Requirements For Outdoor Mobile Robots Include Computer Vision and Time Synchronization

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Outdoor mobile robots, like the more traditional automated mobile robots (AMRs), offer several advantages for users, making them valuable for an array of applications. Firstly, they can navigate and operate in challenging and dynamic environments, such as uneven terrain, forests, and urban landscapes, which is essential for tasks like search and rescue, agriculture, and infrastructure inspection. In addition, outdoor robots can cover large areas efficiently, saving time and resources.

These robots can also operate in harsh weather conditions, expanding their usability for tasks like monitoring environmental data, security, and disaster response. Moreover, outdoor mobile robots can be equipped with various sensors, including GPS, LiDAR, and cameras, to collect data and perform tasks like mapping and exploration. And of course, they can operate 24/7/365, with minimal maintenance in most cases.

In some cases, you can even think of traditional autonomous vehicles as outdoor robots, albeit with people inside them and traveling at higher speeds. But the concepts are quite similar. Furthermore, their autonomy and ability to operate remotely reduces human exposure to dangerous situations.

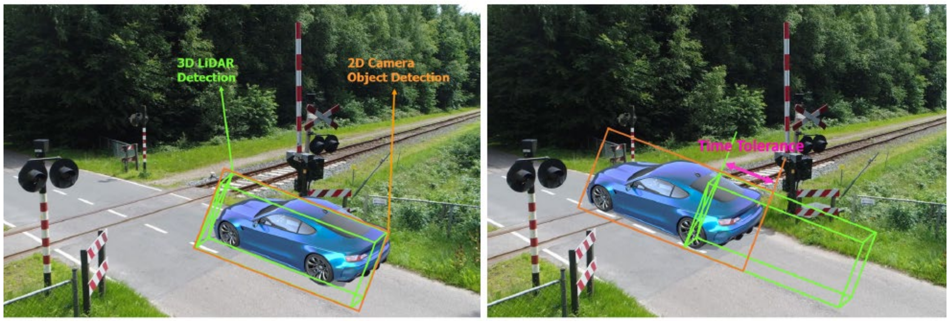
With advancements in machine learning and AI, these robots can make decisions, adapt to changing conditions, and enhance their performance over time. They can alert their operators when maintenance is needed, thereby limiting downtime. Ultimately, outdoor mobile robots have the potential to improve safety, efficiency, and productivity in various fields, making them a valuable technology for today and in the future.

Ensuring Accurate (and Aligned) Data

It's important to note that the data and actions as a result of that data coming out of the robot is only as good as the data going in, and that has a lot to do with not only the sensors themselves, but how (and when) the data from those sensors is received. One phenomenon that could plague outdoor mobile robots is data misalignment, which refers to a situation where the information or data gathered by the robot's sensors, such as cameras, LiDAR, or GPS, does not accurately correspond to the robot's actual physical position or the environment that it is navigating. This misalignment can occur for various reasons, including proper sensor calibration, changes to the environment, mechanical wear and tear across all the components, and the inevitable software bugs.

The bottom line is that if you don't have an accurate time synchronization when the robot starts out, everything you do from that point forward has the potential to be inaccurate. When it comes to calibration, a simple misalignment can result in inaccurate data without the user's knowledge. And we know that outdoor environments can be quite dynamic—cold and rainy one day and warm and sunny the next. We can't let any of those changes affect the incoming data and obviously the outgoing results.

Over time, adjustments must be made as components, like wheels or joints, tend to wear. And history has shown that there is no such thing as perfect (bug-free) code. Those bugs or errors in the robot's control and perception software can lead to data misalignment, causing the robot to make incorrect decisions or navigate inaccurately.



The image above shows an example of data misalignment. In this case, it shows the difference between obtaining data from a 3D LIDAR (left image) verses a 2D LIDAR (right image). If the data is not completely synched up, there's more "wiggle room" and there's the potential for an accident to occur.

Synchronization Through Time Winding

Time winding is a key component of data synchronization. The concept refers to aligning the GNSS (Global Navigation Satellite System) with the internal clock on the robot. GNSS refers to a constellation of satellites that transmits timing data to the receivers within the robots. Time winding also involves continuous PPS (pulse per second) triggering of all nodes, meaning that a signal is transmitted every second. The result should be a guarantee that all sensors are working from the same baseline measurement. Without that initial baseline, it would be impossible to keep the signals synchronized.

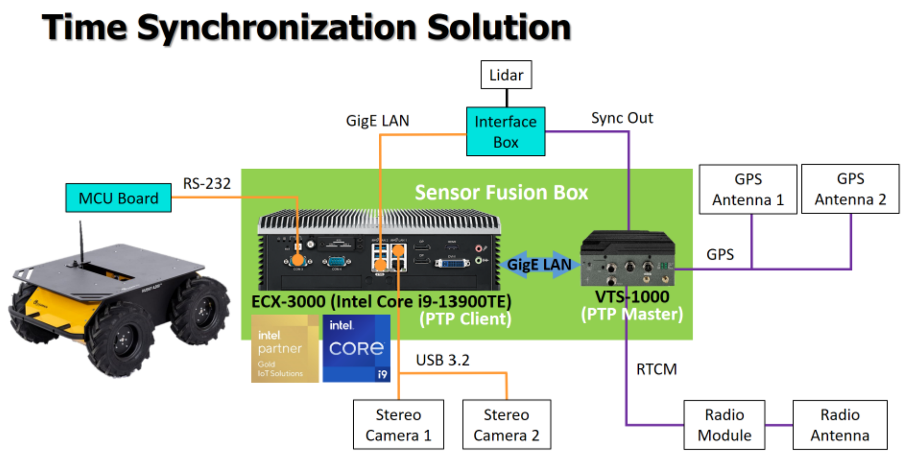
Then comes time stamping, another data-synchronization component where the information is physically written to the sensor. This measurement represents the exact time with nanosecond accuracy. Even if the robot (or vehicle) temporarily loses contact with the satellite, the stamping is still capable to provide the time information to all sensors. That could be the case, for example, if the car gets parked in an underground garage.

Time stamping works hand-in-hand with the time-keeping function, which lets the robot keep time for itself until the robot can reengage with the satellite. Time stamping pushes the time protocol to all nodes and ensures that all sensors are synced, and it typically supports a host of frequencies. The data for the time-keeping function is generated using an FPGA running at a very high speed, which is what permits the nanosecond accuracy. The time-keeping feature manages the precise local time data while employing anti-jamming techniques.

Daisy Chaining

Then there is daisy chaining, a function that's (mostly) specific to Vecow, a provider of embedded computers for outdoor mobile robot applications. Primarily a software function for automated time synchronization, daisy chaining involves expanding the synchronization channels for sensor nodes and controllers. There is typically one master that keeps the time, which is then transmitted to the various slaves within the system. Daisy chaining can be done for a sensor-node-to-sensor-node sync or a controller-to-controller sync.

Another method that's been used is real-time kinematic (RTK) positioning, which is defined as a high-precision satellite navigation technique that can determine the precise position of a receiver. Using this sophisticated statistical method to adjust the phase of these signals can provide an accuracy down to just centimeter-level in many cases.



Pictured is a typical topology of a time synchronization solution. This solution takes advantage of Vecow's ECX-3000 and VTS-1000 systems.

One embedded computing platform that can be embedded into an outdoor mobile robot and handle the time-synchronization process is Vecow's Time Sync Box VTS-1000. The system integrates GNSS and high-precision inertial measurement unit (IMU) components, providing a multi-synchronization function, thereby allowing external sensors to take care of all the sensor synchronization. In the case of the VTS-1000, the three key technologies are covered: time winding, time stamping, and time keeping.

The VTS-1000 also provides the robot operating system (ROS) topics that are needed for robot users to subscribe to the time information, IMU raw data, or additional camera data. Out in the field, the VTS-1000 combines nicely with the company's ECX-3000 high-performance platform, which is powered by 13th Gen Intel Core i9-13900TE (formerly Raptor Lake). Running at 5 GHz and the ability to house up to 24 cores, the Core i9-13900TE is well suited for AI applications and those that require time synchronization.

The ECX-3000 integrates the software and algorithms needed for outdoor mobile robot applications. If AI is required, the ECX-3000 can be configured with a Hailo-8 AI accelerator. Other features include eight independent 2.5G LAN connections with four IEEE 802.3at PoE+ ports, four front-access M.2 SSD trays, and six USB 3.2 Gen 2 ports. Input voltage can range from 9 to 50 Vdc.

The combined solution provides a multi-channel time-of-day (ToD) output for external multi-sensors, a PTP/gPTP Gigabit Ethernet port, and one Gigabit Ethernet port for ROS 2/DDS pub/sub output. It also includes a dual GNSS antenna for robot heading and integrates an Xsens MTi-670 high-precision nine-axis IMU.

The software features of the platform include a daisy chain function that enables the expansion of synchronization channels for sensor nodes and controllers. The integrated dual GNSS antenna and IMU yaw fusion algorithm provides a reliable output through the Ethernet port. For easy configuration of synchronization protocols and frequency based on sensor requirements, Vecow offers a user-friendly Python tool.

Vecow has developed a deep expertise in the combination of outdoor mobile robots and time synchronization solutions, as well as a host of other application areas. To learn more, contact them at info@vecow.com.

About Vecow

Vecow is a team of global embedded experts. We are dedicated to designing, developing, producing, and selling industrial-grade computer products. All of our products are leading in performance, trusted in reliability, exhibit advanced technology, and innovative concepts. Vecow offers AI-ready Inference Systems, AI Computing Systems, Fanless Embedded Systems, Vehicle Computing Systems, Robust Computing Systems, Single Board Computers, Multi-Touch Computers, Multi-Touch Displays, Frame Grabbers, Embedded Peripherals and Design & Manufacturing Services with leading performance, trusted reliability, advanced technology, and innovative concept.

Vecow aims to be your trusted embedded business partner. Our experienced service team is dedicated to creating and maintaining strong partnerships and one-stop integrated solutions. Our services are specific and consider each partner's unique needs in regards to: Autonomous Vehicle, Smart Robotics, Digital Rail, Public Security, Transportation & V2X, Smart Factory, Deep Learning, and any Edge AI applications.

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