ISSN 2616-5775 Vol. 6, Issue 12: 164-169, DOI: 10.25236/AJCIS.2023.061220

# A Risk Management Method for the Whole Route of Ferry Vehicles Based on Machine Recognition

**Xu Huang[1,a], Jing Zhang[2,b], Tianfu Chen[2,c]**

*[1]Huashe Design Group Co., Ltd, Nanjing, 210014, China*
*[2]Nanjing Banqiao Ferry Service Center, Nanjing, 210007, China*
*[a]hohuangpe@163.com, [b]435487907@qq.com, [c]379530320@qq.com*

***Abstract:*** *In response to the current information acquisition methods in the safety management process of crossing transportation vehicles, backwardness of backwardness, large manpower and material consumption, and video surveillance resources are not fully utilized, this article promotes the in -depth integration of artificial intelligence machine vision technology with the ferry business through the automatic analysis and processing technology of monitoring videos. It realizes the real-time monitoring of the operating status of the ferry vehicle and the refined control of dangerous events, providing new means for the operation monitoring of crossing vehicles, and effectively supporting the high -quality development of ferry transportation.*

***Keywords:*** *Ferry vehicles; Machine identification; Risk control; Informatization*

## 1. Introduction

As an important part of transportation, the safety production of waterway transportation is under the key control of industry departments. In recent years, the national and industry competent departments have issued a number of policy documents, requiring further strengthening the control capacity of passenger ships, especially the Yangtze River passenger ships. In 2020, the Safety Committee of the State Council issued the Three Year Action Plan for the Special Rectification of National Work Safety, which pointed out that the safety supervision of "four types of key ships" and "six zones and one line" key waters should be strengthened, and ferries should be severely cracked down on adventurous voyages that exceed routes, passenger quotas, approved load lines, and approved wind resistance levels [1]. In response to the national policy requirements, Jiangsu Province took solving the Yangtze River crossing safety problem as a breakthrough to comprehensively improve the channel safety production management service capacity. Jiangsu Maritime Safety Administration issued the Specifications for Construction and Operation of Shore based Monitoring System for Ferry Units in Jiangsu Section of the Yangtze River. The document clarifies that all units of Yangtze River Ferry should focus on risk management and control and hidden danger management, strengthen the application of scientific and technological means, and must use informatization means to promote the construction of shore based monitoring system and improve the level of safety development. In order to implement the requirements of national and industry regulatory authorities, effectively control major risk sources of ferry transportation, it is particularly necessary to enhance safety management capabilities through information technology, intelligence and other means.

At the same time, the world is now in the gestation stage of a new round of technological revolution, and technological innovation is becoming increasingly active. With the introduction of multiple policies such as the Guiding Opinions on the Development of Intelligent Shipping [2-3], the innovative application of AI, 5G and other high-tech technologies in the fields of ships, ports, waterways, navigation security, safety supervision and operation services is increasingly widespread, which will have a significant impact on waterway infrastructure, transport equipment, transport organization mode and governance mode, giving new momentum and advantages to the development of water transport. Ferry navigation safety is one of the major risk sources of waterway transportation, and ferry vehicles are the main goal of ferry transportation safety. It is an inevitable trend of technology development to improve the safety management ability by using the new generation of information technology, which will also provide important reference cases for the industry.

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## 2. Analysis of the current situation of ferry vehicle management and control business

The on-site management of ferry vehicles belongs to the station area management business. There is a ferry ticket inspection room set up at the ferry terminal site. After the ferry vehicle passes the gate and pays the fare, it enters the ticket waiting area. The ticket inspector collects the toll station's triple copy ticket and scans the QR code to log in to the vehicle information. Afterwards, the ticket checking staff drafted a single ferry transportation plan based on the vehicle type and load capacity. After the ferry docked, the waiting vehicles entered the ferry in an orderly manner according to the guidance of the ferry area staff.

The safety supervision of ferries in the Jiangsu section of the Yangtze River is typical of Banqiao Ferry. Banqiao Ferry has four staff members in the ferry area to carry out traffic management work. One controls the release of vehicles one by one at the ticket checkpoint according to the ferry transportation plan, one guides vehicles to get on and off the ferry at the ferry pier, and two guides vehicles to stop according to the ferry transportation plan on the ferry. During the ferry navigation process, safety inspections are conducted on the ferry vehicles, as shown in Figure 1.

*Figure 1: Traffic management of ferry vehicles*

The traditional manual scheduling method can achieve the safety management of the vast majority of ferry vehicles, but this method has several shortcomings: firstly, the timeliness of vehicle risk control is weak. When safety risk behaviors such as slope sliding, car sliding, and unstopped high-speed trains occur in ferry vehicles, it is difficult for ferry management personnel to intervene in a timely manner. They often intervene urgently after slope sliding and other events occur, which poses certain risks and hidden dangers. Secondly, there is a lack of risk tracking for the entire route of ferry vehicles, and the shore based command center has a blind spot in vehicle risk monitoring. It is unable to track the entire route of safety factors such as the location of vehicles and risk factors, and it is difficult to respond to vehicle risk status in a timely manner based on key node vehicle element information (weight, cargo, passing time, etc.) and make decisions in advance.

The Banqiao ferry transportation area fully covers the 5G ship shore collaborative private network, which can achieve real-time online and backend synchronization of high-definition videos for cross strait and ferry transportation processes. Through the widely distributed video monitoring facilities in the ferry transportation area, combined with the 5G private network, video monitoring of the entire route of ferry vehicles can be achieved. On this basis, real-time monitoring of vehicle safety risk events is achieved through artificial intelligence AI machine vision technology, achieving full route risk tracking of ferry vehicles, and enhancing timely, efficient, and comprehensive coverage of vehicle risk control.

## 3. Research on Target Tracking Technology for Ferry Vehicles Based on AI Machine Vision

Visual sensors can capture road images to obtain contour, color, texture, and deeper level feature information, possessing the ability to detect and recognize objects, such as pedestrians, vehicles, lane lines, and other visual objects in the image [4-6]. The target tracking of ferry vehicles includes two parts: target detection and target tracking. After years of research, vehicle detection methods have evolved from early image feature recognition to machine learning algorithms, and now to deep learning methods.

### *3.1 Comparison and Selection of Traffic Element Target Detection Methods*

The task of object detection is to detect the size and position information of target elements (ferry vehicles) from video frames. The quality of traffic videos is usually affected by factors such as weather and obstacles, making it difficult to achieve robust detection of traffic elements from traffic videos. Traditional target features have certain drawbacks in detecting traffic elements, and are greatly influenced by factors such as light. The features obtained through convolutional neural networks can effectively avoid overfitting and improve accuracy. The results are shown in Table 1.

*Table 1: Comparison of Accuracy and Speed of Various Target Detection Algorithms*

| Algorithms | Average accuracy(%) | Speed(fps) |
|---|---|---|
| R-CNN | 79.2 | 0.007 |
| SPP-net | 81.1 | 0.1 |
| Fast R-CNN | 87.6 | 0.5 |
| Faster R-CNN | 95.2 | 7 |
| YOLO v8 | 98.4 | 7.2 |

In traffic scenarios, accuracy and real-time performance are very important indicators. If there are false detections, it will bring a series of problems to the traffic supervision department. This project focuses on traffic element recognition and tracking. Traffic element recognition based on deep features provides accurate location information and border information as initialization for traffic element tracking. Based on this application requirement, this project chooses traffic element recognition based on Yolo V8 as the foundation for traffic element tracking.

The collected sample data was tested on the Yolo V8 traffic element recognition algorithm mentioned above. Under clear weather, good visual distance (visible to the naked eye), no visual interference factors, and no backlight or reflection, the accuracy of motor vehicle recognition reached over 98%. The detection effect is shown in Figure 2.

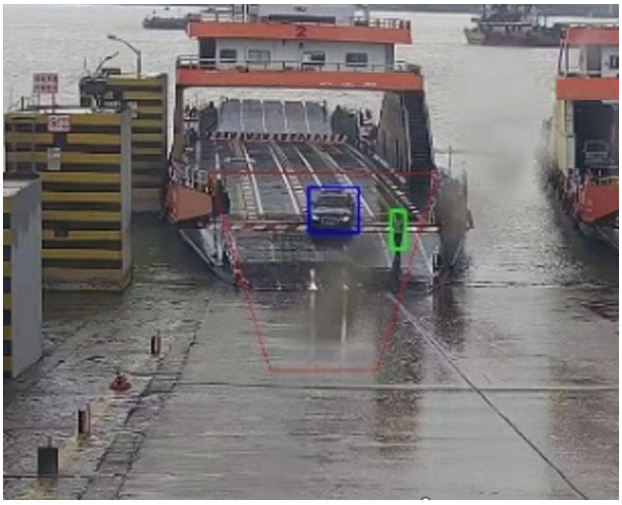

*Figure 2: Motor Vehicle Inspection Results*

### *3.2 Comparison and Selection of Traffic Target Tracking Methods*

The purpose of the target tracking algorithm is to locate the position of the target (ferry vehicle) in each video image frame and generate the target motion trajectory. According to the different number of tracked targets, it can be divided into single-object tracking (SOT) and multi-object tracking (MOT). Due to the mutual influence of multiple tracks, multi target tracking is much more complex than single target tracking [7-10]. The detection of traffic targets in the scene of boarding and disembarking ferries is a typical multi-objective tracking problem.

The development of target tracking has also undergone years of development, such as Kalman filter algorithm, particle filter, mean shift, etc., which are very classic visual target tracking algorithms. However, in practical applications, due to complex changes in the target scene, such as light and shadow interference, tree occlusion, etc., their algorithms generally have low overall accuracy and weak practicality. Compared to traditional object tracking algorithms, deep learning based object tracking

ISSN 2616-5775 Vol. 6, Issue 12: 164-169, DOI: 10.25236/AJCIS.2023.061220

algorithms have also achieved significant improvements in speed and accuracy [11]. In the internationally authoritative MOT challenge multi-objective tracking competition, Byte Track's multi-objective tracking algorithm stands out. This method detects occluded objects from low score detection boxes very succinctly, and has high robustness to occlusion. After extensive testing, it has ranked first in the existing MOT tracking algorithms in MOT17 and MOT21, and its speed has also reached first among all current methods, However, this method is greatly affected by the accuracy of target detection algorithms [12].

In subsequent studies, YOLO's training model was applied to Byte Track target tracking, achieving 80.3 MOTA, 77.3 IDF1, and 63.1 HOTA for the first time on MOT17 at a running speed of 30 FPS, currently ranking first on the MOT Challenge list. Vehicle target tracking based on traffic scenes needs to overcome issues such as occlusion, scale changes, complex traffic scenes, variable vehicle motion states, and real-time requirements. Traditional algorithms are difficult to surpass Byte Track multi-objective tracking algorithms in terms of anti-occlusion and real-time performance.

Based on this, this study adopts Byte Track multi-objective tracking algorithm to track ferry vehicles, and uses YOLO v8 detection results as tracking initialization to improve the accuracy of the tracking algorithm.

## 4. Research on the Risk Control Process and Mode of Ferry Vehicles Based on AI Machine Vision

The control process is shown in Figure 3.

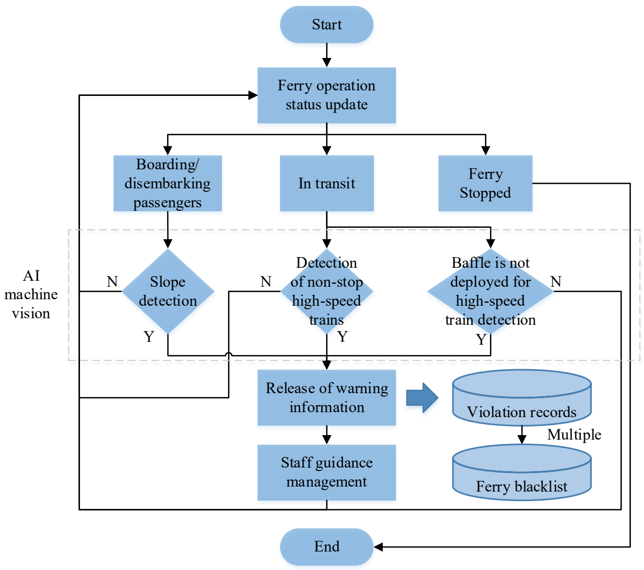


*Figure 3: Risk Control Process for Ferry Vehicles Based on AI Machine Vision*

Ultimately, the entire process and route safety management of ferry vehicles will be achieved. The final risk of the ferry vehicle is displayed on a graph, with the principle shown in Figure 4. The research results are integrated in the vehicle's entire line control platform.


*Figure 4: Schematic diagram of risks for ferry vehicles*

● Detection of ship sliding events

Cars should drive in and out of the dock or ferry at low speeds when entering or exiting the dock or ferry. When driving, the direction should be kept stable, and the accelerator pedal should be controlled to prevent accidents caused by insufficient power or improper handling, which may cause the vehicle to stall and roll back. Therefore, by detecting the operational status of ferry vehicles while boarding and disembarking from the ferry, timely detection of vehicle slip incidents is carried out, and safety organization emergency plans and response measures are provided to prevent and resolve risks.

The characteristic of a ferry sliding event is a sudden change in the direction of the vehicle's travel trajectory during the process of motor vehicle boarding or disembarking. If the ferry vehicle starts to "reverse" its travel trajectory towards the south from a certain moment during the process of boarding or disembarking, it is determined that a ferry sliding event has occurred.

● Detection of non-stopping high-speed train incidents during ferry operation

During the transportation process of a car, the parking brake lever should be tightened at the designated position, the gear lever should be shifted to first or reverse gear, the engine should be turned off, to ensure a safe and stable parking of the vehicle and prevent it from slipping. If the vehicle slides or the driver operates improperly, it is highly likely to cause the vehicle to enter the water or collide with other vehicles or passengers on board.

The characteristic of the event of a motor vehicle not stopping during the operation of a ferry is that the position of the vehicle should remain stationary while the ferry is used as a reference. If it is determined that the event is a motor vehicle not stopping during the operation of the ferry.

● Ship baffle not deployed for high-speed train incident detection

After the ferry docks, due to the completion of berthing safety operations, if the ferry is performing vessel mooring, pushing ashore, or checking whether the mooring is secure, the baffle will be unfolded to release the vehicle. If the baffle is not unfolded, it indicates that the ferry is not safely berthing at this time. If the ferry vehicle forcefully disembarks at this time, it will cause the vehicle to be pushed away from the dock by the reaction force of the vehicle's thrust during the boarding and disembarking process, resulting in the vehicle falling into the water and causing a safety accident.

The characteristic of the ship's barrier not being unfolded high-speed train event is that when the ship is about to dock, the mechanical status of the barrier is recognized or read. If the barrier is not unfolded and the position of the ferry vehicle is identified to have shifted when using the ferry as a reference, it is determined that the ship's barrier not being unfolded high-speed train event has occurred.

## 5. Method implementation and validation

By combining artificial intelligence machine vision with 5G low latency communication technology through system construction, real-time monitoring of the risk status of ferry vehicles along the entire route can be achieved, quickly identifying abnormal risk behaviors such as boarding and sliding, ferry not landing, and high-speed trains with barriers not lowered. The platform displays the collected warning event information in real-time, and has different processing levels for event messages based on different access permissions. The security control platform also has traditional video monitoring functions.

The functional architecture diagram of the risk control system for the front route of the ferry vehicle is shown in Figure 5, which includes five primary functions of risk control, event list display, real-time event monitoring, vehicle trajectory tracking throughout the entire process, and historical event storage, as well as ten secondary function points. The status information of the vehicle in the risk diagram is shown in Figure 6.

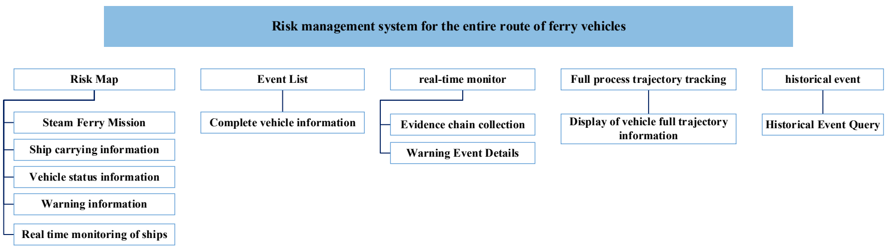


*Figure 5: Functional Architecture of the Risk Control System for the Front Route of Ferry Vehicles*

ISSN 2616-5775 Vol. 6, Issue 12: 164-169, DOI: 10.25236/AJCIS.2023.061220

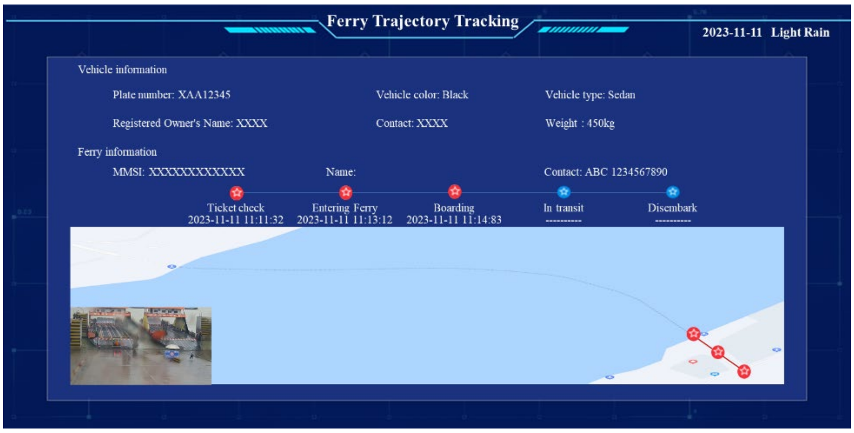


*Figure 6: Schematic diagram of vehicle trajectory tracking throughout the entire process*

## 6. Conclusion

This article is based on AI machine vision to study the full route trajectory tracking, danger warning behavior, and risk control methods of ferry vehicles. It can identify dangerous driving behaviors such as boarding and sliding on slopes, unstopping the ship and moving the train, and unfolding the ship's baffle, forming the function of vehicle trajectory tracking and danger warning throughout the entire process of ferry transportation. On this basis, further closed-loop control of vehicle transportation risks through emergency response processes can effectively improve vehicle safety.

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