of services, and bring positive impact to society and individuals.

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