Design and implementation of airport vehicle intelligent management and control platform based on 3S

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Abstract. At present, there exists the phenomenon that each airport management department does things in his own way and each system operates independently, so it is necessary to establish a unified platform to realize the collaborative operation of multiple departments. In this paper, 3S (GIS/GPS/RS) technology is used to realize precise positioning of vehicles, personnel and flights through multi-sensor fusion. To achieve the dynamic monitoring of vehicles, automatic alarm and fence management, draw a custom electronic map of the airport based on the high-resolution remote sensing image. Adaptive genetic algorithm is applied to optimizing vehicle scheduling. The vehicle asset analysis and vehicle maintenance management are integrated into the vehicle intelligent control platform, so as to realize the organic integration of airlines, ground service, maintenance center, flight, asset procurement and multiple departments of various organizations. Through the establishment of the platform, the accurate and reasonable dispatching and operation of ground vehicles can be achieved, the operational efficiency of the airport can be effectively improved, and the maintenance of airport ground safety provides a powerful guarantee.

1. Introduction
At present, China's civil aviation industry is developing rapidly. With the constantly increasing of flight density, it also brings great challenges to the management and scheduling of airports and the quality of passenger service[1]. The effective management and scientific scheduling of ground vehicles in airports not only affect the work efficiency of airports, but also affect the important link of flight safety[2-3]. With the continuous development of 3S technology[4-6], intelligent perception, positioning, monitoring and management can be achieved combined with internet of vehicles technology, which provides support for the establishment of a comprehensive airport vehicle intelligent control platform[7]. Domestic and foreign scholars mainly focus on 3S technology and vehicle scheduling algorithm in the research of airport vehicle management[8-10]. However, the current GPS positioning technology has problems of inaccurate positioning and signal loss, and the effect of vehicle monitoring is not ideal. The application of genetic algorithm in vehicle scheduling shortens aircraft transit scheduling time[11]. The manual collection of vehicle data in the airport vehicle maintenance system is very labor-intensive, so it is impossible to truly understand the running condition of the vehicle and thus affect the service life of the vehicle[12]. In this paper, according to the characteristics of airport vehicle management and the pain points of previous airport vehicle management, a complete vehicle intelligent control platform framework is built, and a new airport vehicle management mode is proposed based on 3S technology. The problem of inaccurate GPS positioning and signal loss affecting positioning is solved by multi-sensor fusion. To achieve real-time monitoring and management of airport vehicles based on GIS basic map and business integration of
multiple departments from aspects of vehicle monitoring, automatic alarm, maintenance, vehicle scheduling and others.

2. The overall architecture

2.1 Overall platform architecture

Based on information standard system and information security protection system, a complete airport vehicle intelligent control platform is established through five levels of composition. The platform mainly provides daily vehicle and personnel monitoring and management services for airport ground staff, financial department and asset management department, and provides management decision-making basis for airport managers. The management vehicles cover nearly 20 types of ground handling vehicles, including transport and control vehicles, sewage vehicles, refueling vehicles, ferry vehicles and water vehicles. The data layer provides basic data support and provides geographic information data for the positioning of vehicles, personnel and flights at the airport through customized airport maps. The facility layer provides infrastructure and equipment services, and solves the problem of inaccurate positioning of the current airport vehicle management information system by combining vehicle positioning equipment, UWB positioning technology and inertial navigation equipment. The application layer is divided according to functions and business using departments, including dynamic monitoring, fence management, vehicle maintenance management, vehicle asset management and system management five functional subsystems. The method of project management is used in the construction process to make the project meet the requirements of schedule management.

![Diagram of Overall Platform Architecture](image-url)

Figure 1. Overall platform architecture

2.2 Multi-sensor fusion positioning

The positioning accuracy of ordinary GPS is about 10 meters on average. Due to the influence of satellite ephemeris error, satellite clock error, atmospheric delay, receiver error and multi-path effect, the positioning effect of ordinary vehicle-mounted positioning equipment is not ideal. Multi-sensor fusion positioning technology is used to realize the accurate sub-meter positioning of vehicles, aiming at the problem of inaccurate GPS positioning in complex environment. Multi-sensor fusion positioning...
Technology combines satellite positioning, UWB positioning and inertial navigation to realize complementary advantages of various positioning methods, improve positioning stability and correct positioning errors. Based on the fusion positioning method, accurate position, speed, acceleration, course angle and other information of vehicles can be output, and more sophisticated monitoring and management of airport vehicles can be realized, such as real-time monitoring, historical track, electronic fence, automatic alarm, etc.

2.3 Custom electronic map
Choose legitimate and high quality map vendors, purchase the satellite images with a resolution of 0.3m that have been taken. You can also customize the shooting in designated areas according to your needs to obtain the latest image data. Through image correction, you can obtain the digital orthophoto images with sub-meter accuracy, which can be used as the base map of airport electronic maps. Based on the image map of airport plane corrected, draw internal roads, airport buildings, POI points, etc. and calibration of the airport dedicated landmarks, fixed resources including the terminal, the apron, boarding gate, covered bridges, reservation, runway, taxiway, driveway, cargo terminal, entrance, hotel, charging stations, gas stations, etc. Through map rendering and the release of a variety of map services, it provides basic map services for airport vehicle monitoring. The OpenLayers open source map engine was used to realize map operations such as enlargement, shrink, roaming, ranging, surface measurement, rotation, etc., supporting layers hide and show of flights, vehicles, fixed resources and other layers.

3. Function design and implementation of intelligent vehicle control platform

3.1 Dynamic monitoring
The vehicle intelligent control platform is based on a customized electronic map. It not only monitors the status information of relevant vehicles, people and flights inside and outside the airport in real time from a global perspective, but also displays them on the map with different icons, including the real-time vehicle information of online, offline, fault, maintenance, deactivation, etc. At the same time, the system can dynamically update the real-time information of vehicles, personnel and flights in time, and support the accurate positioning and quick search of vehicle personnel. The platform also supports click-to-display of real-time monitoring information, including vehicle information (including VIN, license plate number, vehicle status information, location information, energy consumption information, etc.), personnel information (including terminal number, driver information, job information, etc.), flight information (including passenger information, flight information, flight status information, etc.) to facilitate operator access to vehicle information. The platform can also judge the state of the vehicle according to the real-time data of the vehicle, and timely alarm the driver, reminding the staff to focus on monitoring the faulty vehicle. For offending or dangerous vehicles, the platform can also issue a serious warning to the driver and reverse control to avoid unnecessary property damage.

3.2 Automatic alarm
The vehicle intelligent control platform can automatically alarm according to the real-time positioning data and vehicle status information, including overspeed alarm, fence alarm, position alarm, yaw alarm, fault alarm, domestic and international error alarm. When the overspeed alarm means that the vehicle exceeds the specified speed of the road, the system will pop up an overspeed alarm. Fence alarm means that when the vehicle enters the prohibited area or exits the restricted area, the system will pop up a prohibited area alarm or an out-of-boundary alarm. The aircraft alarm means that when the user bound by the vehicle performs a certain flight task, the system will pop up a position error alarm prompt when the vehicle position is inconsistent with the current mission position. The yaw alarm means that if the vehicle deviates from the specified driving route, the system will generate a yaw alarm. The fault alarm means that when the airport vehicle fails, the platform collects the fault
information of the vehicle and issues a vehicle fault alarm. The domestic and international false alarms mean that when the on-duty personnel perform a domestic flight mission, the vehicle enters the international area, the system will pop up to perform domestic tasks, and call the international drop-off area to call the police; otherwise, if the on-duty personnel perform the international flight mission, but the vehicle enters in the domestic area, the system will pop up to perform international missions and call the domestic drop-off area to call the police.

3.3 Electronic fence management
In order to limit the operating areas of various types of vehicles in the airport, the platform limits its operating area according to the characteristics and tasks of the vehicle, that is, an electronic fence is set on the electronic map. The platform allows the user to add, delete, change, and check the electronic fence, and automatically update the fence status in real time. When the user needs to increase the fence, the platform provides a variety of shape shapes such as polygons, rectangles, and circles for the user to select, and supports the user to draw the fence on the map. The fence permission is set according to the needs of the airport management, including Drive into monitoring, out of control, effective vehicles, etc. If there is an alarm event in the fence of the vehicle triggering, the platform will pop up a fence alarm prompt until the fence alarm event is eliminated.

3.4 Multi-Constrained Vehicle Scheduling
Draw the underlying road network data of the airport and integrate the airport road network data into a customized electronic map. According to the complicated road environment of the airport and numerous constraint rules, the TSP problem is solved by adaptive genetic algorithm, and the optimal vehicle scheduling path is planned. The multi-constraint conditions mainly include road network rule constraints, no collision constraints, time window constraints, distance/time constraints, electronic fence constraints, and so on. The dynamic monitoring module is used to construct an intelligent airport command and dispatch system. Adaptive genetic algorithm constructs a mathematical model of vehicle scheduling according to various types of guarantee services such as airport fueling, catering, and clearing water, and finds the vehicle scheduling solution which meets the time window and the lowest scheduling cost.

3.5 Vehicle asset analysis
The vehicle asset analysis management summarizes the basic data, maintenance data, maintenance data, driving status, task execution and other data of the vehicle, analyzes and displays the status in the vehicle operation management process according to different business scenarios, and establishes a standardized early warning mechanism for different business scenarios. Early warning of business trends and business indicators. The module uses targeted business algorithms to help decision makers analyze business direction and trends. Data mining and analysis through maintenance, use, assets, accessories, procurement, maintenance, consumption and other dimensions to provide decision support for airline procurement, planning, assets and other departments.

3.6 Vehicle maintenance management
Vehicle maintenance management includes maintenance management, maintenance management, statistical reports and basic data. The maintenance management part is completed by the vehicle use unit or the vehicle maintenance center dispatch inspection room to enter and dispatch vehicle maintenance and maintenance information, manage vehicle inspection, acceptance, dispatch, maintenance, repair and other information; The maintenance management section provides maintenance levels for vehicles that reach a fixed kilometre or engine hours according to the vehicle manual and matches the corresponding level of maintenance, maintains the maintenance level, items, cycles, plans, automatically updates the number of hours and kilometers per vehicle every month, and automatically alerts vehicles that meet the maintenance conditions. The statistical report completes the visual display of fault ranking, inspection failure, monthly daily integrity rate and the integrity of each
model. The basic data comprehensively manages data such as maintenance type, brand information, model information, brand manufacturers, and team information to form a complete vehicle maintenance service.

4. conclusion
The intelligent vehicle management and control platform of the airport aims to organically integrate airlines, ground handling services, flights, maintenance centers, asset procurement and institutions at all levels through intelligent management and control based on 3S technology, and interconnect all links, so that each operation unit can work together on the same platform, to truly realize "intelligent" integration. In this paper, the platform of vehicle intelligent management and control is established by means of multiple sensor fusion positioning and based on the sub-meter level precision custom map through system design of multiple modules of dynamic monitoring, automatic alarm, fence management, vehicle scheduling, analysis of vehicle assets, vehicle maintenance management. Improving the intelligent level of airport service and security management, and the satisfactory service facing passengers is realized in the end.

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