White Paper

Intel® Core™ Ultra processors
Intel® oneAPI Toolkit
Intel® Distribution of OpenVINO™ Toolkit
Intel® Robotics SDK

SIASUN Works with Intel to Build High-Performance Mobile Robots, Helping to Accelerate Intelligent Transformation

SIASUN

"Mobile robots are playing an increasingly important role in industries like energy and manufacturing in the process of digital and intelligent transformation. Our collaboration with Intel has enabled us to create AI-powered intelligent autonomous mobile robots featuring man-machine collaboration and multi-modal integration, which meet the stringent requirements for robots in scenarios such as coal mine inspection and security patrol. As an intelligent replacement of high-risk and highly repetitive labor, mobile robots will lead a new round of technological revolution and industrial transformation."

– Bing Liu
General Manager
Tianjin SIASUN Intelligent Technology Co., Ltd.

Overview

With high efficiency, scenario adaptability, and economic benefit, mobile robots have been increasingly used in a wide range of scenarios, including industrial inspection, security patrol, and park service, demonstrating great development potential. As a key module of mobile robots, the controller is responsible for important workloads, such as sensor data integration, processing and control, and needs to overcome severe challenges in algorithm, computing power, stability, and ease of use to accelerate the application of mobile robot solutions in different scenarios.

Tianjin SIASUN Intelligent Technology Co., Ltd. (hereinafter referred to as "SIASUN") has launched a mobile robot controller solution based on Intel® architecture. Equipped with Intel® Core™ Ultra processor, as well as software like Intel® oneAPI Toolkit, Intel® Distribution of OpenVINO™ Toolkit, and Intel® Robotics SDK, SIASUN mobile robot controller flexibly meets the computing and I/O needs of SIASUN robots, shortens the research and development cycle, and reduces the investment in computing platform. Meanwhile, the solution integrates the 3D point cloud + vision multi-sensor fusion technology introduced by Intel and SIASUN jointly, which satisfies the requirements of scenarios like mobile inspection, and helps customers realize digital and intelligent transformation.

Background and Challenges

At present, customers in industry, logistics, electricity, retail, healthcare and other sectors are actively embracing mobile robots to promote business transformation and upgrading. According to the statistics of the New Strategic Mobile Robot Industry Research Institute, from 2015 to 2023 in China, the mobile robot (including AGVs and AMRs) industry developed at a compound annual growth rate of 43.18%; in 2023, the market size of mobile robots was RMB 21.2 billion approximately in China, an increase of 14.59% year-on-year, with 125,000 units sold, up 34.41% year-on-year[1]. In particular, autonomous mobile robots (AMRs) have achieved significant growth in China: In 2023, about 49,000 AMRs were sold, up 60.13% year-on-year[2].

To accelerate the application of mobile robots in specific scenarios and meet users' growing demand for mobile robots, the providers of mobile robot products and solutions should solve the following challenges in computing power, stability, and economic efficiency:

- **Complex workloads require more robust computing power:** To meet the requirements of more complex application in a wider range of scenarios, and achieve a higher level of task accuracy and intelligence, mobile robots are enhancing the application of technologies including 3D point cloud + vision multi-sensor fusion, and deep learning inference. These application workloads demand higher computing performance.

[1] Data source: http://www.agv-amr.com/news/show.php?itemid=1732, visited in July 2024.

[2] Data source: http://m.agv-amr.com/news/show.php?itemid=1605, visited in July 2024.

- **High technical threshold makes it difficult to develop products:** Mobile robot is a relatively complex machine platform, which should meet the demand of inspection, material operation and other scenarios alike for real-time control. Its technical difficulty and computing complexity far outstrips ordinary robots, which means higher technical threshold.
- **A variety of modules and peripherals bring multiple challenges such as cost, reliability, operation and maintenance:** In the development of mobile robots, there are various modules and peripherals in large quantities; the deployment of different components will lead to great challenges in robot design.

Solution: SIASUN mobile robot controller based on Intel® Core™ Ultra processors

SIASUN has teamed up with Intel to introduce SIASUN mobile robot controller based on Intel® Core™ Ultra processors. The controller not only has hardware modules, but integrates navigation, obstacle avoidance and other algorithms and software, which centrally handle and accelerate the workloads of human-machine interaction, energy charging and storage, motion control, environmental awareness, and wireless communication, and meet the stability and scalability requirements of mobile robots. So far, the controller has been widely used in SIASUN intelligent patrol robot, power inspection robot, security patrol robot, park unattended robot, coal mine wheeled unmanned robot, and other products to meet the application needs of various scenarios.

In hardware, SIASUN mobile robot controller supports the architecture that pairs CPU core modules with I/O extended modules, providing exceptional scalability and flexibility, while enhancing stability through industrial-grade connectors and a robust fanless design.

SIASUN mobile robot controller supports the first generation of Intel® Core™ Ultra processor (code-named "Meteor Lake"), which innovatively uses a hybrid architecture composed of 4 independent chiplets - compute tile, SoC tile, graphics tile and I/O tile, assembled with Foveros 3D packaging technology. Intel® Core™ Ultra processor has built-in Intel Arc™ GPU with up to 8 X^e cores (up to 128 graphics execution units) for powerful graphics performance. For the first time, the processor integrates a neural processing unit (NPU), which will accelerate AI workloads as a special computing unit to meet the demanding requirements for AI inference. The collaboration of Intel® Core™ Ultra processor, its built-in Intel Arc™ GPU, and the NPU will fully support the complex workloads of SIASUN mobile robots.

Figure 1. SIASUN coal mine wheeled unmanned robot

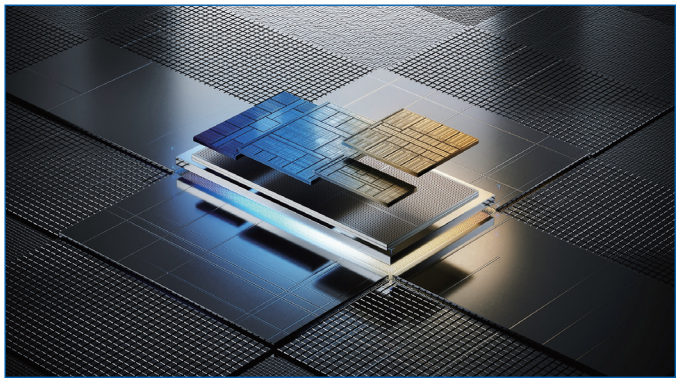

Figure 3. Intel® Core™ Ultra processor

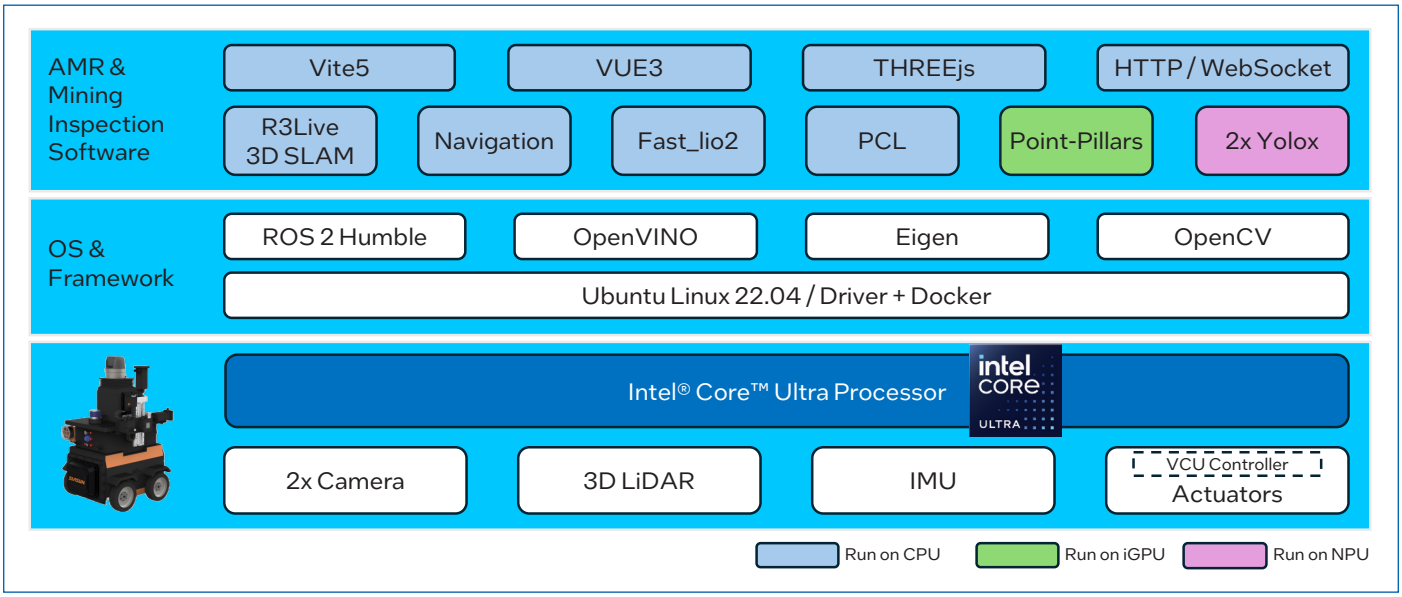

Figure 2. Software architecture of SIASUN mobile robot controller

In addition, the future generations of Intel® Core™ Ultra processor (including "Panther Lake" and "Arrow Lake") will have higher AI computing power: With one SoC tile, they can simultaneously handle basic functions, such as motion control and positioning, as well as intelligent innovative workloads.

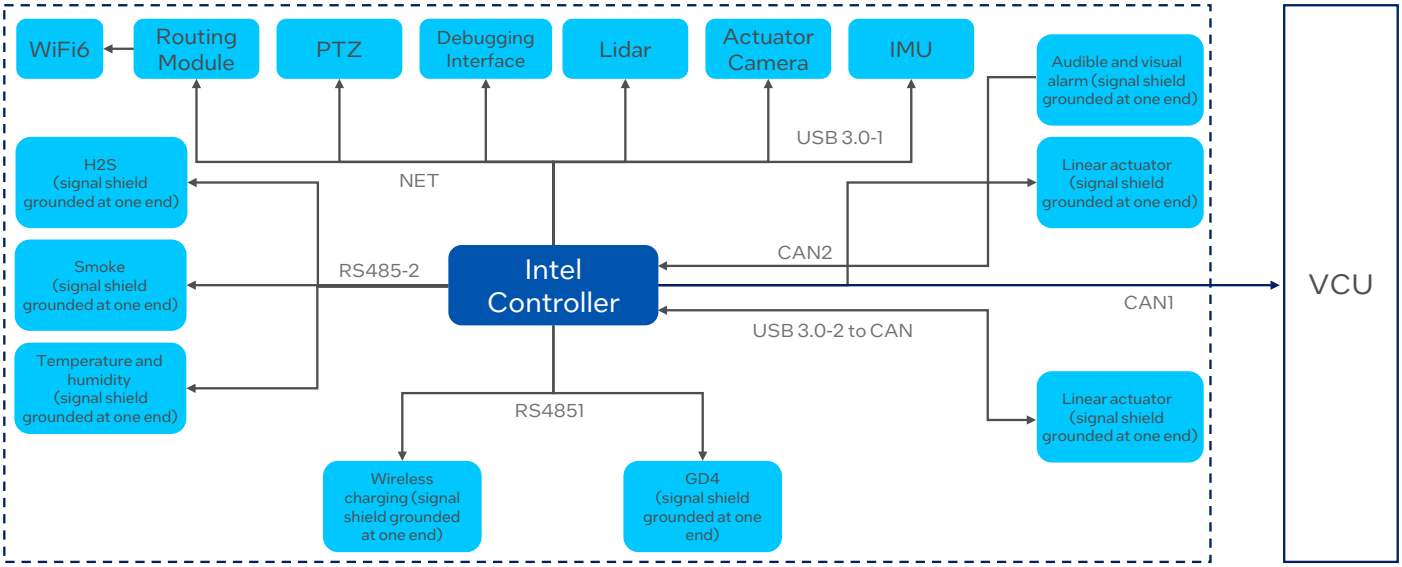

Figure 4. Architecture of SIASUN mobile robot based on Intel® Architecture

In terms of software and algorithm, SIASUN mobile robot controller supports the positioning based on 3D point cloud + vision multi-sensor fusion, and adopts lidar and ultrasonic radar to avoid obstacles for multi-dimensional protection. The navigation software architecture of SIASUN mobile robot controller mainly consists of the data layer, perception layer, fusion layer, path planning layer, control layer, and application layer.

- The data layer mainly acquires lidar data, inertial navigation data, and chassis VCU data to support the sensing layer.
- The perception layer mainly includes point cloud clustering module, 3D modeling module, inertial navigation data processing module, ultrasonic data processing module, and VCU processing module. It is able to obtain environmental data through multiple sensors and generate 3D information of object models and locations using 3D point cloud technology. At the same time, the vision sensor will provide rich image information for tasks like target recognition and scene understanding.
- The fusion layer is mainly divided into laser odometer and data fusion positioning. The laser odometer calculates the displacement and rotation of the robot by matching the current point cloud data with the 3D map, and integrates the inertial navigation data to calculate the position of the robot.
- The path planning layer is mainly divided into robot path planning and navigation task planning.
- The control layer mainly includes trajectory tracking, obstacle avoidance, and automatic charging. PID control is adopted for robots' trajectory tracking and motion control.
- The application layer offers MQTT service and HTTP service, with tile map and road network service for front-end interaction, and Web application for human-machine interaction.

Table 1. Performance test data of SIASUN mobile robot[3]

	Indicators	1st time	2nd time	3rd time	4th time	5th time	Average
Maximum movement speed	1.0m/s	1.08m/s	1.12m/s	1.1m/s	1.09m/s	1.11m/s	1.1m/s
Movement positioning accuracy	±1cm	0.5cm	0.5cm	0.8cm	0.7cm	0.6cm	0.62cm
Endurance Time	8h	8.6h	8.5h	8.8h	8.7h	8.8h	8.68h
Charging Time	4h	4h	3.9h	4h	4h	3.9h	3.96h
Image recognition accuracy	98%	98.50%	97.90%	98%	98.20%	98.10%	98.14%

[3] Data quoted from internal test data of SIASIN as of June 2024. Intel does not control or audit third-party data. You should consult other sources to evaluate accuracy.

SIASUN mobile robot controller also integrates an AI recognition algorithm, which detects the target scenario based on visible light images. The data acquisition device is an onboard PTZ camera, which the patrol vehicle controller uses to acquire image data. Through MQTT service and HTTP protocol, the vision system allows information interaction between various systems, receives visual tasks from other systems, processes images according to task requirements, and then sends the processing results to the service requester.

SIASUN mobile robot controller is capable of AI model recognition and inference based on Intel® Core™ Ultra processor. With Intel® oneAPI Toolkit and Intel® Distribution of OpenVINO™ Toolkit, its inference performance is further enhanced. The OpenVINO™ toolkit mainly consists of a model optimizer and an inference engine, which provide highly optimized neural network computing power, and accelerates the inference of deep learning models based on Intel hardware platforms including Intel CPU, iGPU, NPU, and FPGA. Test data shows that when the iGPU of Intel® Core™ Ultra processor is used for inference and the "Multi-Threaded" mode is enabled, SIASUN PointPillar's 3D target detection model can reach up to 26.53 FPS of inference performance, while the CPU usage of PointPillars is reduced to 14%[4]. In actual working conditions when complex workloads are loaded simultaneously, the detection time of PointPillars can be as low as 50ms and the two-way Yolox inference time can be as low as 26ms, which meet the requirements of practical applications. As iGPU and NPU share some of the workloads, the CPU takes only about 34% of the overall work, allowing it to better support more complex service processes.

Table 2. Performance of Intel® Core™ Ultra processor in application scenarios of SIASUN mobile robot

	Devices	iGPU usage (%)	CPU usage (%)	NPU usage (%)	Inference Time (ms)	Release Frequency (Hz)
Pointpillars	iGPU	49.59	14.0	/	50	10
Yolox	NPU	/	1.9	30.4[5]	26	10
3D SLAM	CPU	/	9.2	/	/	15
Fast_lio2	CPU	/	8.7	/	/	10

In addition to the existing solution, SIASUN plans to adopt Intel® Robotics SDK to accelerate the development, building and deployment of end-to-end mobile robot applications. Intel® Robotics SDK includes libraries, middleware, and sample applications based on the open source ROS2 Humble (robot operating system), allowing the deployment of codes on multiple hardware once for all. It shortens the evaluation and development time to accelerate the deployment of Ros2-based customer applications and the execution of algorithms and applications, so as to build a complete end-to-end solution from device to edge.

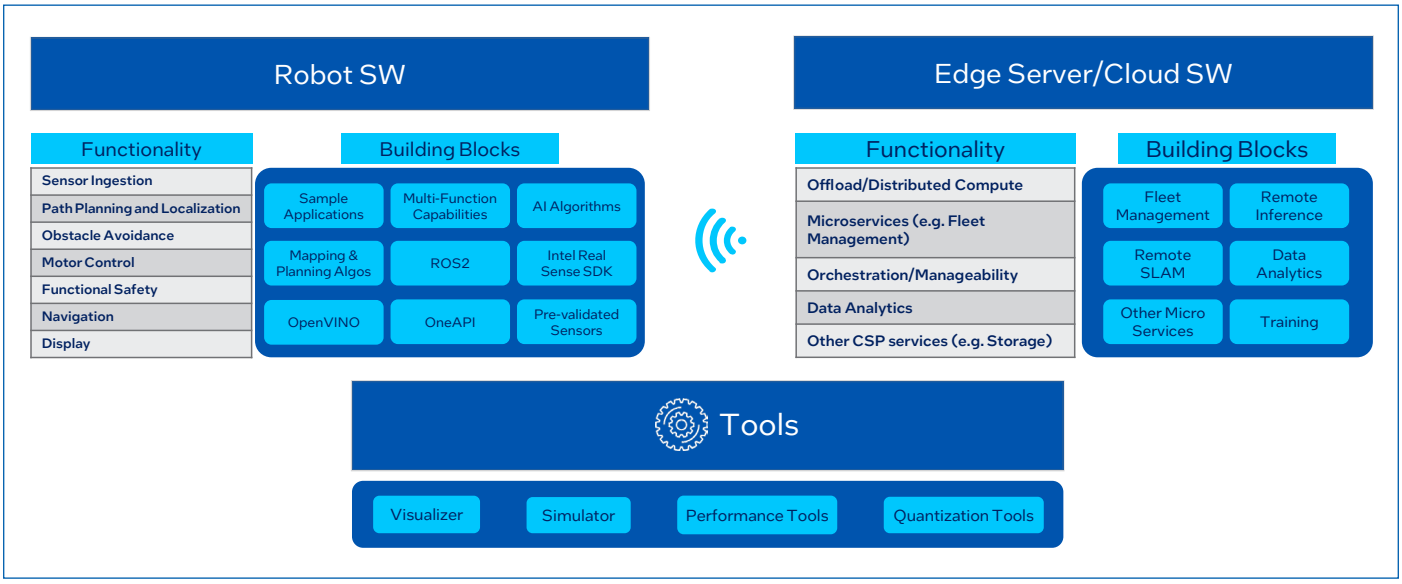

Figure 5. Software architecture of Intel® Robotics SDK

[4] Data quoted from internal test data of SIASIN as of June 2024. Intel does not control or audit third-party data. You should consult other sources to evaluate accuracy.

[5] NPU usage rate is calculated based on the time span of Yolox inference.

Application Scenarios

So far, SIASUN mobile robot controller has been applied in a variety of products and scenarios, such as the coal mine inspection robot. Despite complex geological conditions and harsh working environment underground, most of China's coal enterprises still rely on the traditional human shift system to inspect key underground places, such as central substations and central pump rooms. This method, highly dependent on human labor, has a low degree of automation. With different levels of experience and subjective consciousness, the operators can hardly perceive the current working status of various devices in a timely and comprehensive manner, and lack scientific and effective data analysis and a sense of early warning for the equipment operating status. In that case, safety accidents are inevitable. Therefore, it is necessary to introduce intelligent inspection robots.

SIASUN intelligent unattended robot for coal mine inspection has integrated the functions of computing, sensing, automation, and information communication. It features small size, flexible movement, powerful inspection function, low use cost, and low maintenance cost. It can successfully solve the problems of high intensity, low efficiency, high risk and poor reliability of coal mine manual inspection, and will achieve the following benefits:

- Reduce the underground inspection frequency of personnel and cut the number of inspection personnel, which is expected to save hundreds of thousands of yuan every year.
- Sharply reduce the safety hazards for underground personnel, eliminate the casualties due to mine accidents, and minimize the threat of coal ash, dust or toxic gas to inspection personnel.
- Solve the problem of unsafe production in the coal industry from the root, improve the efficiency of coal mine production, and fundamentally reduce the number of coal mine workers, so as to comply with the requirements of "personal reduction" for coal mine development in China, and truly realize unattended inspection.
- Provide accurate and effective decision-making information for management departments to reduce direct economic losses caused by equipment failures.

Figure 6. SIASUN intelligent unattended robot for coal mine inspection

Outlook

With continuous technological innovation, and corporate digitalization and intelligentization, mobile robots will further evolve and play a more important role in social economy. For example, the cloud-edge-end integration technology based on 5G will be able to expand the space for capability design of mobile robots, thereby freeing the dependence on hardware capabilities of robots, reducing costs, and promoting the large-scale deployment of mobile robots.

Intel® Core™ Ultra processors have become an important computing base for robot products, and can be used in various forms of robots, such as human-shaped robots and mobile robots. In the face of a new wave of mobile robot development, Intel is giving full play to its end-to-end technical strength, working with SIASUN and other partners to carry out multi-dimensional application practices, actively exploring and constantly introducing highly flexible and optimized solutions to accelerate sustainable development of the mobile robot industry.

About SIASUN

Tianjin SIASUN Intelligent Technology Co., Ltd., affiliated to Shenyang SIASUN Robot & Automation Co., Ltd., is a national innovative high-tech enterprise focusing on the research and development of intelligent systems in the field of rail transit energy. With AI technology as the core, SIASUN closely follows the global AI development wave, and adheres to the concept of "core technology as foundation, innovation in industry application, and win-win situation based on ecological cooperation". Abiding by the AI-centered "3+2+X" strategy, SIASUN is dedicated to making breakthroughs and innovations in vertical segments, providing users with competitive unattended robot systems and intelligent guided driving system.

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.com and intel.com.