Enabling Industrial Robotics Capabilities in Space. M. Day Towler[1], F. Martinez[1], and D. Anthony[1]. [1]Southwest Research Institute, 6220 Culebra Rd., San Antonio, TX 78238 (Contact: meera.towler@swri.org)

Introduction: Recent years have seen significant advancements in robotics, which is causing a proliferation of robotics across numerous industries historically not open to automation. While automotive and welding are fields with extensive investment in robotics for decades, the last few years have seen increased investments in robotics for industrial applications such as blending, excess material removal, and assembly [1].

These advances are making automation cheaper and more agile. Requiring less programming for setup allows end users to integrate robotics into their processes without the expense of a dedicated robotics department for installation and maintenance. Additionally, recent development in image processing and machine vision are making a number of industrial processes easier and more efficient. Improved automated vehicles imaging techniques are bringing efficiency and speed to machine vision for industrial robotics.

With such a wide range of highly advanced robotics capabilities available to industrial processes on Earth, the next frontier is robotics in space. Autonomy in space will enable more complex missions farther from Earth and will make space missions cheaper and more accessible.

Industrial Robotics Capabilities for Space: A few capabilities are particularly valuable to the current and future needs of the space industry. Scan-n-Plan™ identifies 3D geometries and plan paths for various industrial processes. Event-based cameras provide high-speed sparse data sets that are well suited to the limited processing power available on FPGAs.

Scan-n-Plan™

Scan-n-Plan™ technologies are a suite of software tools that are developed by SwRI under the Robot Operating System (ROS) development environment for industrial applications over the last decade.

The major components include:

- Automated calibration tools
- Scan acquisition software
- Automated tool path planning tools
- Process coverage simulation tools
- Automated robot path planning tools
- Image classification tools

These tools are deployed in numerous robotics systems, including sanding, grit blasting, chemical de-paint, power-wash, grinding, and painting.

Event-based Cameras

Event-based, or neuromorphic, cameras are a recent maturation in camera technology that produce "events" that are changes in lighting intensity on a per-pixel basis (Figure 1), at the sensor level. The events create a sparse representation of changes in an image, resulting in a much sparser representation of the environment, reducing bandwidth and processing requirements.

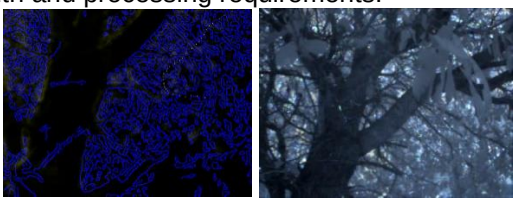

Figure 1. Event-based camera image processed to show edges (left); equivalent image from normal camera (right).

Effectively, an event-based camera compresses the information in the environment to only the changing elements at the sensor level, allowing computer vision algorithms to operate only on relevant portions of an image, as opposed to a traditional camera pipeline, where a computer must first process full resolution camera images to isolate regions of interest in an image. Additionally, because the event-based camera detects both increases and decreases in light intensity, it can detect portions of an object occluding a light source, as well as light reflecting from a target object. This increases its versatility and allows it to operate in a wider variety of lighting conditions. Moreover, event-based cameras have an extremely high dynamic range, often above 110dB, which allows them to operate in rapidly changing lighting conditions.

Conclusion: Robotics capabilities developed for Earth-based industrial processes can be used for space to enable missions farther away from Earth and make spaceflight less expensive.

References:

[1] Rose J. (2021) *A3 Association for Advanced Automation "For First Time on Record, Yearly Non-Automotive Robotic Orders Higher than Automotive Orders."*