How Real-Time Operating Systems Handle Data-Intensive Machine Vision Applications

Data-intensive workloads are now a fundamental prerequisite for modern image-processing and AI-based applications. But how can the resulting data volumes still be stored in a timely manner? The Storage Module of Kithara's real-time operating system provides an answer.

Although machine vision technologies have always been data-intensive, the demands placed on the storage systems of camera-based control software are still increasing dramatically. In many image-based applications, there is a frequent need to exchange large amounts of information with the storage medium at high speed—especially when data communication must also take place in real time.

Compared with many other industrial domains, machine vision applications in particular present demanding challenges in terms of data management. Data-intensive sources such as cameras and high-performance sensors, the growing use of multi-camera systems, and the integration of AI functions are making connected storage media increasingly important. Rising resolutions and frame rates allow camera functions to be integrated into ever more application areas and, in some cases, enable entirely new use cases. In view of this qualitative and quantitative development—especially with regard to the frequent use of machine learning functions—handling large volumes of data has been a decisive issue in industrial image processing for quite some time.

Software-Optimized Storage Solution

Due to the immense data volumes involved, many connected storage systems are often unable to ensure seamless and loss-free data acquisition and thus become a critical bottleneck. As a result, the storage mechanisms of computers used in areas such as automotive engineering, quality assurance, or production—where real-time camera functions are employed—quickly reach their limits as image acquisition and processing become increasingly data-intensive.

Even SSDs with NVMe specifications are, from a hardware perspective, well suited for applications with high data throughput. However, standard drivers are not optimized for extreme storage tasks.

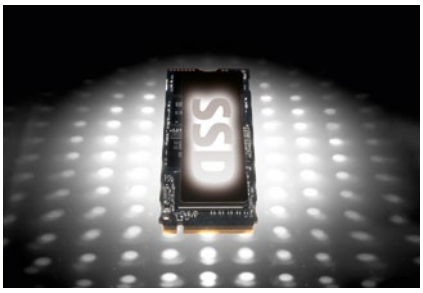
The specially developed Storage Module, as part of the Kithara RealTime Suite real-time operating system, provides a solution to the growing demand for high-performance, real-time-capable storage systems. The software module enables NVMe-based SSDs to achieve data throughput rates of several gigabytes per second, even in continuous operation. This includes both writing and reading data in hard real time.

Thanks to optimized real-time drivers for the NVMe protocol, the Storage Module can even achieve higher read and write speeds with the same SSD hardware than would be possible in standard operation. Users also have the option of bundling multiple solid-state drives. Using RAID 0 (Redundant Array of Independent Disks), several NVMe SSDs can be combined, increasing not only storage capacity but also throughput proportionally to the number of drives used. The so-called stripe depth—the size of the data blocks for individual write operations—can be freely configured by the user to meet specific requirements.

Overlapping Application Areas

The Storage Module is already being used in automotive development, for example in the development and testing of automated vehicle control systems such as driver assistance systems or autonomous driving functions. Since multiple application domains—such as image processing, measurement technology, and integrated vehicle software—overlap in these scenarios, the requirements placed on the data system are correspondingly high.

For instance, a test bench for a multi-camera-based vehicle control system that also uses real-time image processing would be confronted with enormous data volumes that could no longer be handled by the storage system of a conventional development PC. The Storage Module is therefore also used to make development platforms more flexible and easier to integrate without having to forgo a powerful storage system within a real-time environment. This eliminates the time- and cost-intensive implementation of specialized hardware solutions. The Storage Module is also ideally suited for demanding hardware-in-the-loop applications, where realistic simulation of real-world conditions generates substantial volumes of data.



Integration into a Real-Time Context

Fast data storage for demanding projects—particularly those involving machine vision—is a key component in many industrial sectors today. Within the Kithara real-time operating system, support for various relevant communication standards, automation protocols, camera interfaces, and automotive bus systems is available. All of these data formats can be stored using the Storage Module, enabling the realization of data-intensive real-time applications across a wide range of industrial use cases.

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