

Utilization of a Vision System to Automate Mobile Machine Tools

Ryan Haldimann and Daniel Orf
Electroimpact Inc.

ABSTRACT

In an attempt to be more flexible and cost effective, Aerospace Manufacturers have increasingly chosen to adapt a manufacturing style which borrows heavily from the Automotive industry. To facilitate this change in methodologies a system for locating robots has been developed which utilizes cameras for both locating and guidance of a mobile platform for a robot with drilling and fastening end effector.

CITATION: Haldimann, R. and Orf, D., "Utilization of a Vision System to Automate Mobile Machine Tools," *SAE Int. J. Mater. Manf.* 8(1):2015, doi:10.4271/2014-01-2271.

INTRODUCTION

The Automotive industry extensively uses AGV's in conjunction with robots and moving line technologies to efficiently manufacture automobiles with high quality and low defect rates. Applying this technology to the Aerospace industry requires some adaptations. Although it is possible to manufacture an airframe utilizing a continuously moving line, pulse line style manufacturing is easier to adapt and when integrated with a flat factory floor, a system that is easier to reconfigure is produced. Future adaptation to a larger or longer airframe is realized with little effort and infrastructure change.

MOBILE ROBOTIC SYSTEM

System Architecture

The robot based system is comprised of a KUKA industrial robot placed on top of a mobility platform. The robot incorporates a drilling and fastening end effector which is used for assembly and integration of Aircraft structures. In this integrated system, the cameras that are used for guidance of the mobility platform are also used by the robot to determine its position on the open factory floor as well as guidance between stations. The platform moves from station to station using lines placed on the floor. It then finds valued targets on the floor calculating its location in the world coordinate system. The proper part programs are then loaded and executed. When complete the system is moved to the next station or removed from the cell for part extraction.



Figure 1. Robotic Automation System

Guidance While Moving

The mobility platform is comprised of 4 air bearings, 4 laser scanners, 2 air drives systems, 2 cameras and a PLC for controls. The platform is driven using a pendant or control panel with the cameras activated for guidance along a line placed on the floor using tape or paint. The path is easily reconfigurable if using tape. When in position the cameras datum on a precision fiducial which informs the machine which station it is in, which part program to load and which transforms to use to align the robot coordinates with airplane coordinates.

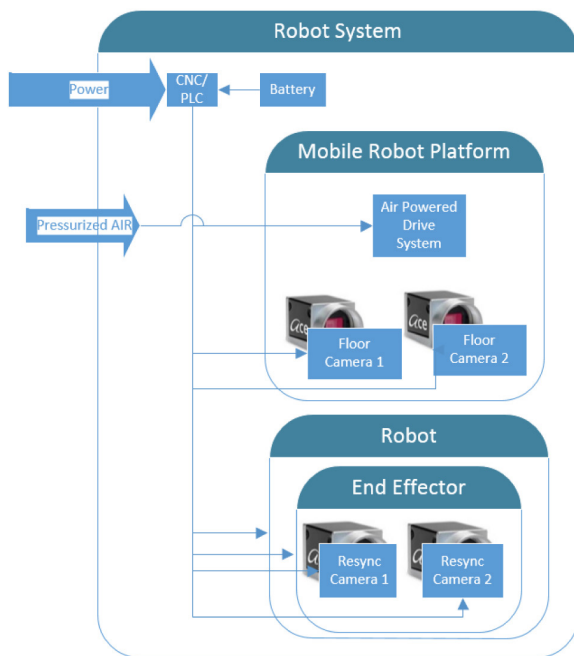


Figure 2. System Architecture

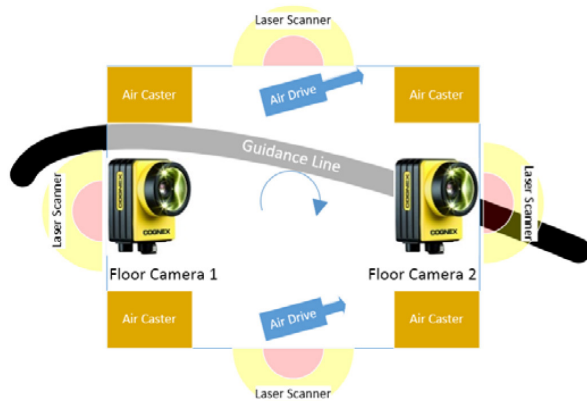


Figure 3. Mobility System Layout

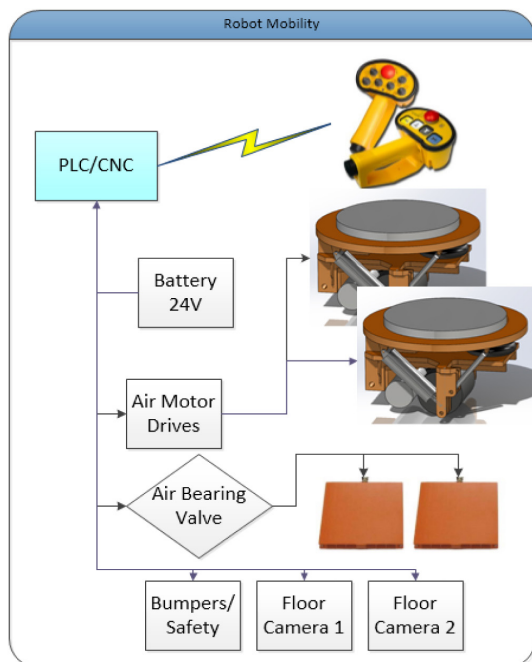


Figure 4. Propulsion

The use of a smart camera allows direct integration into PLC PROFINET infrastructure without having to have a separate PC for processing.



Figure 5. Smart Camera

Kinematics integrate the error reported by each camera into steering and velocity for each drive wheel. Owing to the use of air propulsion PID controls within the PLC are used for velocity and orientation control. Laser scanners provide collision safety and are utilized by the robot during manufacturing operation and during transport operation.

Accurate Datuming to Part

To locate the robot within each station the location of 2 fiducial targets are valued with a laser tracker relative to the world coordinates.



Figure 6. Floor Barcode Fiducial

The transform from robot to camera is calculated using a calibration plate that is seen by the camera and valued by a laser tracker in robot coordinates.

The 2 floor cameras then locate the two targets and load the values based on each targets barcode. The transform to world coordinates, ξ_R , is then calculated using the 2 target actual values ($C^1\xi_p$ and $C^2\xi_p$) and the nominal values. After calculating transform ξ_R , the robot is accurate to ± 0.40 mm in the Work Frame. This calculation takes less than 3 seconds to execute.