Application Analysis of Unmanned Technology in Construction Machinery

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Abstract: With the combination of computer and automation technology, unmanned driving technology is developing rapidly, especially in the field of engineering machinery. The application of driverless technology is more prominent. It improves vehicle driving performance, reduces driver's labor intensity and reduces the incidence of traffic accidents and the operation in harsh conditions and extreme conditions have great prospects. This paper mainly analyzes the specific application of driverless technology in the field of engineering machinery.

1. Introduction

Unmanned driving as a future research direction for automobiles has a profound impact on the transportation industry. The advent of driverless technology will be able to liberate human hands, reduce the frequency of traffic accidents, and ensure people's safety. At the same time, with the breakthrough and continuous advancement of core technologies such as artificial intelligence and sensor detection, unmanned driving will be more intelligent, and at the same time, the industrialization of driverless cars can be realized. However, the emergence of any technology is a process of gradual and continuous innovation. Unmanned driving from emergence to maturity and then can be used worldwide, has proved its powerful application space.

The unmanned driving of construction machinery has realized the new four-level construction of national basic engineering, controlling electrification, information digitization, communication network, and intelligent operation. It has the advantages of high efficiency, low error, informatization of construction data, and real-time online monitoring of construction quality.
2. Device analysis

Engine is a kind of machine that converts other forms of energy into mechanical energy. The driving power of an engineering machine comes from the engine. Throttle is used to control the power of the engine. On a piston engine, the throttle controls the throttle opening of the carburetor to control the amount of cylinder charge to determine the engine's output. The accelerator pedal is part of the automotive fuel supply system. By controlling the amount of pedaling, the engine throttle opening is controlled, the intake air amount is controlled, and the computer controls the amount of oil to control the engine speed. The throttle on the car is the medium for the driver to control the vehicle's power. It directly receives the driver's driving intention and feeds the driver's intention into the vehicle's power system. The engine's control is adjusted through the internal control of the power system. The operating state is achieved to achieve the driver's driving purpose. In the vehicle, the driver directly touches the accelerator pedal.

There are two different types of throttles, one is the mechanical throttle and the other is the electronic throttle. The mechanical accelerator pedal is a type of accelerator pedal that is used earlier in the car and has a longer duration. It is connected to the mechanical throttle of the vehicle engine through the throttle cable. The force of stepping on the throttle is different, and the opening of the throttle is different; the throttle The opening degree will transmit the opening degree to the ECU of the engine through the position sensor installed above. When the ECU receives the signal, it will judge the driver's intention according to the MAP data and other related parameters that have been calibrated, and calculate the appropriate The amount of fuel injected controls the fuel injection system to complete the fuel injection action, and finally releases the power required by the driver through the combustion release and power transmission of the engine. Corresponding to the mechanical accelerator pedal and throttle are the electronic accelerator pedal and the electronic throttle, which means that the system transmits electrical signals. After the driver controls the throttle, the throttle generates an electrical signal to the ECU of the engine. After processing, the ECU controls the stepping motor of the electronic throttle to open the electronic throttle to a proper opening degree, and determines the appropriate fuel injection amount according to other parameters. Complete engine power output.

In two different throttle systems, the throttle has a bypass structure, and the idle speed can be adjusted by the bypass structure engine. For example, in different states such as cold car, hot car or air conditioner,
the driver does not need to control. The throttle, the vehicle engine ECU can adjust the current working state of the engine according to various parameters and switching signals received.

How to automatically control the engine, a device can be connected between the accelerator pedal and the engine. This device can convert the mechanical adjustment into electrical regulation. When the accelerator pedal is connected, the throttle linkage plate is connected. The connecting device includes the motor and the encoder, gear reducer, etc., the accelerator pedal and the gas door linkage are rotated by the rotating arm. The DC motor is used to drive the rotating arm. Before the bulldozer starts working, the corresponding construction data is manually input, and the vehicle controller ECU automatically generates commands. The encoder converts the rotation angle of the collected DC motor into an electrical signal and transmits it to the on-board controller ECU through the cable. After the vehicle controller ECU analyzes, judges, and calculates, the relationship between the generated command signal and the electrical signal sensed by the encoder is obtained. According to the relationship between the two, and issued a command to the DC motor, the DC motor is controlled to change the DC motor forward and reverse, and the opening of the throttle is controlled by the cable of the gear reducer to adjust the combustible mixture. The flow rate, when the load is heavy, the throttle opening is large, and the flammability entering the cylinder. There is a lot of mixture to control the speed of the car.

Figure 2 Schematic diagram of engineering machinery engine automation control

The steering angle measurement of an unmanned roller compactor is relatively simple and can be solved with a dual laser sensor. The dual laser sensor and the reflector are mounted on the front and rear wheels of the roller, respectively, and the mounting orientation is perpendicular to the axis of the vehicle body. The steering angle measurement of the roller is based on measuring the distance between the dual laser sensor and the reflector. That is, each laser sensor emits laser light at a time, receives the laser reflected from the reflector, and calculates the installation distance between the laser sensor and the reflector through the time difference. The dual laser sensor measurement signal is received by the signal acquisition instrument and the steering angle of the roller is determined based on the installation distance between the two laser sensors. This on-line measuring roller steering angle technology is an active non-contact method, which is not affected by the hinged clearance of the front and rear of the roller, the telescopic error of the steering drive cylinder, temperature, etc. It has the characteristics of high precision, high speed and wide adaptability, and is very suitable for the driverless roller, thus suiting the need for steering angle measurement and control.

The steering angle measurement of an unmanned bulldozer is more complicated than that of a roller compactor. A conventional track-type tractor usually has only one engine and requires a horizontal shaft
to transmit power to the drive wheels on both sides. Therefore, the most common steering method is
The use of two clutches between the horizontal axis and the final drive on both sides, cutting off one
side of the power can cause speed differences on both sides of the track to achieve steering. Therefore,
the steering mode is actually closely related to the transmission mode. We can roughly measure the
steering angle of the crawler bulldozer in the following way: When the bulldozer turns to the right, the
hydraulic pump supplies power to the left drive wheel, and the clutch cuts off the power of the right
drive wheel, so that when turning, the bulldozer makes the right The driving wheel is a circular motion
of the center of the circle. Using the physical knowledge of the circular motion, the arc of the left driving
wheel can be obtained, and the steering angle can be obtained by using the arc.

There is still a problem that how to automate the control of the steering wheel, the steering system
of the unmanned bulldozer includes steering gear, steering controller and full hydraulic steering. When
the roller automatically turns to the steering, the steering controller first receives the command in real
time. The steering angle is then measured by the above method and a steering angle signal is sent to the
steering controller. The steering controller analyzes, judges, and calculates both the received corner
command and the detected corner signal, and issues a command to the steering motor according to the
relationship between the two. The steering motor applies a steering torque to the steering wheel that
passes through the steering shaft, the steering universal joint and the steering transmission shaft, and
finally the hydraulic steering gear. The hydraulic steering gear controls the movement of the telescopic
steering hydraulic cylinder to realize hydraulic steering.

The steering motor adopts three-loop control, which is mainly for the closed-loop control of the
steering motor system. The so-called three-ring is three closed-loop negative feedback PID adjustment
systems. The voltage mapping current changes, the current mapping torque magnitude, the torque
magnitude maps the change of the rotational speed, and the rotational speed also maps the change of the
angular position, and the electrical and physical fusion is achieved through the three-loop control. This
can help to achieve very precise and reliable control of the steering motor system.

1. steering wheel 2. steering rod 3. universal joint
4. Sensor 5. Steering motor 6. Hydraulic pump
Figure 3 Schematic diagram of automation control of engineering machinery steering mechanism
Some construction machinery construction work is more complicated, but some are relatively simple. Installing radar on the front and rear of the roller compactor can avoid collision with obstacles, but bulldozers and excavators are not. Driverless, must be involved in computer vision. Furthermore, it refers to the use of cameras and computers instead of the human eye to identify, track and measure the machine vision, and further graphic processing, so that the computer processing becomes more suitable for human eye observation or transmission to the image of the detection as a Science disciplines, theories and techniques related to computer vision research, and the creation of artificial intelligence systems that can capture "information" from images or multidimensional data.

3. Application of computer vision

Computer vision involves images, cameras, and GPU computing. The image contains: dimension, height, width, depth, channel number, color format, data first address, end address, data volume, and so on. Industrial cameras are generally used for photographing, but the specific camera used depends on the actual scene. It is possible that the algorithm cannot solve the problem. It only needs to be replaced by a hardware and can be easily solved. Computer vision and image processing certainly cannot skip GPU computing. The GPU pays attention to throughput and can process large amounts of data at the same time.

Taking the bulldozer as an example, the bulldozer needs to identify obstacles when working. The obstacles also include the operating object, that is, the mound. Then how to accurately identify the mound. In deep learning, convolutional neural networks are a class of feedforward neural networks with convolutional computation and deep structure. They can be constructed by mimicking the visual perception mechanism of biology and can be used for supervised learning and unsupervised learning. In the convolutional neural network, we first choose the Relu function. The definition of the Relu function is:

\[ f(x) = \max(0, x) \]  

The image of the Relu function is shown below:

The convolutional neural network consists of several convolutional layers, a Pooling layer, and a fully connected layer, and various convolutional neural networks can be constructed.
The layer structure of the convolutional neural network is quite different from the layer structure of the fully connected neural network. The neurons in each layer of the fully connected neural network are arranged in one dimension; while the neurons in each layer of the convolutional neural network are in three dimensions. The last two layers of the network shown above are fully connected layers. Each neuron in the first fully connected layer is connected to each of the five Feature Maps in the previous layer, and each neuron in the second fully connected layer (that is, the output layer) is connected to each element of the Feature Map. Thus, obtaining the output of the entire network.

In the convolution calculation process, we can number each pixel of the image. Use $i$ and $j$ to indicate the $i$ row and $j$ column elements of the image. Number each weight of the filter, use $w_{m,n}$ to indicate the weight of row $m$ and column $n$, with the $w_b$ offset term representing filter. Number each element of the Feature Map, use $a_{i,j}$ to represent the $i$ row and $j$ column elements of the Feature Map. Use the representation activation function (this example selects the Relu function as the activation function). Then, use the following formula to calculate the convolution:

$$a_{i,j} = f \left( \sum_{m=0}^{2} \sum_{n=0}^{2} W_{m,n} x_{i+m,j+n} + w_b \right)$$

(2)

In the following two formulas, $W_2$ is the width of the Feature Map after convolution; $W_1$ is the width of the image before convolution; $F$ is the width of the filter; $P$ is the number of Zero Padding, which is a number of zeros around the original image, if the value of $P$ is 1, then make 1 circle 0; $S$ is the stride; $H_2$ is the height of the Feature Map after convolution; $H_1$ is the width of the image before convolution.

$$W_2 = (W_1 - F + 2P) / S + 1$$

$$H_2 = (W_2 - F + 2P) / S + 1$$

(3)

The training of convolutional neural networks is more complex than the fully connected neural network. The chain derivative is used to calculate the partial derivative of the loss function for each weight, and then the weight is updated according to the gradient descent formula. The training algorithm is still a back propagation algorithm.

In the context of big data, we can get the training model through caffe, first Data preparation, prepare obstacles that may be encountered by bulldozers at work, such as people, mounds, other construction machinery, etc., create a database, then conduct a training network, then test the network using test data, and test the network using an image. The extracted features are displayed, and finally the mound is accurately identified, and the bulldozer starts the operation.

Unmanned construction machinery has many system advantages, such as bulldozers. The unmanned
bulldozer is fully automated in terms of engine control, steering wheel control, travel control, and job control. In the future, the infrastructure projects in the country will also be basically unmanned, and the labor will be completely replaced by automation. The driver can be completely liberated without having to operate the bulldozer for construction work. Before carrying out construction work, you only need to send some construction data to the bulldozer. After the bulldozer receives the command from the on-board controller, it automatically starts working without human intervention. The unmanned bulldozer can also realize the cluster operation, and one person can control several bulldozers, effectively liberating the labor and saving labor costs.

In summary, with the development of economy and technology, the driverless technology has been widely applied to civil engineering and water conservancy projects, and has been accepted by the development of society. Through the combination of unmanned technology and engineering machinery, it has been improved. The efficiency and precision of construction machinery construction operations improve the development speed of construction machinery.

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