Case Study

11th Gen Intel® Core™ Processors
Intel® Distribution of OpenVINO™ Toolkit
Intel® AI Box

Precise Identification of Vehicles Ensures Efficient Tolling Systems

The Xiaoshen Hitomi Toll Vehicle Identification System Empowers the Construction of Smart Transportation

"Sinoits has been focusing on the application of AI since its inception, particularly in the field of smart transportation. Through the integration of our long-term innovations in algorithms and solution design with Intel's end-to-end advantages in AI technology, our solution is capable of accurately and efficiently identifying key information such as vehicle models to ensure traffic safety and improve traffic efficiency to form a safe, efficient, and environmentally friendly smart transportation system."

- Wu Kewei
CEO, Sinoits

Overview

Smart transportation has been proven to be an effective method to solve traffic congestion, reduce the frequency of traffic accidents, and improve the quality of life for residents. Through the innovation and implementation of artificial intelligence (AI), computer vision, cloud computing, IoT, edge computing, digital twin, and other technologies, smart transportation has seen wide applications in Internet of Vehicles (IoV), smart traffic lights, automated toll collection, smart parking, and other fields. A smart transportation system with perception and smart decision-making functionality has been developed, empowering the in-depth development of the social economy.

Intel offers cloud-to-end solutions for different application scenarios that provide innovative technical support for the development of partners in smart transportation and other fields. Through deepening collaboration with ecosystem partners, Intel has integrated its leading technologies and innovation capabilities to facilitate the innovation and application of smart transportation on a global level.

In order to meet the needs of expressway network toll collection, key vehicle supervision, and smart logistics management, Sinoits has launched the Xiaoshen Hitomi Toll Vehicle Identification and Management Solution based on the Yuntu EdgeVision AI Box. The solution has integrated the Xiaoshen Hitomi All-in-One Machine with a proprietary Sinoits vehicle identification algorithm, and through the Yuntu EdgeVision AI Box based on 11th Gen Intel® Core™ processors and Intel® Movidius™ Myriad™ VPUs, realizes AI inference at the edge and accurate identification of vehicles. The solution can be used to support manual toll data inspection and can connect to toll data inspection platforms to realize fully automated data inspection and evidence collection, improve the quality and standardization of expressway toll management, and reduce the occurrence of traffic safety hazards.

Smart Transportation Accelerates the Social Economy

The digital transformation of transportation infrastructure and the acceleration of smart transportation have become key tasks for transportation agencies around the world. The Chinese government issued the "Outline for National Transportation Development" in September 2019, which outlined the accelerated development of a modern comprehensive transportation system and the transformation of China into a global transportation leader by 2035. In August 2020, the Ministry of Transport issued the "Guiding Opinions on Accelerating the Construction of New Infrastructure in Transportation", which outlined the further digitalization of highways throughout the period. In February 2021, the Chinese government issued the "National Comprehensive Three-Dimensional Transportation Network Planning Outline", which noted the need to construct a smart transit platform based on an urban data model platform that integrates dynamic and static urban data.

Driven by policy and innovations in digital technology, smart transportation is showing a trend of rigorous development in China. According to the "Market Operational Management and Investment Prospect Forecast Report for the Chinese Smart Transportation Industry (2021-2027)" published

by the Intelligence Research Group, the market size of China's smart transportation industry in 2020 was CNY 100 billion, a 22.7% year-on-year increase. The size of China's smart expressway market was CNY 63.2 billion, an increase of 14.7% year-on-year[1]. In addition to further improving transportation efficiency and safety, the booming smart transportation market has also stimulated the potential for innovation in the smart transportation sector.

With further technical innovation and development in smart transportation, more stakeholders are getting involved to create an active smart transportation ecosystem. These include organizations responsible for smart transportation management, planning, and demand upstream of the industry chain; system integrators in the middle of the industry chain; and hardware providers, OEMs, and independent software vendors (ISVs) downstream of the industry chain.

Driven by this ecosystem, smart transportation has presented the following key development characteristics:

Vehicle-Road Synergy Through Deep Integration of MEC and C-V2X

Multi-access edge computing (MEC) is a network architecture concept used to implement cloud computing functions and IT service environments at the edge of a cellular network. In addition to transferring data to the edge for processing and reducing the pressure of data transmission and processing across the network, MEC also works with cellular vehicle-to-everything (C-V2X) wireless communication technology to realize multi-vehicle collaboration, road test intelligence, and other application scenarios to meet the needs of data sharing and transmission, intelligent intersection control, coordinated traffic scheduling, dangerous driving warnings, traffic violation warnings, and vehicle perception sharing.

End-to-End AI Integration

AI technology is the key to the implementation of smart transportation systems. While conventional solutions have relied on cloud computing to meet the computing power requirements of AI algorithm training and inference, such architecture cannot adequately meet the latency, stability, and other requirements of smart transportation scenarios. The adoption of an edge-to-cloud architecture reduces the latency and instability caused by network transmission by processing part of the AI load at the edge while still supporting centralized management and the agile allocation of resources through the cloud.

Centralized Processing of Multiple Loads

The continuous implementation of innovative smart transportation applications in scenarios such as expressways and urban transit creates different requirements for basic resources such as computing, storage, and networks. The use of decentralized processing methods to meet this resources requirements results in higher costs, data islands, complex O&M, and other issues. By contrast, workload consolidation means that more new and old workloads can be run on fewer independent devices, thereby reducing storage requirements and the complexity of the system and environment. This approach to smart transportation can help reduce capital expenditures (CapEx) while reducing operating expenditures (OpEx) by improving efficiency, simplifying operations, and improving support for equipment maintenance and end-of-life servicing.

Smart Expressway Toll Collection

Toll collection for expressways and other scenarios is a key part of smart transportation systems. The efficiency and accuracy of toll collection greatly influences the efficiency of expressways and has a long-term impact on the social economy. While the expressway toll booth has conventionally relied on manual collection, this method is on the verge of elimination as it cannot adapt to the needs of modern transportation systems.

The advent and implementation of electronic toll collection (ETC) has become an integral part of building a safe, convenient, efficient, green, and comprehensive modern transportation system. In May 2019, the General Office of the Ministry of Transport issued the "Notice on Actively Accelerating the Development and Application of Expressway ETC", which required the active acceleration of ETC installation and application to create the conditions for the retirement of expressway toll stations on provincial borders. According to data released by the Ministry of Transport, the national expressway ETC utilization rate exceeded 65.98% as of October 26, 2020. Specifically, the passenger car ETC utilization rate exceeded 70% and the truck ETC utilization rate exceeded 53%, playing an important role in improving traffic efficiency and supporting refined traffic management.[2]

At the same time, the inconsistent toll collection standards for different large passenger vehicles, trucks, and SUVs can often create problems

[1] Data provided by the Intelligence Research Group: https://www.chyxx.com/research/202012/916515.html

[2] Data quoted from the Ministry of Transportation: https://www.mot.gov.cn/2020wangshangzhibo/jingjiyx/zhibozhaiyao/202010/t20201028_3481017.html

in inspection and tolling, making it difficult to meet the requirements of refined management and toll collection. In January 1, 2021, the "Vehicle Classifications for Collection on Toll Roads" issued by the Ministry of Transport was implemented, which clarified new standards such as a vehicle classification system, passenger car classification parameters, and truck classification parameters. In addition to defining toll collection standards for various vehicle types, the standards also introduce several new challenges to the toll collection and inspection process.

- The massive variance of models, payload capacity, axle types, and other factors in large passenger cars, trucks, and SUVs has a practical on toll collection standards. As the classification of car models is a complex and high-variance procedure, there are significant challenges to accurate model identification.
- The manual operation of vehicle type identification, toll collection, inspection, and other tasks leads to high personnel costs and cannot effectively meet the needs of smart transportation in terms of efficiency.
- The detection of traffic violations in a more timely and accurate manner also serves as a significant challenge. As national policies have required the active retirement of expressway toll stations on provincial borders, the frequency of manual inspection stations on expressways has been significantly reduced. It has become imperative to strengthen traffic supervision through technological means to effectively curb the use of unconventional methods such as vehicle modification, VIN cloning, blocking of license plates, and license plate removal to evade tolls or engage in traffic violations.

Xiaoshen Hitomi Toll Vehicle Identification and Management Solution Based on Intel Architecture

The Sinoits Xiaoshen Hitomi Toll Vehicle Identification and Management Solution utilizes edge computing, AI image recognition, and other technologies integrated with smart cameras, edge computing, smart fill lighting, IoT monitoring, and radar sensors.

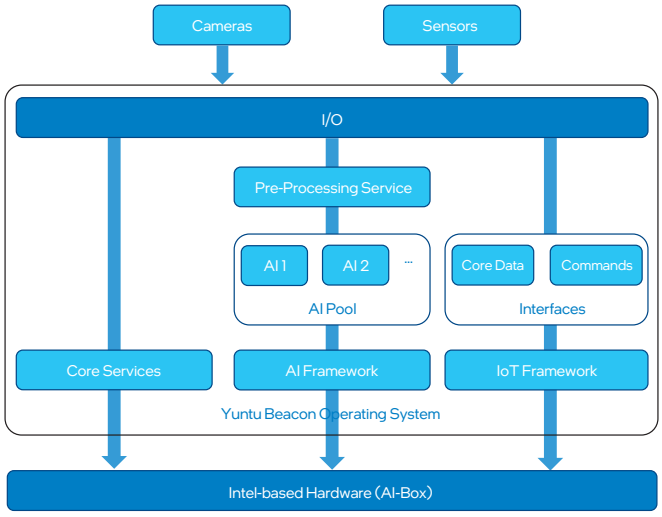

Figure 1. Xiaoshen Hitomi Toll Vehicle Identification and Management Solution Architecture

Through patented multi-feed 3D vehicle identification technology, the system realizes the collection of frontal, side, and rear vehicle features and the analysis and restoration of vehicle body (length, number of axles, wheelbase, axle type, number of wheels, side features, etc.) features to provide key supporting data for the classification of vehicle types, along with the comparison and analysis of various vehicle body features. The system can also use multi-view feature fusion and feature extraction technology to collect and restore images of ultra-long vehicle bodies an identify body feature data in distances of under 1 meter from the vehicle.

High-Def Frontal Images: License plates license plate color, vehicle brand, hazardous chemicals, special vehicle identification, etc.

High-Def Rear Images: License plates license plate color, vehicle brand, hazardous chemicals, special vehicle identification, etc.

≥5s full process video

Model, axle count, axle type (truck, 6 axle, 1-2-3 axle)

Video and auxiliary sensor fusion technology enables precise measurement of vehicle body length and accurate restoration of vehicle body images

License plate color map

Figure 2. Vehicle Feature Extraction Performed by the Xiaoshen Hitomi Toll Vehicle Identification and Management Solution

Features extracted by the solution can be seamlessly connected with expressway ETC and MTC systems, along with toll collection big data inspection platforms.

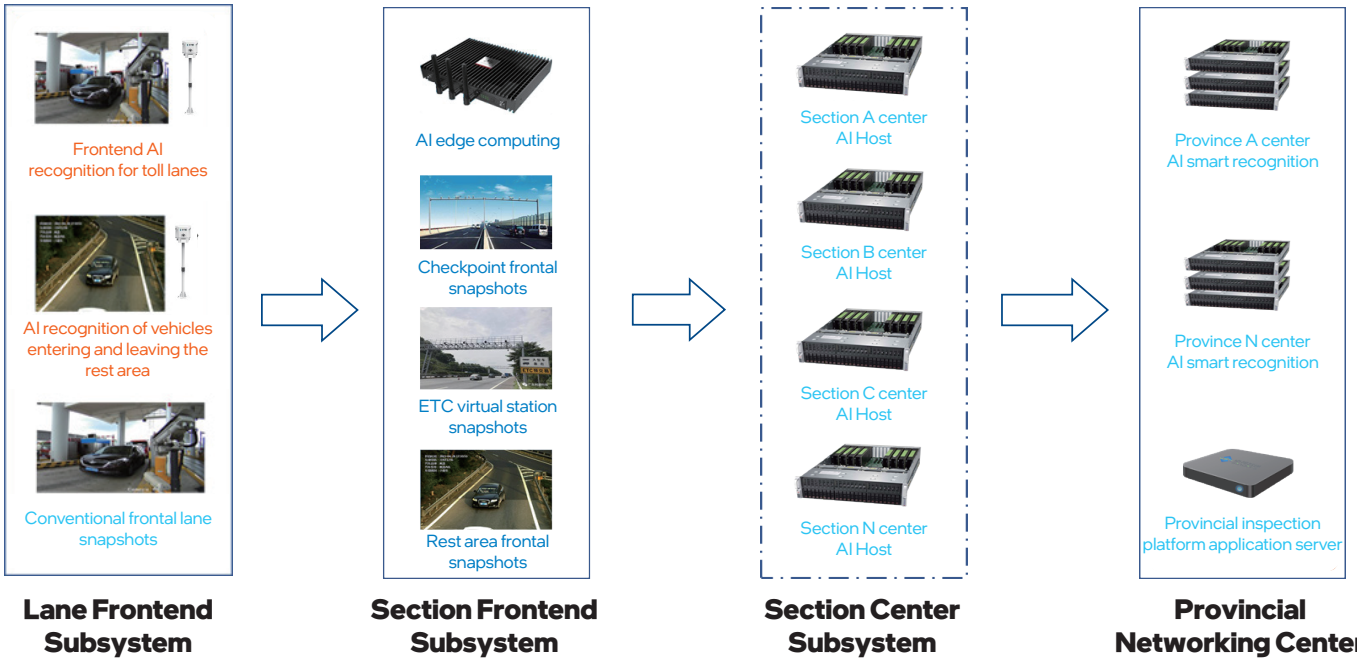

Figure 3. Xiaoshen Hitomi Toll Vehicle Identification and Management Solution Network Topology

Figure 4. Xiaoshen Hitomi All-in-One Machine

The primary product of the solution is the Xiaoshen Hitomi all-in-one machine, which is equipped with a frontal camera, rear camera, assisted detection, body camera, body fill light, tail fill light, frontal license plate fill light, frontal fill light, and other components. The machine is capable of providing high-quality frontal vehicle images and supports extraction of multiple features such as vehicle types no matter the time of day.

The Xiaoshen Hitomi All-in-One Machine is integrated with the Yuntu EdgeVision AI Box equipped with 11th Gen Intel® Core™ processors and Intel® Movidius™ Myriad™ VPUs. Running on the edge, the machine provides general support for models trained by all mainstream AI frameworks, helps developers and customers reduce deployment time and costs, supports diversified compute requirements and a variety of application scenarios, and realizes the AI processing of vision and other data.

Based on the Intel® AI Box, the Yuntu EdgeVision AI Box provides cost-effective hardware solutions for AI applications and has helped Sinoits construct a highly integrated edge platform. Through integration with the Xiaoshen Hitomi All-in-One Machine based on Intel architecture, Sinoits has developed a hybrid architecture capable of realizing the heterogeneous processing of a variety of AI applications.

In particular, applications such as image stitching are supported by 11th Gen Intel® Core™ processors, which boast powerful computing power, a wide range of product options, I/O integration functionality, superb scalability, and wide-ranging compatibility capable of supporting all components of the Xiaoshen Hitomi All-in-One Machine. The processors also come integrated with Intel® HD Graphics, which offers rich graphical performance capable of meeting the needs of applications such as image stitching and video encoding/decoding.

Intel® Movidius™ Myriad™ VPUs provide a unique energy-efficient, high-performance, and smart computer vision solution capable of supporting constantly updated smart and automated devices, along with significantly accelerating smart computer vision applications.

The Yuntu EdgeVision AI Box also integrates software such as the OpenVINO™ toolkit and Intel® Smart Video Evaluation Toolkit (SVET) through Beacon OS to provide system-level support and performance optimization for AI inference and video processing. Beacon OS also comes with other powerful built-in IoT components and frameworks such as EdgeX Foundary, which supports the access and analysis of cameras and other sensors to provide a powerful software foundation for comprehensive scene perception.

Figure 5. 11th Gen Intel® Core™ Processors Meet the Needs of Applications Such as Image Stitching and Video Encoding/Decoding

The Xiaoshen Hitomi All-in-One Machine is integrated with the Sinoits multi-feed 3D vehicle identification algorithm optimized for performance through the OpenVINO™ toolkit. With support for the acceleration of deployment across a wide range of deep learning inference applications and solutions, the OpenVINO™ toolkit provides developers with industry-standard AI frameworks along with standard or custom layers to seamlessly integrate deep learning inference with applications, and enhance performance through Intel hardware (including accelerators). Utilizing the Model Optimizer (MO) for pre-inference models and the Inference Engine (IE) for hardware acceleration, the OpenVINO™ toolkit supports neural network acceleration and deployment across a variety of Intel platforms, significantly increasing the speed of image inference without sacrificing accuracy.

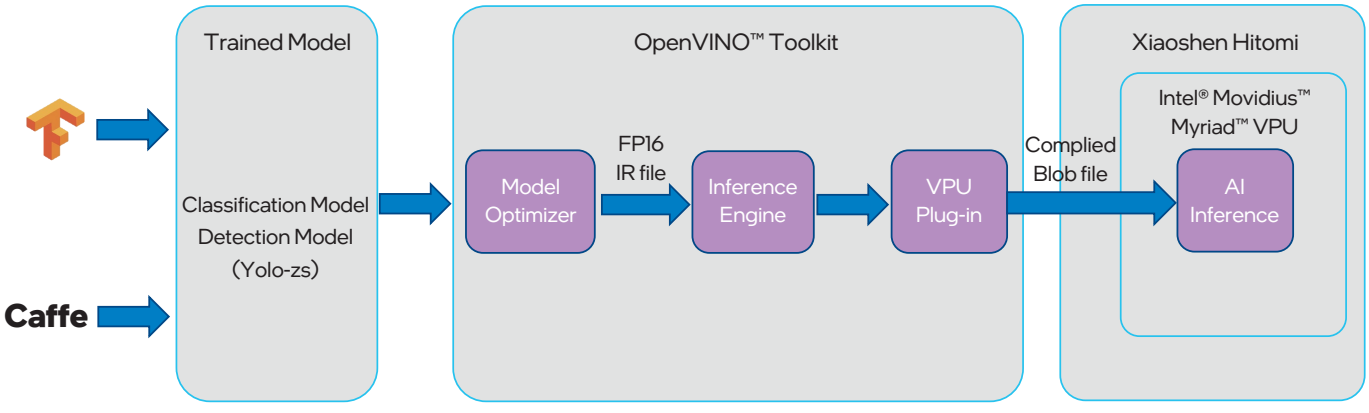

Figure 6. Sinoits Utilizes the OpenVINO™ Toolkit and Intel® Movidius™ Myriad™ VPUs for Algorithm Acceleration

Testing performed by Sinoits before and after acceleration found that the utilization of the OpenVINO™ toolkit and Intel® Movidius™ Myriad™ VPUs increased algorithm performance fivefold[3], from 0.6 FPS to 3 FPS. Owing to its ability to improve performance without significant investments into hardware, the solution is capable of significantly reducing the total cost of ownership (TCO).

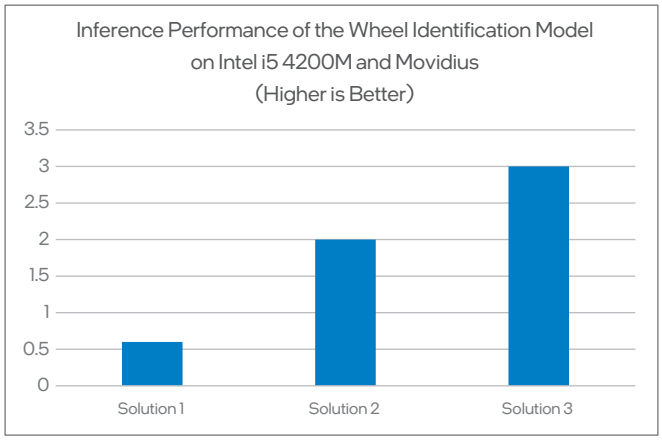

Figure 7. Performance Before and After Optimization

Acceleration helped significantly improve the performance of the multi-feed 3D vehicle identification algorithm running on the Xiaoshen Hitomi All-in-One Machine, thereby eliminating the high procurement, storage, and operational costs associated with the use of discrete GPUs and providing better support for the special edge application scenarios of the machine.

Through in-depth mining and multi-dimensional analysis of vehicle feature data, license plates, smart cards, on-board units (OBUs), and more, the Xiaoshen Hitomi Toll Vehicle Identification and Management Solution provides reliable support for a variety of application scenarios including expressway vehicle path identification and expressway big data inspection. System inspection data sample testing found that the solution is capable of achieving a vehicle identification accuracy of >99.99% under expressway conditions.[4]

The Xiaoshen Hitomi Toll Vehicle Identification and Management Solution offers a variety of benefits to traffic management.

- Accurate identification and classification of toll models, along with core functionality such as card issuance and toll collection by vehicle type that can be used to support and gradually replace manual toll data inspection processes. After further data optimization and transformation, the solution can be integrated to the toll data inspection platform to realize fully automated data inspection and evidence collection.
- Effective response to vehicles using unconventional methods such as vehicle modification, VIN cloning, blocking of license plates, and license plate removal to evade tolls.
- Provide a wealth of in-depth insights and facilitate smart transportation management through AI image recognition of vehicle data.

"Our AI Box solutions provide excellent performance and reliable support for the execution of algorithms for key AI application scenarios such as smart transportation. Through in-depth cooperation with Intel and Sinoits, we facilitate the integration of algorithms into solutions and help realize smart transportation construction."

- Meng Ying
Founder and CEO, Yuntu EdgeVision

[3] Test results provided by Sinoits. Test Configuration – Scenario 1: Intel® Core™ i5 4200M processor, Yolo-zs; Scenario 2: Intel® Core™ i5 4200M processor + OpenVINO™ toolkit, Yolo-zs; Scenario 3: Intel® Movidius™ Myriad™ VPU + OpenVINO™ toolkit, Yolo-zs.

[4] Data provided by Sinoits.

Xiaoshen Hitomi All-in-One Machine Empowers the Application of Smart Transportation

At present, the Xiaoshen Hitomi All-in-One Machine has seen wide use across a variety of smart transportation application scenarios and played a key role in traffic management across the country.

- Henan Expressway Development Corporation Management Center – ETC/MTC Management

  The management center of Henan Expressway Development Corporation installed the Xiaoshen Hitomi All-in-One Machine on the ETC/MTC lane of its toll station. Through the continuous scanning of 3D video, data was extracted from the entire vehicle passing process with accurate license plate, length, width, height, axle, axle type, model, and other multi-dimensional vehicle data identified and uploaded to the toll platform. By comparing OBUs and CPCs, the machine was able to identify vehicle tag and other discrepancies, and charge toll fees after ensuring the accuracy of model and license plate data, significantly reducing losses in toll income caused by inaccurate data collection.

Figure 8. Xiaoshen Hitomi All-in-One Machine ETC/MTC Management

- Vehicle Management and Control in Jiangsu Rest Areas

  Rest areas in Jiangsu expressways were equipped with the Xiaoshen Hitomi All-in-One Machine, making use of the solution's 3D vehicle identification and big data analysis technology to scan, detect, and identify a variety of vehicle bodies; output multi-dimensional vehicle microfeature data such as number of axles, license plates, and models; and provide high-definition images of vehicle bodies to realize the real-time control and data comparison of vehicles entering and exiting the rest area, and provide powerful data support for subsequent monitoring and inspection operations.

Figure 9. Xiaoshen Hitomi All-in-One Machine Expressway Overload Management

- Expressway Overload Management

  The Xiaoshen Hitomi All-in-One Machine can be installed in overload stations/lanes to output high-definition frontal and rear vehicle images along with full-scale restored vehicle body images by continuously scanning smart 3D videos with a length of no less than 5 seconds. The machine is capable of recording panoramic images of the vehicle from different angles across the process of entering the weighing equipment and overload detection at the toll entrance, then exporting duplicate weighing operations to provide clear and complete imaging and model data. Vehicles can be identified and data read from ETC antennas can be verified to ensure the accuracy of vehicle type/axle type and license plate data. When integrated with weighing data, overload data collection and unified upload to the overload/collection system can be completed.

Edge AI Improves the Intelligence of Traffic Management

The application of edge AI is of great significance to traffic management scenarios. By processing AI loads at the edge instead of the cloud, traffic management departments can more efficiently perform AI analysis on traffic monitoring videos to meet application requirements such as automated toll inspections and smart detection of illegal activity. Edge AI applications can also help reduce processing delays caused by network transmission and improve application availability. Data collected from the edge can interact with the section center subsystem and provincial networking center to meet the management requirements of smart transportation through cloud-edge-end integration.

In terms of cloud-edge-end architecture, Sinoits will continue to cooperate with Yuntu EdgeVision and Intel to integrate more algorithms into the Xiaoshen Hitomi All-in-One Machine to better meet the needs of vehicle identification and other functions. In addition to expressways, the solution can also be used across a wide variety of scenarios such as vehicle-road synergy and logistics parks to provide intelligence through vehicle identification and other functionality, thereby accelerating the efficiency of transportation systems and cutting down on costs. Based on an open and mature architecture, the solution can flexibly and rapidly deploy and adjust relevant algorithms according to needs of the application scenario.

The solution boasts a wide range of identification algorithms including vehicle, model, road surface water/damage, severe weather, and more. All algorithms are deployed through OTA to provide a powerful, stable, and flexible foundation for AI and edge computing and protect user investment.

Focusing on data, Intel will make use of its leading end-to-end technology, strong computing power, rich product portfolio, and cooperation with Sinoits, Yuntu EdgeVision, and other industry partners to contribute to the continuous innovation and development of the smart transportation industry both in China and across the world. Through rich integration of products and solutions across all nodes of the cloud-edge-end, Intel helps meet the needs of loads such as data calculation, store and forward, lane equipment control, data analysis, and computer vision processing while actively empowering the continued innovation of smart transportation.

About Sinoits

Sinoits is a leading AI technology company founded by a team of world-renowned computer vision scientists and senior experts with international experience. Based on its 5G + AI technologies, the company has developed a suite of completely proprietary advanced frontal vehicle recognition, traffic video fusion perception, and vehicle-road synergy products that have seen wide application in more than 20 provinces and cities in China (including Beijing), covering tens of thousands of kilometers of expressway.

About Yuntu EdgeVision

Founded in 2017, Yuntu EdgeVision has helped integrate a variety of partners such as algorithm providers, hardware providers, and solution providers across the AI ecosystem with its proprietary AI-Box, Beacon OS, and algorithm database solutions. Through its standardized architecture, the company helps users select, deploy, and run their desired AI algorithms in just 15 minutes, thereby ensuring that algorithms are both easy to find and deploy. Yuntu EdgeVision and Intel jointly created the AI Edge Computing and Reference Design in 2020 to provide further standards for edge computing. The company's vision is to use AI to free people from tedious labor and extract greater value. Through our efforts, we hope that like air and water, AI will become a basic commodity that anyone can enjoy.

About Intel

Intel (Nasdaq: INTC) is an industry leader, creating world-changing technology that enables global progress and enriches lives. Inspired by Moore's Law, we continuously work to advance the design and manufacturing of semiconductors to help address our customers' greatest challenges. By embedding intelligence in the cloud, network, edge and every kind of computing device, we unleash the potential of data to transform business and society for the better. To learn more about Intel's innovations, go to newsroom.intel.cn and intel.cn.