

The Cloud-Based Design of Unmanned Constant Temperature Food Delivery Trolley in the Context of Artificial Intelligence

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Abstract: This article pertains to an unmanned food delivery trolley, equipped with a transmission system, an obstacle avoidance mechanism, a data acquisition and processing module, a navigation and positioning system, a motion control unit, a hot and cold storage unit, and a facial recognition technology. The trolley's microprocessor, housed within the data acquisition and processing module, drives the radar and camera via a serial port connection circuit, with the host computer utilized to represent the trolley's field position. Unmanned food delivery trolleys contribute to enhancing the efficiency of the takeaway industry by reducing labor and time costs. As artificial intelligence develops rapidly, the pace of innovation in logistics is also accelerating.

Keywords: Obstacle Avoidance Mechanism, Navigation Mechanism, Artificial Intelligence Technology, Fully Automatic, Artificial Intelligence, Automated Driving, Facial Recognition, Radar Sensing.

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1 Introduction

1.1 The Development Prospect of Unmanned Constant Temperature Food Delivery Trolley

On May 29, 2018, Ele.me announced that it had been approved to open the first batch of drone instant delivery routes, and users could receive takeout in an average of only 20 minutes from placing an order[1]. The project was launched in Jinshan Industrial Park because the area is vast, the distance between buildings is large, and the distance between the office and the restaurant is far. However, this delivery requires two riders, one to load the takeout onto a drone, and the other to deliver the final meal to the consumer[3]. Drawing upon Ele.me's utilization of drones for takeaway delivery, it can be deduced that drone-based takeaway services are generally appropriate for areas with extensive delivery routes and expansive landmasses. In localities where food is delivered in proximity to the restaurant, labor costs may escalate, and the stability of the drone may be challenged in severe weather conditions. Additionally, managing urban drone operations is a significant challenge due to factors such as avoiding

densely populated areas, skyscrapers, high-voltage power lines, airports, and restricted airspace. Consequently, numerous constraints hinder the widespread implementation of drones within city limits. At present, the drones available on the market cannot guarantee a 100% bombing-free operation, and their frequency and reach within the food delivery sector are limited. This is exacerbated by the dense urban population, leading to increased safety risks. During a drone's flight, the lack of monitoring may facilitate malicious intercepts. In recent years, driverless cars have gained increasing popularity and have evolved into a growing trend. This will ultimately lead to the regularization, automation, and intelligence of future road systems. Intelligent food delivery vehicles, which incorporate the concept of unmanned driving, can save on labor costs and help mitigate traffic congestion, thereby reducing the likelihood of traffic accidents. Merchants need only to load the goods into the refrigerated unit, and the food delivery truck can deliver the food to the customer along the predetermined route, simultaneously handling multiple takeaway orders.

1.2 The Current State of AI Development and Its Future

In recent years, with the development of technology, artificial intelligence technology has become increasingly mature, and the size of the artificial intelligence market continues to grow rapidly. It is predicted that the global scale of direct and indirect applications of artificial intelligence will increase from \$640 million in 2016 to \$36.8 billion in 2025, a growth of nearly 57 times. The scale of China's artificial intelligence market was 21.69 billion yuan in 2017, and has grown more than twice to 71 billion yuan in 2020.

Artificial intelligence is an emerging strategic technology that leads the future and is an important force driving a new round of technological revolution and industrial transformation. This emphasizes the need to deeply understand the characteristics of the development of the new generation of artificial intelligence, strengthen the integration of artificial intelligence and industrial development, and provide new impetus for high-quality development. In recent years, technologies related to artificial intelligence have continued to evolve, and the process of industrialization and commercialization has been accelerating. This acceleration is facilitating the deep integration with various industries. A comprehensive review of the development trends of artificial intelligence policies, technologies, applications, and governance can be beneficial for consolidating industry consensus and promoting the sustainable and healthy development of artificial intelligence.

1.3 System Design Purpose and Benefits

Fully automated food delivery is revolutionizing traditional delivery methods, bringing a new level of intelligence to the food delivery industry. Users can create facial recognition profiles before placing an order on the mobile ordering client. During the order, the mobile client transmits both the user's order information and corresponding facial recognition profile to the cloud server.

Once the food delivery truck arrives at the designated location, it automatically notifies the customer's mobile terminal. Users can then scan their faces in front of the intelligent facial recognition food pickup machine to retrieve their food promptly and accurately. This not only ensures timely delivery but also enhances efficiency. The car significantly improves operational efficiency and, simultaneously, reduces labor costs.

To ensure the safety of schools, communities, and other areas, there is a growing trend of restricting express delivery drivers from entering these spaces. The increase in these restrictions is a response to the need for safety within these environments. Express delivery drivers, in their pursuit of efficiency, sometimes speed through school campuses, posing a threat to the personal safety of students and

teachers. Additionally, this behavior makes it challenging for the drivers to ensure their own safety. The entry and exit of outsiders, including delivery drivers, also raise concerns among residents in residential areas regarding their personal and property safety.

2 Requirements Analysis

2.1 Overall Demand Analysis

The current fast-paced lifestyle places significant pressure on the development level of human labor. On one hand, food delivery needs to be timely, yet the delivery personnel, running errands daily, still struggle to meet the demands of over a billion consumers nationwide. To enhance delivery efficiency and reduce labor costs, the industry will inevitably rely on "intelligent, integrated, and automated" means. On the other hand, with the rapid development of the Internet era, people's purchasing power is continually increasing, and they demand better, faster, and stronger services.

Rapid economic development has led to increasingly fierce social competition and a fast-paced lifestyle, giving rise to the food delivery industry. Ordering takeout has gradually become the preferred choice for most people in society, and contemporary college students are no exception. The quality of takeout food significantly influences the dining experience and the physical and mental health of college students, holding great significance for campus planning and urban environment improvement.

For example, in today's fast-paced era, white-collar workers in companies and college students are also preferable choices. After years of development, the food delivery industry is moving towards diversification[2], and in the future, more competitors will emerge to promote industry development.

The food delivery industry can be divided into two service directions: online and offline. Now is the Internet era. The development of technology has provided more possibilities for online services and has facilitated the growth of the takeaway industry. People can use electronic devices to enjoy high-quality services in the food delivery industry, making life increasingly convenient.

2.2 Functional Requirements Analysis

The unmanned constant temperature food delivery cart aims to provide efficient and reliable food transportation services while maintaining a constant temperature to ensure the quality and safety of food delivery items. Its system will include hardware and software components, utilizing cloud technology for remote monitoring, control, and data management. In terms of hardware components, temperature control units, GPS and navigation systems, battery and power management systems, communication modules (Wi-Fi, cellular), and sensors for temperature monitoring and obstacle detection are required. In terms of software

components, cloud-based platforms are used for centralized control and monitoring, car control algorithms, user interfaces for clients and administrators, security and authentication protocols, and data recording and analysis tools. Regarding temperature control, the system must be able to maintain a constant and adjustable temperature inside the handcart to preserve the quality of food during transportation. The temperature control unit should have a real-time feedback mechanism to adjust settings based on external conditions.

2.3 Functional Requirements Analysis

With the continuous development of society, the living pressures of contemporary people are increasing day by day. Almost all of our time has been commercialized, and our free time in daily life is usually compressed by busy work hours, preventing consumers from maintaining a slow-paced lifestyle. Considering the value of time, an increasing number of consumers opt for ordering takeout to save time. As the post-90s and post-2000s gradually integrate into society and are deeply influenced by the internet, they prefer staying at home on weekends and using food delivery platforms to meet their daily needs. Driven by the lazy economy, it is anticipated that the market size of the takeaway industry will further expand.

The demand for service levels and delivery efficiency in the external sales industry is increasing day by day. Traditional food delivery services rely on manual delivery, which poses problems such as low efficiency and safety. In response to this situation, we integrate big data and artificial intelligence technology to shift delivery from traditional shoulder-to-hand methods and lead the way into a new era of unmanned food delivery. The unmanned constant temperature delivery car aims to address the "last step" in people's daily dining – how to quickly, safely, and efficiently transport food from restaurants to users.

2.4 Feasibility Analysis

1. The delivery truck features six storage cabinets with cooling and insulation functions.
2. The delivery truck is versatile, capable of transporting goods both indoors and outdoors on various surfaces, including cement or gravel ground.
3. With a high transportation efficiency, the delivery truck is equipped with an obstacle avoidance and shock absorption system, minimizing unnecessary customer complaints arising from transportation issues.
4. The delivery truck boasts high speed, leveraging GPS technology for precise real-time positioning. It provides updates on current road conditions, enhancing and accelerating the overall delivery speed.
5. Incorporating a facial recognition system, the delivery truck offers a convenient and rapid food pickup experience, ensuring accurate transactions through

intelligent facial recognition technology.

3 Overall Design of the System

3.1. Analysis of System Function Modules

3.1.1 Bi-directional operation

The unmanned thermostatic food delivery trolley features a two-way control function, offering protection for intelligent food transportation and accident prevention. This is achieved through both the auto-drive system and the manual remote control system. The trolley is equipped with a camera device on the roof and utilizes GPS positioning to accurately locate its position, mitigating the risk of item loss during delivery.

3.1.2 Thermal insulation and quality shelf

The freezer incorporates shock-absorbing insulation and barrier materials, utilizing the refrigeration principle of semiconductor refrigeration sheets. The heat dissipation fan extracts hot air, which is then laterally discharged through a filter screen, facilitating the refrigeration process. Additionally, the insulation cabinet is constructed using shock-absorbing insulation and barrier materials, and its insulation is maintained through periodic heating of the board.

3.1.3 Confidentiality

The front of the car is equipped with a camera that monitors the road surface in real-time, preventing accidental theft. This feature ensures customers can safely pick up meals, provides protection for customer information, and enhances overall confidentiality.

3.1.4 Security

The unmanned constant temperature food delivery car features two sets of wheels symmetrically arranged at the bottom of the vehicle, connected to a motion control mechanism that provides power and direction. It is equipped with a camera for real-time monitoring of the road surface, utilizing adaptive cruise control or laser ranging systems to navigate around obstacles on the road.

The camera, a conventional four-eye high-definition camera, supports multi-object recognition and possesses robust color recognition and color block tracking functions. It demonstrates a keen sensitivity to image color, enabling it to analyze and recognize objects around the car, such as pedestrians, sidewalks, and traffic lights, as well as other living biological information. The environmental information data captured by the image sensors is transmitted to the microprocessor. The microprocessor then calculates the movement of living organisms or the conventional path of moving bodies and subsequently controls the car to navigate around obstacles, avoid pedestrians and vehicles, and recognize traffic signals including those on sidewalks and traffic lights.

3.1.5 Accuracy

When reaching the designated location for goods pickup, the AI delivery truck automatically notifies the customer's mobile terminal. Upon arrival, users can conveniently scan their faces in front of the intelligent facial recognition pickup machine. The corresponding order information and facial recognition files are transmitted to the cloud server for recognition, ensuring accurate and efficient delivery of meals to users. The Yunyan car not only enhances efficiency but also reduces labor costs.

The driving route is strategically planned, utilizing satellite navigation maps to monitor, locate, and assess real-time road conditions[4]. Delivery vehicles are connected to the internet, allowing users to conveniently track the specific location of the delivery vehicles through mobile terminals. Additionally, the vehicle is equipped with a camera that monitors the road surface in real-time, preventing accidental theft. To navigate the road, adaptive cruise control or laser ranging systems are employed to avoid obstacles.

The GPS positioning device within the navigation positioning mechanism is linked to BeiDou satellite navigation data, facilitating access to the latest maps. This integration enables the accurate real-time positioning of the intelligent food delivery car, ensuring precise and timely meal deliveries.

3.2 Conceptual Model Design

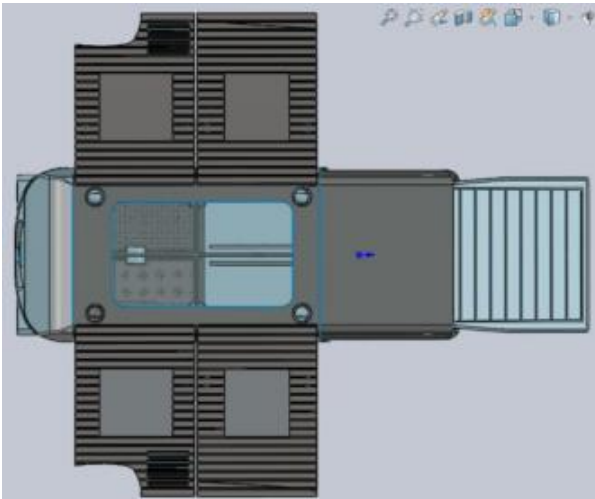


Figure 1. Conceptual Model Design1



Figure 2. Conceptual Model Design2

4 System Technical Requirements

4.1 Motion control mechanisms

The motion control mechanism of the car is interconnected with the obstacle avoidance mechanism, data acquisition and processing, navigation and positioning systems.

4.2 Obstacle avoidance mechanism

The obstacle avoidance mechanism comprises a camera, radar, thermal imaging probe, and ultrasonic probe. The detection data from each component is transmitted to the data acquisition and processing mechanism through a serial port protocol. The radar is connected to the Raspberry Pi using a serial port protocol for preliminary positioning. The data collection and processing mechanism, incorporating a car microprocessor, is linked to the obstacle avoidance mechanism, positioning mechanism, and motion control mechanism through a serial port protocol. The car microprocessor gathers data from the obstacle avoidance and navigation positioning mechanisms at regular intervals, processes the collected information, and sends instructions to the motion control mechanism for execution. Here's a breakdown of each component: Camera: Utilized for visual recognition of obstacles, capturing images or video frames for further processing. Radar: Detects distant objects using radio waves, providing information about the distance and relative velocity of obstacles. The Thermal Imaging Probe: Senses the thermal signal of objects, effective for detecting organisms or hot surfaces. Ultrasonic Probe: Emits ultrasonic waves and measures the time for them to rebound, providing information about the distance to the object. The overall obstacle avoidance mechanism receives data from cameras, radars, thermal imaging probes, and ultrasonic probes for effective obstacle detection.

4.3 Navigation Mechanism

The navigation positioning mechanism incorporates a GPS positioning device connected to BeiDou satellite navigation data, facilitating the importation of the latest maps for precise real-time localization of the intelligent food delivery car. The GPS positioning device establishes a connection to the car microprocessor via a serial port protocol, providing the car's position information. It then analyzes the upcoming road conditions and transmits parameter data to the car microprocessor.

GPS Positioning Device: Integrates GPS and BeiDou satellite navigation systems to enhance accuracy, retrieving real-time position data by receiving signals from multiple satellites.

Map Import: Regularly updates and imports the latest map data to ensure the cart possesses current information about road layout, obstacles, and relevant points of interest.

Serial Protocol: Utilizes a serial protocol to seamlessly

connect GPS positioning devices to the handcart microprocessor for efficient data communication.

Data Reception: The car microprocessor receives position data from GPS positioning devices through a serial protocol.

Road Condition Analysis: Utilizes received location data to analyze the road conditions ahead, taking into account factors such as traffic, obstacles, and the current state of the road.

Parameter Data Transmission: Sends the analyzed road condition parameters to the specialized knowledge module in the car microprocessor for further processing.

4.4 Motion Control Mechanism

The motion control mechanism features a DC deceleration motor, complemented by a gyroscope and magnetometer for PID algorithm data processing. It receives operational instructions from the car microprocessor for motion and offers feedback on the direction of operational data back to the car microprocessor. This ensures the normal operation and driving of the car.

4.5 Freezer Settings

Select cutting-edge insulation materials with high heat resistance to minimize heat transfer and ensure effective temperature control. Consider employing vacuum insulation boards or advanced foam insulation materials to achieve outstanding performance. Implement the most advanced temperature control system, equipped with precise sensors for real-time monitoring. Through the use of an intelligent controller, cooling settings can be dynamically adjusted based on external conditions and load changes. Explore a dual-mode cooling system capable of switching between freezing and cooling modes. This flexibility accommodates various types of food and enhances the versatility of delivery carts. Opt for energy-saving cooling technologies, such as variable-speed compressors and advanced refrigerants. Additionally, consider incorporating innovative technologies like magnetic refrigeration to further improve energy efficiency and environmental sustainability.

4.6 Data Collection and Processing Institutions

The main body of the car should feature an interactive interface for users, providing operational assistance during the meal pickup process. This interface enables users to directly set commands, establishing a connection to the data acquisition and processing mechanism through a serial port protocol for signal interaction. The data acquisition and processing mechanism is further linked to the central control center system through an antenna set on the top of the car body. This allows ordering customers to exchange information on their mobile devices, facilitating efficient remote monitoring of third-party information.

4.7 Facial Recognition System

Facial recognition technology employs computer image processing to extract facial feature points from images, subsequently analyzing them using the principles of biostatistics and establishing facial feature templates. Additionally, it integrates seamlessly with the OA system. Users define the docking protocol and create facial recognition profile information on the mobile ordering client before placing an order. During the ordering process, the mobile ordering client transmits the user's order information along with the corresponding facial information from the facial recognition profile to the cloud server. This efficient process ensures fast facial recognition for meal pickup.

5 Conclusion

In conclusion, the research on the cloud design of unmanned constant temperature delivery vehicles represents a revolutionary and pivotal advancement in the realm of automatic delivery systems, particularly in ensuring the quality and safety of temperature-sensitive products. The amalgamation of cloud technology with advanced sensing and control mechanisms has ushered in a new era of intelligent and efficient meal delivery. As we navigate an era where autonomous systems progressively shape various industries, the insights presented in this paper underscore the transformative potential of cloud-designed unmanned constant temperature delivery vehicles in redefining last-mile logistics. Fueled by ongoing research and advancements, the continuous evolution of these systems is poised to redefine the landscape of food delivery, offering unprecedented efficiency, reliability, and sustainability.

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inquiries can be directed to the corresponding author.

Conflict of Interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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