International Core Journal of Engineering Volume 7 Issue 8, 2021
ISSN: 2414-1895 DOI: 10.6919/ICJE.202108_7(8).0002

Driving Safety Daemon-intelligent Track Monitoring Device

Yujun Pan[1,a], Yuji Sui[1], Luying Yuan[1], Jinyingjie Zheng[1], Bingxiang Liu[1], Junyi Zhou[1], Linxin Chen[1]

[1]Ryan College, Wenzhou Polytechnic, Wenzhou 325035, China.

[a]panyujun0713@126.com

Abstract

"Safety first" is the basic requirement for passengers to take rail transit, and it is also the primary task of rail transit operation and management. In order to solve the existing track monitoring problems, improve the ways of track maintenance, and reduce the investment of human resources in track monitoring, a set of intelligent track monitoring devices was innovatively designed. This device uses ultrasonic technology to obtain the information of the measured object and processes it to form an image for rail monitoring; uses thermal imaging technology to decompose the thermal radiation pattern of the object received by the infrared telescope into thermal radiation signals, and focus it on the infrared detector for detection Together with the image and video system, the thermal radiation signal is amplified and converted into a video signal, which is transmitted to the train cab and ECU for monitoring; Through the three-level early warning technology, different signals from the wireless sensors received by the controller are used to activate different levels of early warning mechanisms and processing schemes. This device has the advantages of high monitoring efficiency, high reliability, and low manufacturing cost, and the device is marketable.

Keywords

Rail Transit; Smart Track Monitoring; Three-level Early Warning.

1. Introduction

Smart cities are subtly entering all areas of our lives, such as smart industries, smart applications, smart services, smart governance, and smart transportation. Among them, the development of smart urban rail has only just started and is rarely applied to the grassroots of railroads.Although the track problem may seem trivial, it is crucial to driving safety.

"Safety first" is the basic needs and primary standards of passengers [1], and it is also the subject of rail transit operation and management.Driving safety is an important issue that cannot be ignored in rail transit, a prerequisite for smooth and efficient operation of rail transit systems, and a goal pursued by every urban rail person.Under the guidance of the modern rail transit spirit of "safe, high-quality, and prosperous roads", we strive to monitor driving safety by building smart rails and promote the vigorous development of my country's rail transit industry.

Now, China's urban rail transit has the largest operating mileage in the world, far higher than other countries in the world. As of the end of 2020, a total of 45 cities in mainland China have opened 244 urban rail transit operating lines, with a total length of 7969.7 kilometers. The length of newly added operating lines that year was 1233.5 kilometers , see Figure 1 [2].

Even with such a powerful scale, there are still many small problems, such as track damage, debris intrusion, biological invasion, etc. These seemingly inadequate problems have hidden huge safety

ISSN: 2414-1895 DOI: 10.6919/ICJE.202108_7(8).0002

hazards behind them, which require a lot of human resources to carry out. Monitoring and maintenance.

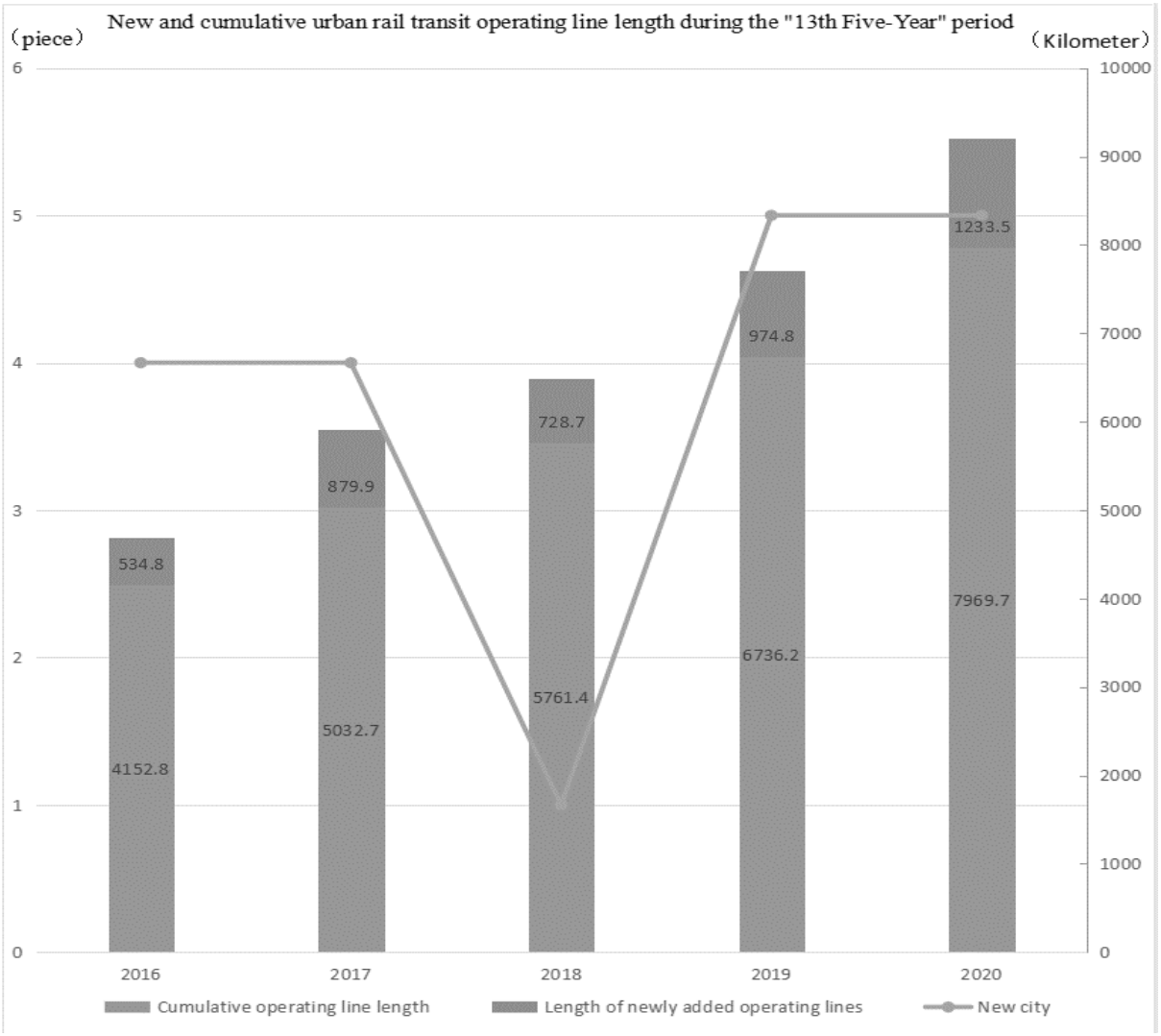

Figure 1. New and cumulative urban rail operating line length during the "13th Five-Year Plan" period

There are hard-working maintenance personnel on each track, and it is sad that every year, many workers are injured or even killed by the work of maintaining the track. There are also many tragic accidents involving heavy casualties and economic losses caused by track foreign bodies and improper track maintenance.

However, behind every serious accident, there are 29 minor accidents, 300 near misses and 1000 hidden dangers [3]. This also warns us that we should take precautions against gradual failures, increase the monitoring and maintenance of tracks, and eliminate hidden track hazards that affect driving safety in the bud.

2. Development status at home and abroad

With the development of science and technology, more and more attention has been paid to environmental issues. In the early stages of rail transit development, due to lack of technology, manual cleaning of road surfaces was the only option. However, manual cleaning methods are not only labor-intensive, but also very inefficient Therefore, foreign countries have begun to develop various cleaning machinery. Since the 1960s, in many industrialized countries, such as Europe, the United States and Australia, track cleaning has received unprecedented attention and development.

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Since the 1960s, my country has gradually begun to attach importance to track cleaning technology, and introduced foreign technology and equipment, and successively developed a variety of track cleaning devices. In 1964, the Research Institute of Railway Forces designed my country's first track cleaning equipment. However, because the quality of domestic hydraulic components was not good enough at that time, there was a serious oil leakage situation, which caused unstable work and often derailed. After a period of actual work, it could not be put into use.Due to the very limited conditions in all aspects of our country at that time, it was unable to support the research, so that the development of domestic track cleaning equipment stagnated for more than two decades. In 1986, under the joint efforts of Jilin Province General Machinery Factory and the Locomotive Depot of Shenyang Railway Bureau, a relatively technologically perfect track cleaning equipment was developed, and in 1987 it passed the national technical appraisal. But its functions are limited to railway shunting machines, transporting goods and small operations [4].

Up to now, my country's technology in track cleaning and maintenance is still not very mature, and manual cleaning and maintenance methods are basically used. This not only consumes a lot of human resources, but also makes track monitoring work inefficient. For some dedicated tracks, due to the special environment in which they are located, it is required that the tracks must be cleaned and maintained frequently. In response to the above problems, we have developed a smart track monitoring device with good reliability and advanced technology. The main design idea is to upgrade the train's own obstacle removal device to meet the specific cleaning requirements during train operation.

3. The basic idea

There are three main ways of track monitoring: one is manual monitoring, which arranges track staff for regular inspection and maintenance; the other is track cleaning and maintenance vehicles, which patrol and maintain on time; the third is to upgrade and upgrade the train’s own obstacle removal device. Become a smart track monitoring device. The above-mentioned scheme one is not only labor-intensive, but also unable to improve work efficiency and cannot meet the requirements; scheme two is currently not mature enough in domestic technology, the research and development costs are high, and implementation is difficult; and the third scheme provides for the existing rail transit A simple, effective and practical solution, moderate cost, small workload, and real-time monitoring of track conditions during train operation, complete maintenance work, and ensure driving safety.

Therefore, this work provides a smart track monitoring device that is conducive to ensuring the safety of driving. It combines ultrasonic technology and thermal imaging technology to solve the defects in the existing technology, improve the way of track maintenance, and reduce the investment of human resources in the track. , To realize the intelligence, visualization and networking of track monitoring. Through various data researches, the smart track monitoring device has multiple advantages such as high reliability, convenient disassembly, energy saving and environmental protection. The product innovation points are shown in the figure.

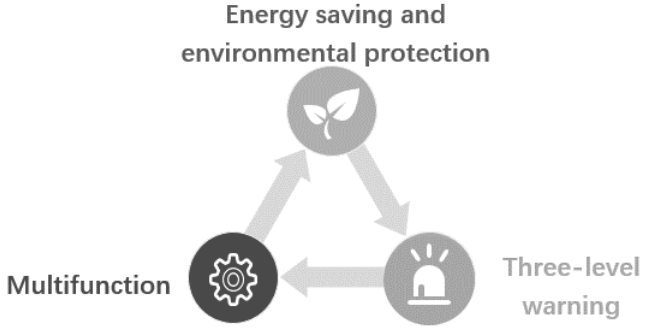

Figure 2. Product innovation

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4. Analysis of key technologies

4.1 Working principle of three-level early warning

According to the different operating status of the train, intelligent monitoring of three-level early warning transmission is carried out. Through the operation of the train, the gear pair (consisting of the transmission gear 1, the transmission gear 2, the driving gear, and the internal gear) is driven to run, and at the same time the arc plate is driven to rotate, and the foreign matter on the track is cleaned. When the train is running and encounters trackside foreign objects of different sizes, the controller receives different signals from the wireless sensors and activates different levels of early warning mechanisms and processing schemes. (Figure 3, Figure 4.)

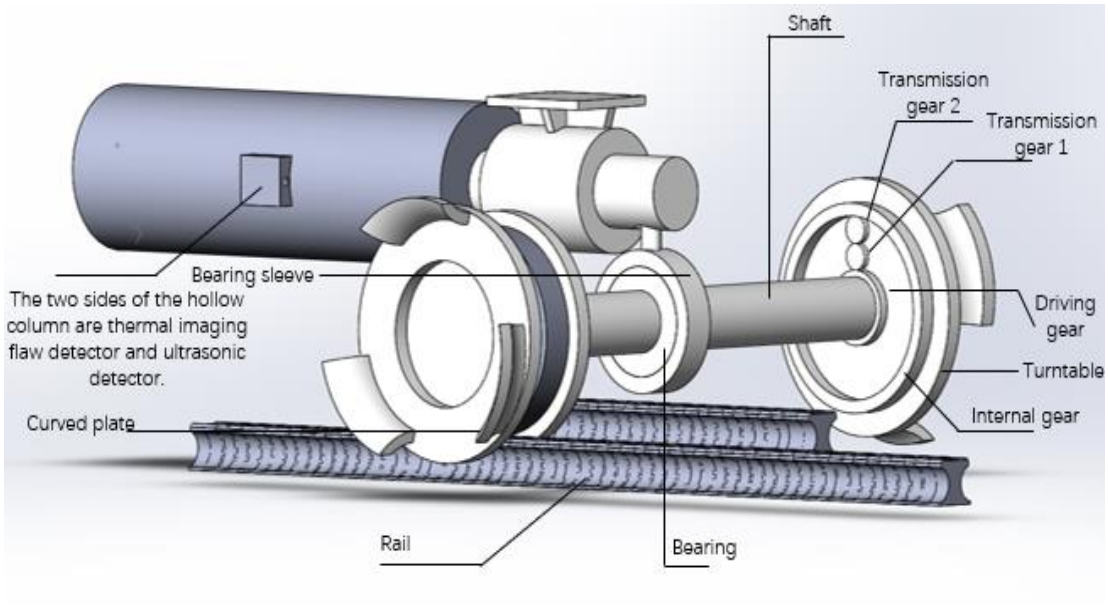

Figure 3. Verall equipment diagram of the device

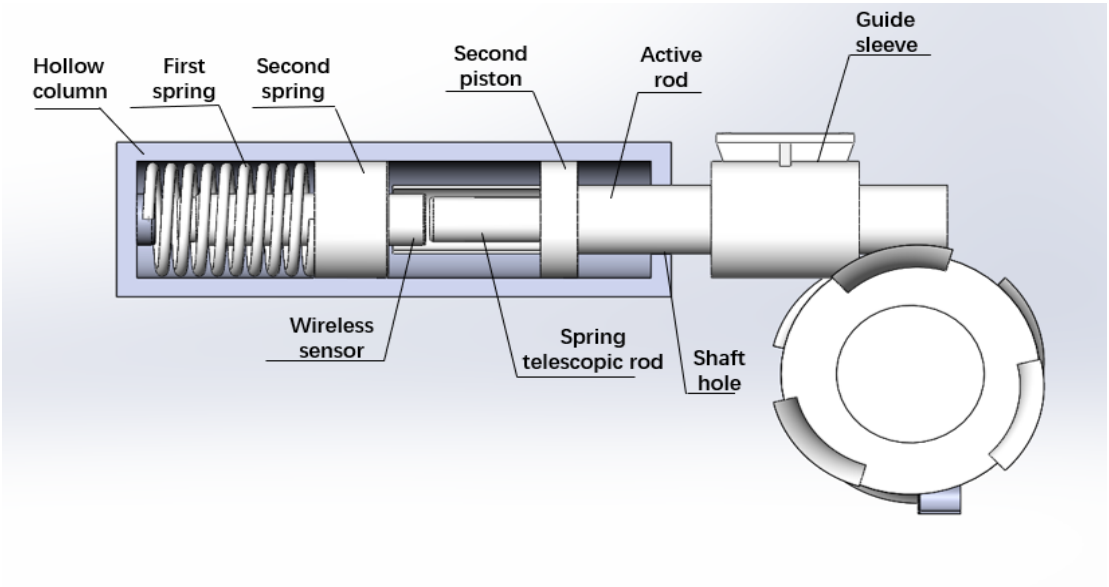

Figure 4. The interior display of the hollow column

When the train is running and encounters a small foreign object beside the track, the controller will receive the signal from the front wireless sensor and give a first-level warning, and the curved board will automatically remove the foreign object (as shown in Figure 5).

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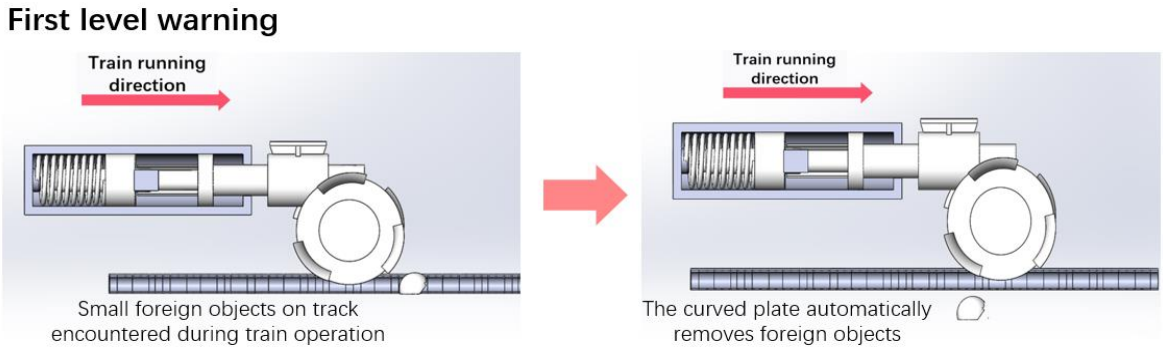

Figure 5. First-level early warning simulation

When the train is running and encounters a large foreign object beside the track, the telescopic rod will contact the wireless sensor, and the controller will receive the signal from the wireless sensor at the rear, and activate the secondary warning, control the train to decelerate by 20-30%, and help the train to run smoothly. (Figure 6).

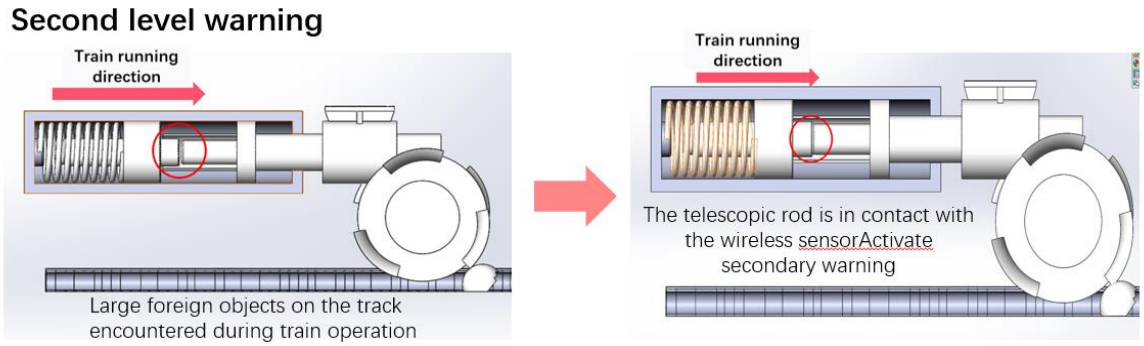

Figure 6. Second-level early warning simulation

When the train is running and encounters large trackside foreign objects continuously, the telescopic rod and the wireless sensor continuously contact for many times. The controller continuously receives the signal sent by the wireless sensor, starts a three-level warning, and controls the train to decelerate by 30-40%, and Transmit the track obstacle signal to the master control room, and the dispatcher will send inspectors to clean up the corresponding track foreign objects, and at the same time order the driver to self-check the train to determine whether it can continue to run (Figure 7).

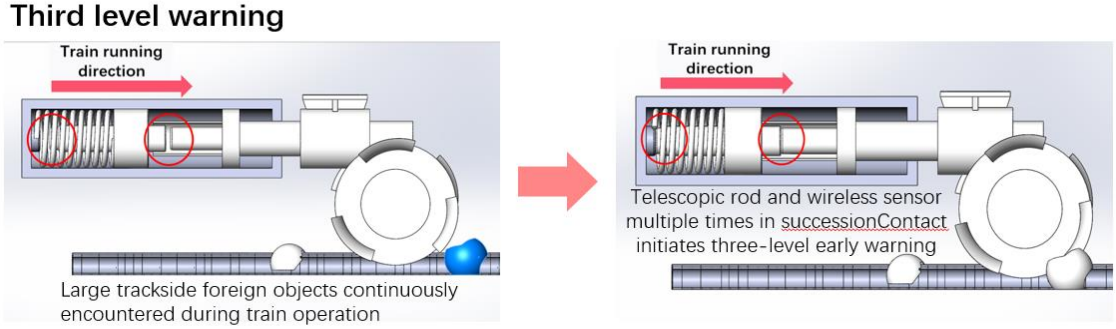

Figure 7. Third-level early warning simulation

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4.2 The working principle of thermal imager

The thermal imager decomposes the thermal radiation pattern of the object received by the infrared telescope into thermal radiation signals and focuses them on the infrared detectors. The detectors and the image video system amplify the thermal radiation signals and convert them into video signals for transmission to the train cab and ECU monitors (Figure8.).

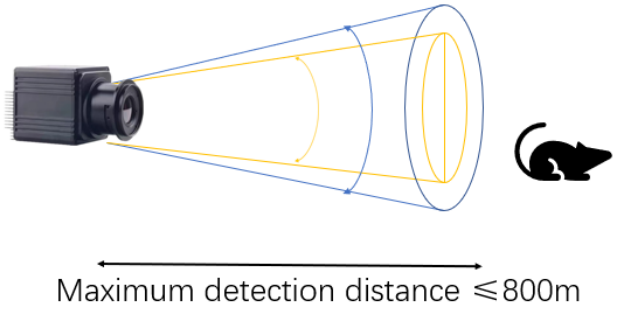

Figure 8. Thermal Imager

4.3 Working principle of ultrasonic flaw detector

Ultrasonic flaw detectors use the principle that changes in different materials and substances have a certain influence on the transmission of ultrasonic waves, and use their reflection and Doppler effect to obtain information about the object to be tested and processed to form an image for monitoring (Figure9.).

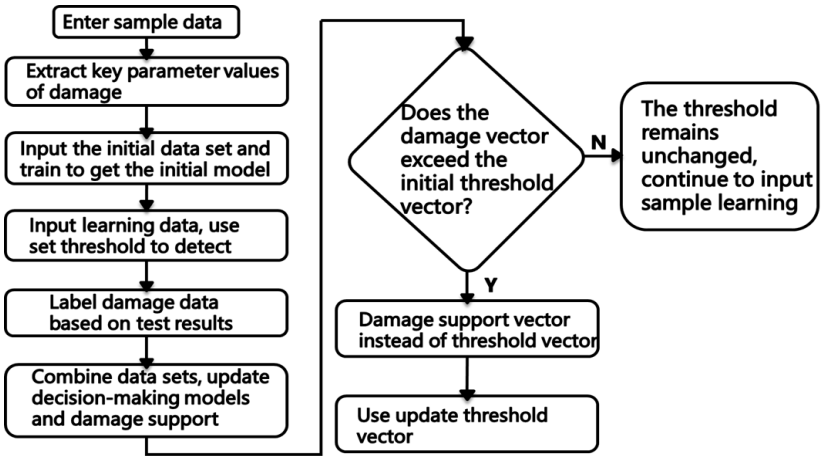

Figure 9. Working principle of ultrasonic flaw detector

4.4 Technical route

The smart track monitoring device uses ECU as the control core, records GPS information at all times, and is also equipped with a foreign body cleaning device and a wireless pressure sensor. When encountering trackside foreign objects of different sizes, the ECU receives different signals from the wireless pressure sensor and activates different levels of early warning mechanisms. When the first-level warning is activated, the arc-shaped plate on the foreign body cleaning device automatically removes the foreign bodies; when the second and third-level warning is activated, the ECU transmits the received warning signal to the locomotive, the train decelerates, and the master control room judges and selects the specific treatment plan . At the same time, this product is equipped with other intelligent modules, which comprehensively apply thermal imaging technology and ultrasonic flaw detection technology. It detects and recognizes the living beings through the infrared thermal imager,

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and sends the imaging target to the ECU to prompt the train to whistle to drive away the living beings. Using ultrasonic flaw detection, the defect wave signal is sent to the ECU, and the main control room dispatches maintenance personnel to inspect and repair the track. In addition, a variety of intelligent modules can be additionally configured in the later period to facilitate user operation (as shown in Figure 10.).

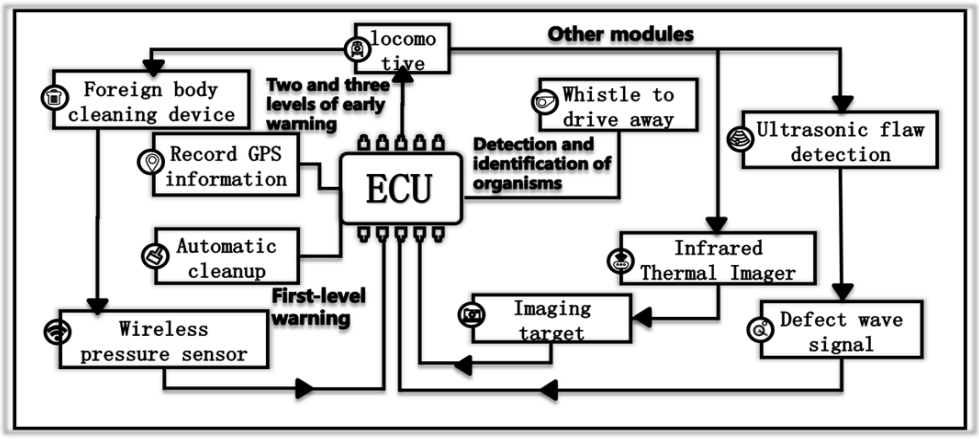

Figure 10. Technical route of smart track monitoring device

5. Application prospects

5.1 Product instructions

The smart track monitoring device uses ECU as the control core, and the train's own obstacle removal device is modified and upgraded. As the train moves forward, the curved plate is located on the outer side of the track and rotates with the turntable to remove foreign objects such as stones beside the track to avoid disturbing the train. Affects the operation of the company. Simultaneous detection beside the track creatures with thermal imaging, ultrasonic flaw detection technology is used to monitor track damage, and human-computer interaction is realized through wireless sensing devices, and faults can be quickly analyzed and eliminated. A variety of modules can be additionally configured to facilitate user operation. Convenient disassembly, energy saving and environmental protection, low cost, convenient use, centralized maintenance, and a wide range of functions.

5.2 Advantage

The device has high reliability, greatly improves driving safety, solves the defects in the prior art, reduces the waste of human resources, and realizes the intelligence, visualization and networking of track monitoring. This device can clean the small and medium-sized gravel on the track through the three-level early warning method, and ensure the smooth and safe operation of the train. It also combines the use of ultrasonic flaw detection technology and thermal imaging technology to achieve track monitoring; it can also be installed in the track cruise on the vehicle, it can clean up foreign matter in the track. In the case of serious obstacles in the track foreign matter, the manual inspection can reduce the investment in orbit human resources and reduce the burden on cruise personnel; this device can also replace some human judgments and cooperate with the sensor can be used for drone driving.

5.3 Adaptation scope and promotion prospects

The original intention of the smart track monitoring device is to ensure the safety of train operation, clean foreign objects on both sides of the track, and prevent the train from derailing and squeezing due to foreign objects during the traveling process. At present, my country's rail transit industry is developing rapidly. Major cities have successively invested heavily in the construction of rail transit. After meeting people's needs for convenient travel, safety issues during rail transit operations have

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become the most concerned issue. The smart track monitoring device developed by us can remove foreign objects on the track in real time during the operation of the train, monitor the track condition, and complete maintenance work to ensure people's travel safety. This device will continue to improve and improve related technologies and equipment. While providing a strong guarantee for the safety of domestic rail transit, the device technology can also be brought to the countries along the Belt and Road through the One Belt One Road strategic plan, such as my country's Pakistan, which has had friendly diplomatic relations for decades, has frequent railway safety incidents and lacks relevant safety protection facilities. If the item device is used, it will be of great help to reduce railway safety accidents and improve driving safety.

5.4 Market analysis and economic benefit forecast

The smart track monitoring device selects the appropriate configuration according to the market changes in the price of related important parts, and its cost can be controlled at 50000-100000 yuan. Compared with other rail transit equipment, its manufacturing cost is lower. After deducting the Early installation and post-maintenance costs, its profit can be nearly 30%, and the utilization rate of human resources can be reduced by more than 70%, which not only ensures people's travel safety, but also reduces the labor cost of rail transit operations. Based on the rapid development of urban rail transit in my country, as of the end of 2020, 45 cities in mainland China (excluding Hong Kong, Macao and Taiwan) have opened urban rail transit, with 244 operating lines and a total length of 7969.7 kilometers. The market demand potential is huge, and Compared with the existing related track-clearing equipment in foreign countries, based on its cost and high introduction cost, the benefits of putting it into use will be much lower than this device. Therefore, the smart track monitoring device has a huge market development potential.

With the continuous improvement of people's living standards, the increasing demand for fast-paced travel, and the country and the government vigorously develop the rail transit industry and promote the continuous development and maturity of related safety equipment, this product will definitely be able to achieve more substantial development in the future. Wide range of applications.

6. Conclusion

Through research, it is concluded that the smart track monitoring device proposed in this paper has the advantages of high reliability, energy saving, environmental protection and diversified functions, which solves the shortcomings of the existing track monitoring technology and reduces the use of human resources. The combination of thermal imaging technology and ultrasonic technology improves the safety and monitoring efficiency of trains during driving. And the three-level early warning is flexibly applied to the smart track monitoring device to ensure the smooth and safe operation of the train and improve the comfort of passengers.

This device mainly reduces the manufacturing cost by refitting the old a pair of wheels and simplifying the structure. It has a huge market development potential and popularization, and it will achieve considerable development and wide application in the future.

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