Scalable Compute Module Design for Service Robots

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Introduction

Advancements in Digital Technologies are transforming how traditional kiosks are being used to provide service to end users. In the latest trend, we are seeing a shift from static and passive interactive kiosks to mobile smart kiosks. These mobile smart kiosks are changing the landscape of the service robot industry since they are autonomous, approachable, interactive, and provide multi-function services.

New emerging service robots are used for commercial applications in various industries like retail, banking, hospitality, education, healthcare, warehouses, law enforcement, and agricultural sectors. The adoption of service robot provides a high ROI for commercial providers, primarily due to savings in labor costs.

An aging population in some countries is shrinking the workforce and spurring robot deployment. Moreover, the new normal due to the pandemic has provided a boost to the adoption of service robots for performing various tasks. For example, service robots can be used for contactless delivery operations, disinfections, wayfinding, security, and assisting border controls.

Figure 1: Kiosk transformation

Challenges

There has been an explosive growth of service robots in the commercial sector as evidenced by the many different use cases for them. For instance, service robots can be used as mobile signages and self-service kiosks. Such usage requires the support of various kinds of workloads associated with those functions. It necessitates the deployment of a capable compute module reference design that can meet the expanded and varied workloads. The challenges, therefore, can be listed as follows:

- **Support for advanced navigation and analytics:** Currently, modern service robots use computer vision and depth sensors/cameras to complement LiDAR for object recognition and collision avoidance. With the expansion in the kind of usage, the compute module not only needs to provide the computation power for complex navigation and maneuvering, it also needs the headroom to support AI workload, media processing, and such other operations.
- **Scalability and time to market:** Service robots belong to a very fragmented industry. Robots are available in a range of sizes and capabilities depending on the application. The design and validation cycles required for each use case are extensive and can hamper the product's time to market. Such delays add to the cost and may not be feasible for small scale deployment.

A scalable compute module design is one that can accommodate the different workloads that a service robot is expected to execute. Such a design eliminates the need for constant redesigning and reduces the product's time to market.

The Intel® Mobile Smart Kiosk Design has been developed specifically to address these issues in the service robot industry.

This paper explores an extensible approach for a service robot compute module reference design to accelerate time to market of service robot designs.

Figure 2 A typical service robot structure

Solutions

A typical service robot consists of a navigation module and an application module that provides service to the users.

The function of the navigation module is entirely dedicated to providing self-localization, map building/interpretation, and path planning. However, the function of the application module differs depending on how the service robot is used and requires customization.

The Intel® MSK modular design, therefore, consists of the following components:

- Main compute board that provides a cost-optimized base platform to enable the navigation module
- I/O expansion board that can be easily customized to support the I/O connectivity required by application modules to provide service

The main compute board provides the I/O connectivity that is required by the navigation module. The navigation module relies on a set of peripherals, such as LiDAR, depth cameras, and proximity sensors, to provide inputs for it to perform the self-localization and map building/interpretation functions.

The main compute board also provides connectivity to the motor controllers to move wheels or mechanical legs to navigate within its surroundings.

To reduce cost and to accommodate smaller service robots, the main compute board is based off a standard 3.5-inch form factor. However, it comes with optional onboard expansion modules that provide Wi-Fi and cellular connectivity to expand its usability.

System integrators have the option to integrate VPU (vision processing unit) and GPU (graphics processing unit) modules to support additional workloads. A 15 W Core i5 ULT CPU provides the best-in-class performance/wattage to be super-efficient while improving running hours on batteries.

The Intel® MSK Design's I/O expansion board provides the I/O connectivity required by the application module to provide various services to end users. System integrators can easily customize the I/O expansion board to support a wide range of applications.

Additionally, a cable-based connector allows flexible positioning of the I/O expansion board to connect peripherals that

reside far away from the main compute board.

The Platform I/O table outlines the I/O connectivity on both the main compute board and the expansion board.

Hardware Reference Design

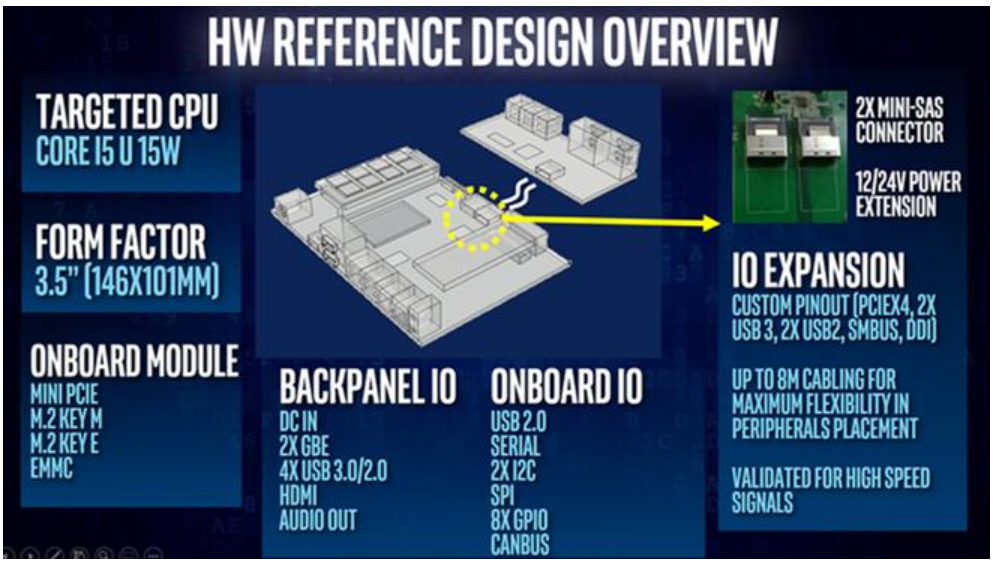

Figure 3 provides a high-level specification of the Intel® MSK Design's main compute board and I/O expansion board.

Figure 4 shows the actual photos of main compute board and I/O expansion board.

Figure 5 shows the mini SAS interconnection between the main compute board and I/O expansion board.

Platform I/O

A cable-based connector allows flexible positioning of the I/O expansion board to connect peripherals that reside far away from the main compute board.

Modules	Description
Main Compute Board	
Display	HDMI, eDP
Audio	LineOut/MIC, Speaker
LAN	2x RJ45
USB	4x USB 2.0, 4x USB 3.0

COM	5*UARTs COM1-RS232; COM2-TTL; COM3-5(TX, RX)
GPIO	8* GPIOs
CAN & I^2C	Controller Area Network and I^2C serial communication protocol devices
I/O Expansion Board	
PCIE	PCIE 4X slot Co-lay with a MINI-PCIE
USB	USB 2.0, USB 3.0
Display	DP

Customer Testimonials

Slamtec

"The Intel® MSK platform provides a good support for robot scenarios by integrating powerful Intel® Core™ processors and other peripherals. It greatly simplified our hardware architecture and improved system stability as well as the performance Intel Allen platform provides wide range of CPU choices, flexible memory configuration, and rich extensibility. So, we can always find the sweet spot to balance the cost and performance according to various workloads.

With outstanding hardware like the Intel® Core™ processor and Intel® RealSense™ camera with VPU, combined with Intel's Fast Mapping, OpenVINO™, Celadon, and other software solutions, we can make our products, including general robotics platforms and retail robots, reach a whole new level. It will also bring a huge new business value to our customers.

The Intel® MSK platform is easy to integrate, which becomes easier with the help of the Intel support team. As a result, we can integrate the platform into our systems and products in just a few weeks."

- Tony Huang, CTO of Slamtec

Ecovacs

The Intel® MSK platform has powerful AI processing capabilities and it can save a lot of development effort when it is combined with the stable and easy-to-use OpenVINO™ toolkit. The platform has good stability and the equipped I5 processor and VPU can provide the robot with image reconstruction and processing capability. The inference speed for human detection algorithm is also improved from 10 fps to 20 fps, which greatly improves the real-time performance. This improvement is essential in enabling the deployment of the proactive 'greet' and 'follow me' features in service robots."

- Shao Changdong, CTO of Ecovacs

Comstar

"Intel® MSK core module can be configured with different CPUs to achieve different capabilities. It can meet the requirement of basic applications such as positioning, navigation, and maneuverability on an AGV. With the addition of the I/O extension board, users can connect graphic card, AI accelerator card, and motion control card, to meet high-end requirements like visual recognition, AI processing, and motion control. Moreover, the speed and scalability of the CAN module allows more choices in the selection of downstream sensing modules. With the increasing number of CAN modules at present, this function is more and more valued by system manufacturers!

Here is a compute module that can meet the requirements from entry-level to the most high-end service robot applications. It can meet a variety of different use cases and requirements. One size fit all! One solution that meets all the industry ask!"

- Frank Yuan, Founder and CEO of Comstar

Conclusion

As the market of service robot expands, so does the demand for a smarter compute module with advanced capabilities such as workload consolidation, artificial intelligence, 5G connectivity, remote manageability, and data analytics.

Intel® MSK Design is architected specifically to address the demanding needs for the service robot industry while streamlining the wide array of use cases into a small but expandable form factor.

The main compute board is cost-efficient and tailor-made to support workload consolidations in service robots. The I/O expansion boards give system integrators the flexibility to add extra peripherals to support customized service to end users.

The end goal of Intel® MSK Design is to create a gold standard that makes it easy to add new capabilities and increase functionality. In addition, it enables using the service robot for different use cases that accelerates time-to-market and reduces the total cost for ecosystem partners.

References

You may know us for our processors, but we do so much more. Intel invents at the boundaries of technology to make amazing experiences possible for business and society, and for every person on Earth. By harnessing the capability of the cloud, the ubiquity of the Internet of Things, and the latest advances in memory and programmable solutions, Intel is disrupting the retail industry. With our rich portfolio of AI Technologies and the promise of always-on connectivity, Intel is helping solve the toughest challenges.

Intel Compute Platforms for kiosks:

Intel® Open Pluggable Specification

Intel® Smart Display Module

Intel® Smart Kiosk Module

Intel Resources:

Intel® Distribution of OpenVINO™ Toolkit

Intel® OpenVINO™ Pre-trained Models

Intel® Core™ Processors

Intel® Vision Accelerator Design Products

Intel® RealSense™ Technology

Intel® RealSense™ SDK 2.0

Intel® Resource and Design Center

Intel® Developer Zone