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Intelligent Assisted Travel Wheelchair Based on Image Recognition Technology

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Abstract: This paper introduces an intelligent image recognition system integrated into a wheelchair based on deep learning in cold environments, aiming to improve the convenience and safety of disabled individuals. The system adopts advanced image recognition technology to monitor road conditions in real-time through the camera and to detect and measure distance to foreign objects on the road. The system visualizes the detection results on the wheelchair screen to assist the user in avoiding and improving the safety of their daily travel. In addition, the system also includes crawler tracks, seat heating, snow and rain protection, and other functions. The wheelchair has a wide range of application prospects and development potential. It is expected to be widely used in the future, providing a strong guarantee for the safe travel of disabled individuals in China.

Keywords: Image recognition; Traffic safety; Travel security

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1. Project overview

1.1. Study significance

China has a large number of disabled individuals, but they face many challenges, including inconvenient transportation, road obstacles, and other problems, which create significant difficulties in their travel. The intelligent assisted wheelchair uses image recognition technology, which can intelligently identify the environment, avoid obstacles, and provide accurate navigation services, thus significantly improving the travel experience of the disabled in cold environments. Research on this wheelchair can provide convenient and safe ways for disabled individuals to travel, improve their travel quality, and enhance their life happiness. At the same time, the study will also help promote the application of intelligent assisted technology in the field of travel for the disabled, provide more intelligent auxiliary equipment, and promote the inclusive and sustainable development of society. Therefore, it is of great significance to study the intelligent assisted travel wheelchair in cold environments based on image recognition technology for better travel quality for disabled people in China.

1.2. Analysis of domestic and foreign research status quo

Based on the research of the traditional electric wheelchairs, Zhang Huanlin of Xidian University optimized the control system structure of the wheelchair and used multi-sensor data fusion and other technologies to realize that the wheelchair can automatically drive along the road in the outdoor environment [1]. Aside from that, Zhang Jianru and others proposed a double-layer structure control system of autonomous following and obstacle avoidance with a compensation mechanism [2]. Liu Kai *et al.* from the Rail Transit School of Wuyi University innovatively designed a multifunctional intelligent assisted wheelchair based on laser Simultaneous Localization and Mapping (SLAM) navigation technology [3]. Additionally, Zhu Hua *et al.* from the School of Mechanical and Electrical Engineering of Jiangxi University of Science and Technology designed a wheel and track climbing wheelchair with the articular swing arm track chassis for the stair climbing mechanism together with the new wheel and track switching mode [4]. Song Chengji and others from Shaanxi Industrial Vocational and Technical College designed an artificial intelligence wheelchair with voice interaction and lidar obstacle avoidance function [5]. Alongside that, Fu Zidong from the School of Mechanical Engineering of Suzhou University of Science and Technology designed an intelligent wheelchair with a Programmable Logic Controllers (PLC) function and automatic obstacle avoidance function [6].

1.3. Study objectives

The study focuses on disabled individuals in cold environments in China. The main obstacles they faced on the roads, such as snow and ice, are detected and measured through deep learning and, in certain circumstances, auxiliary laser detection. The data is displayed on the wheelchair's screen to assist drivers in avoiding these obstacles. Additionally, the system includes features such as crawler tracks, seat heating, and a rain and snow canopy structure, enhancing the wheelchair's stability and comfort, thereby improving the safety of people's daily travel.

2. Technical description

2.1. Road surface foreign body identification system

To enhance the safety performance of the intelligent wheelchair, a camera is installed on the wheelchair, and the deep learning computing power of Raspberry Pi is used to analyze the road conditions ahead in real-time. By capturing the image data entered by the camera, the system can determine whether there are obstacles ahead affecting the navigation of the wheelchair. In realizing accurate foreign body identification and detection, the system needs to train and learn data for some time. The model will be optimized to accurately identify the presence of obstacles to the wheelchair in the practical application. Once an obstacle is detected, the system will warn the user promptly and activate the automatic avoidance function to ensure navigation safety.

With Raspberry Pi's powerful computing power, advanced You Only Look Once (YOLO) v5 image recognition, deep learning algorithms, and SLAM technology, the intelligent wheelchair can more accurately identify and analyze its surrounding environment. To improve the accuracy of identification, diverse road scene data were collected during training. The data includes obstacles of different types, shapes, and sizes, and labels the foreign objects in each image as a training set to ensure that the model can cope with a variety of emergencies. Through the deep learning algorithm training, the model reaches a certain accuracy, to realize the road foreign body identification function. **Figure 1** is a diagram of the sidewalk obstacles which is used to measure the possibility of the detected item as foreign objects.

Figure 1. Diagram of sidewalk obstacles

Through a series of technological innovations and optimization, the intelligent wheelchair will be able to accurately, quickly, and correctly identify obstacles and foreign objects on the road while navigating. This will greatly improve the autonomous navigation of wheelchairs, making them safer and more reliable in complex environments.

2.2. Wheelchair automatic vehicle avoidance system

The core goal of the wheelchair automatic avoidance system is to give a timely warning to avoid collision incidents when the wheelchair user fails to notice the obstacles ahead for various reasons. The main principle of such systems is to use sensors to monitor the environment around the wheelchair and help in avoiding when faced with obstacles.

The wheelchair automatic avoidance system works mainly in two ways. Firstly, the system will use the installed ultrasonic sensor on the wheelchair. When the ultrasonic wave encounters an obstacle, an echo is generated. These echoes will be captured and analyzed by the system to determine the environment around the wheelchair. The main task of this module is to provide real-time external environment information for the automatic obstacle avoidance module to ensure the normal navigation of the wheelchair.

The system can also use the Raspberry Pi camera to monitor the environment in front in real-time. By collecting the image data input by the camera, the system can analyze the road ahead. After a period of data training and learning, the model can identify whether there are obstacles to the wheelchair. Once an obstacle is found, the system will immediately send the relevant information to the buzzer and the central controller through the wireless transmission module.

Secondly, after receiving the information, the central controller will adjust the corresponding operation strategy of different situations according to the pre-set automatic obstacle avoidance model. This way, the wheelchair can automatically avoid obstacles according to the actual situation, ensuring the safety of the user. A schematic diagram of the wheelchair's automatic avoidance feature is shown in **Figure 2**.

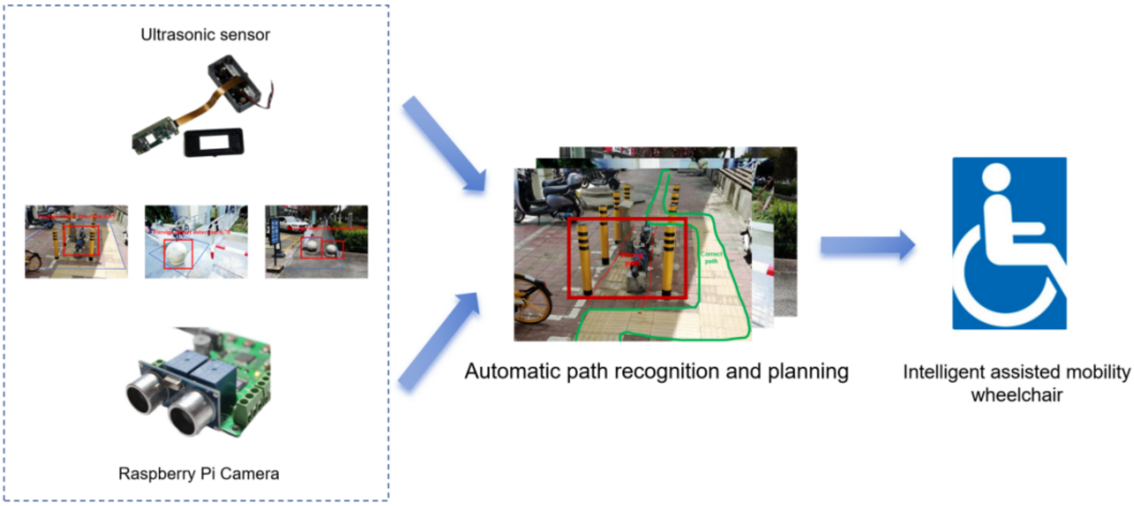

Figure 2. Schematic diagram of the wheelchair automatic avoidance function

2.3. Structural design of the new wheelchair

The newly innovated wheelchair includes the wheelchair frame comprising the seat frame and the back frame. The specific overall structure is shown in **Figure 3**.

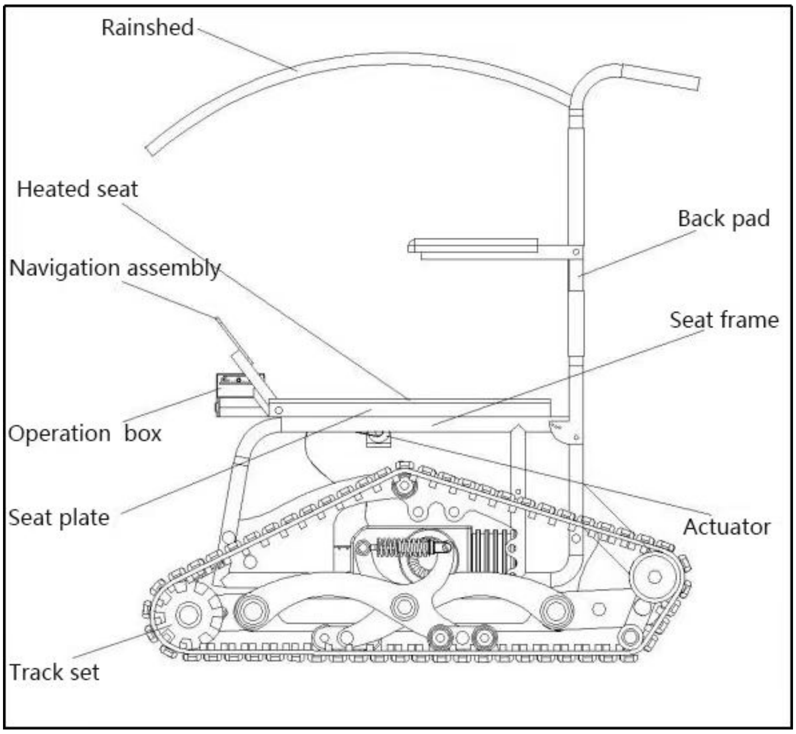

Figure 3. Overall structure diagram of the intelligent wheelchair

The back frame is installed at the upper end of the main frame, with a rain shed canopy fixed at the top of the back frame. The bottom end of the seat box group and navigation components is located at the front end of the seat plate. The lower end of the seat plate is equipped with the drive unit of the navigation component, while the upper end of the seat plate is also fitted with a heated seat.

The operation box includes a storage shell and a control board, which is firmly mounted on the housing board. The control board is rotatably mounted within the storage shell. The lower end of the storage shell has a detection box, with a radar probe fixed to the front end of the detection box. The navigation assembly consists of a spin shaft, a flip lever, and a navigation screen, with one end of the flip lever securely attached to the spin shaft and the navigation screen fixed to the other end of the flip lever. The drive component includes an electric unit and a drive belt that secures the lower surface of the present plate while the electric unit is connected to the rotating shaft via the drive belt. The heating seat features a frame and an electric heating pad mounted on the upper face of the plate and the center of the frame. There is also a storage slot for the flip rod and a matching slot for the drive belt connection. The schematic diagram of each device is shown in **Figure 4**.

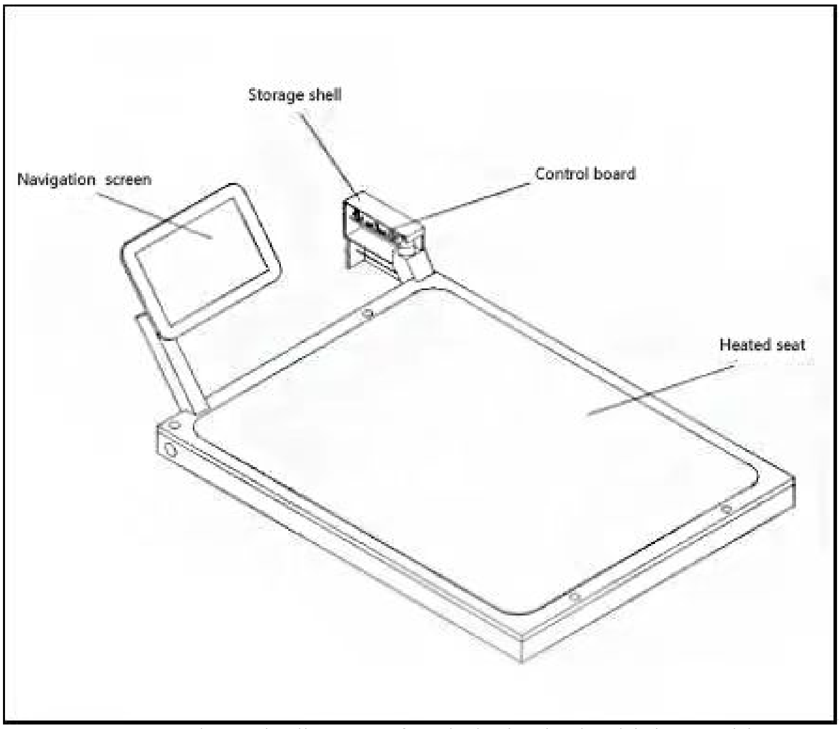

Figure 4. Schematic diagram of each device in the driving position

3. Specific implementation methods

3.1. System functional composition

(1) Road foreign body recognition system: A camera is installed on the wheelchair to collect the image data of the surrounding environment in real-time. The image processing algorithm analyzes and identifies the collected images to identify the foreign bodies and obstacles on the road surface.

(2) Wheelchair automatic avoidance system: Based on the foreign body identification results and user input, the wheelchair will automatically adjust the travel direction and speed to avoid the detected obstacles. The system can realize the automatic avoidance function through the motor control of the electric wheelchair, to ensure that the user can drive safely and comfortably.

(3) Wheelchair structure design: Crawler tracks are fixed on both sides of the lower end of the frame. The crawler tracks use drive wheels and guide wheels to support the track structure. The drive wheels rotate, propelling the tracks to move steadily across slippery surfaces. The heating seat includes the frame and the electric heating pad. The frame is fixed on the upper end of the present plate while the electric heating pad is fixed in the middle of the present frame. The temperature can be adjusted by using the control plate. The canopy is installed through a vertical frame and features a removable side-wrapping structure that can be taken off when not in use. Additionally, the canopy is designed to be foldable, allowing it to be

extended when needed and folded back onto the back frame when not in use.

When needing to use the wheelchair, the user should rotate the control board from its storage shell and flip the navigation components into position. This allows users to easily sit on the wheelchair's electric heating pad. Once seated, the control board can be used to operate the wheelchair's movement, ensuring stable navigation. For navigation, the drive should be engaged to position the navigation components, and the destination can be entered into the navigation screen according to the planned route. The specific working diagram of the radar probe, detection box, conveyor belts, and electric unit is shown in **Figure 5**.

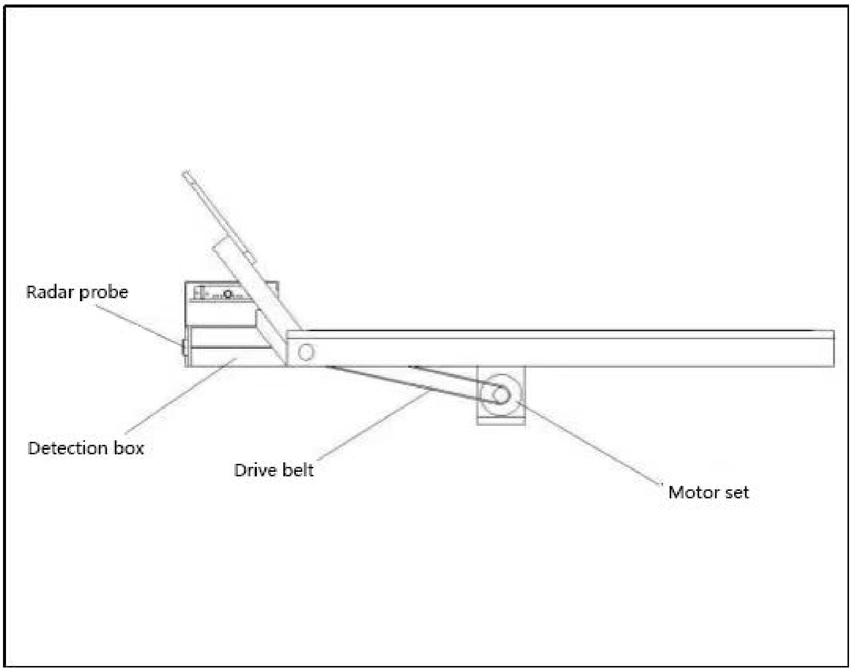

Figure 5. Schematic diagram of the operation structure of the intelligent wheelchair device

Through the above implementation method, this intelligent assisted travel wheelchair can effectively identify foreign bodies on the road and automatically avoid them, improve the safety and convenience of users' travel, and provide more intelligent travel solutions for people with mobility difficulties.

3.2. Innovation

The innovation of this intelligent wheelchair compared with the traditional intelligent wheelchair lies in the following aspects:

(1) Image recognition function of deep learning: The wheelchair is equipped with image recognition technology, which can identify the surrounding environment through the camera and help users navigate and avoid obstacles more accurately. Deep learning techniques can constantly learn and improve recognition accuracy, and the system will perform better over time. At the same time, deep learning technology can also adapt to different environments and scenarios, providing users with more intelligent auxiliary functions.

(2) Automatic avoidance function: With the help of advanced image recognition technology, the wheelchair can realize the function of automatically avoiding obstacles, to improve the safety and convenience of navigating. The image recognition technology of deep learning allows the wheelchair to automatically avoid obstacles. Through the camera monitoring the surrounding environment in real-time, the system can identify obstacles on the road and make distance measurements, thus assisting users in avoiding obstacles

and improving the safety and convenience of wheelchair users. This function can not only reduce the operation burden of users but also provide timely warning and intervention when they fail to detect obstacles in time. By combining deep learning technology and automation functions, the wheelchair realizes an intelligent navigating mode, providing users with a more intelligent and safe travel experience.

(3) Main structure design of the wheelchair: The removable canopy is designed to provide additional protection so that users can still ride comfortably in bad weather. The heated seats provide additional comfort, allowing users to feel warm in cold weather. The wheelchair uses crawler tracks with drive wheels which enhance passability and stability, making it suitable for various terrains. This design increases the wheelchair's scope of application and overall convenience.

These innovative designs make the intelligent wheelchair more advanced and practical than traditional wheelchairs in terms of functionality, safety, and comfort.

4. Conclusion

In conclusion, the intelligent assisted wheelchair designed in this study is innovative and improved compared to the traditional electric wheelchair. It includes image recognition, automatic avoidance, a removable canopy, a heated seat, and crawler tracks with drive wheels. These innovative designs have significantly improved the smart wheelchair in terms of navigation, safety, and comfort, providing a more convenient and comfortable way to travel for people with mobility difficulties. The future research direction can further optimize the function of the intelligent wheelchair, improve its intelligence level and user experience, and make more contributions to barrier-free travel in society. It is hoped that this study can provide useful references and enlightenment for the development of the field of intelligent assistive devices.

Disclosure statement

The author declares no conflict of interest.

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