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VISION-GUIDED ROBOTICS

Mobile robots inspect rails, consumer goods

Coupling the latest technological advances in robotics with audio, visual, and tactile feedback systems and software is paving the way for the next generation of mobile robots. This was the theme of a presentation at this year's NIWeek by Luca Lattanzi, a machine-vision and robotics specialist with the Loccioni Group (www.loccioni.com). In his presentation, Lattanzi described the development of a mobile robot for railroad switch inspection and another for consumer goods inspection.

"While many rail inspection systems can inspect the condition of the rail tracks," says Lattanzi, "these systems are not designed to measure the rail switches—the linked tapering rails that are used to guide a train from one track to another." To inspect these, the Loccioni Group has developed Felix, an autonomous mobile robot that provides remote inspectors with visual profiles of these switches (see Fig. 1).

Mounted on the railway track, the Felix robot is equipped *Robots continued on page 16*

ENVIRONMENT/AGRICULTURE

Autonomous vehicle images apple orchard yields

In work funded by the USDA Specialty Crop Research Initiative (www.nifa.usda.gov), engineers led by Qi Wang, PhD, from the Robotics Institute at Carnegie Mellon University (www.cmu.edu) have developed a computer vision-based system that can accurately estimate the yields from orchards of apple trees.

Two D300 cameras from Nikon (www.nikon.com) fitted with wide-angle lenses were fixed to an aluminum bar about 0.28 m apart to form a stereo pair, after which they were mounted at the rear of an autonomous vehicle (see figure) to capture images of the fruit. To reduce the variance of natural illumination and allow the system to operate at night, the trees were illuminated with two AlienBees ABR800 flash lights from Paul C. Buff (www.paulcbuff.com).

The autonomous vehicle travels through orchard aisles at a preset constant speed of 0.25 m/sec by following fruit tree rows in the orchard. As it does so, the system scans both sides of each tree row in the orchard. Sequentially acquired images provide multiple views of every tree from different perspectives to reduce the occlusion of apples by foliage and branches.

Online software developed in Python from the Python Software Foundation (www.python.org) controls the image acquisition process. Once acquired, data are then processed offline by software developed in MATLAB from The MathWorks (www.mathworks.com), which detects the apples, identifies the location of the apples from sequential acquired images, *Orchard continued on page 20*

METROLOGY

Japanese companies display ingenuity with vision offerings at NIWeek

Every year in August, National Instruments (NI; www.ni.com) holds its annual conference and exhibition to demonstrate the latest products and applications based the company's graphical system design approach and NI LabVIEW system design software. On the show floor this year, the organizers highlighted some of the latest vision products being developed in Japan. These included a range of rugged programmable smart cameras, a test system to measure the brightness and chromaticity of LEDs, and a system to allow operators to visually locate the origin of a sound source.

For integrators wishing to deploy rugged, explosion-proof cameras in their systems, ORIENT BRAINS (www.orientbrains.com) showed three cameras capable of daylight, near-infrared (NIR), and IR imaging (see Fig. 1). ORIENT BRAINS has chosen to integrate off-the-shelf camera modules from Basler (www.baslerweb.com)—for the visible and NIR versions—and the A35 microbolometer-based camera from FLIR (www.flir.com), embedded in rugged housings.

Known as Next-Eye programmable smart cameras, these devices also embed a custom-built, Atom-based compact vision *NIWeek continued on page 18*

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Robots continued from page 15 with two 3-D profilometers developed by Loccioni, based on a Z-Laser ZM18 red laser-line projector (www.z-laser.com) and an IDS UI-5490SE GigE camera (www.ids-imaging.com). Specific diagnostic algorithms have also been developed in order to process and analyze acquired data. Reflected laser light is captured by the profilometer's 2-D camera, a depth map computed, and from this depth map the contour and profile of the tracks and rail switches determined. Once this information is computed, track and switch point distance can also be determined. Image and measurement data are then transmitted wirelessly to an operator for further analysis.

"In many robotics applications," says Lattanzi, "it is not only necessary for such robots to take 3-D visual measurements but also to perform acoustic and vibration analysis." This is especially important where robots are expected to test consumer products.

Tasked with developing a robot for quality-control testing of washing machines, Lattanzi and his colleagues developed a Mobile Quality Control Robot called Mo.Di.Bot that emulates many of the functions of a human operator and is capable of autonomously navigating a testing laboratory replete with multiple machines (see Fig. 2).

FIGURE 2. Mo.Di.Bot emulates many of the functions of a human operator and is capable of autonomously navigating and testing a laboratory replete with multiple washing machines.

Multiple sensory systems were integrated around a RobuLaB80 from Robosoft (www.robosoft.com). To emulate the movement of the human hand, the robot is equipped with a dexterous three-fingered hand employing tactile sensors from Schunk (www.us.schunk.com). This in turn is attached to a MINI45 six-axis force/torque transducer by ATI Industrial Automation (www.ati-ia.com) and a Schunk lightweight arm that provides seven degrees of freedom.

To perform environmental perception and model- *Robots continues on page 18*

FIGURE 1. Felix is an autonomous mobile robot that provides remote inspectors with visual profiles of railroad switches.

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Robots continued from page 16 ing, the robot is equipped with both a SICK (www.sickivp.com) S3000 collision avoidance and safety laser system and a Microsoft (www.microsoft.com) Kinect 3-D sensor. While audio data are captured with an electret microphone, visual data are imaged using a USB UI-1480SE 2560 × 1920-pixel color USB 2.0 camera from IDS.

USB data captured from these devices are transferred to host PC memory using a USB-9229/9239 interface from National Instruments (NI; www.ni.com) while an NI PCI-4472 analog interface card is used to capture audio data. This analog interface card is also used to transfer data to the PC from a single-point PIVS 300 industrial vibrometer from Polytec (www.polytec.com) that measures any vibration of the unit under test.

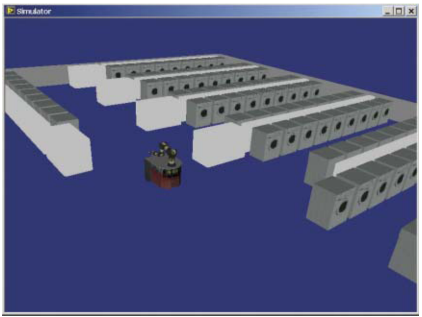

FIGURE 3. To allow Mo.Di.Bot to perform tasks autonomously, the washing machine quality-control inspection system was first modeled using Microsoft Robotics Studio and NI's Robotics Simulator.

To allow the robot to perform tasks autonomously, the washing machine quality-control inspection system was first modeled using Microsoft Robotics Studio and NI's Robotics Simulator (see Fig. 3). By modeling the location of each of the washing machines to be analyzed, the trajectory of the robot can be optimized.

Once the modeling is accomplished, the robot autonomously moves to each machine, performing tasks such as opening and closing of the front door of the machine and initiating specific machine cycles by manipulating switches and rotary controls of the machine. Diagnostic vision tasks are then performed using the onboard vision inspection, vibration analysis, and acoustic measurement systems written in NI's LabVIEW graphical programming language. A video of the robot in action can be found at http://research.loccioni.com/projects/interaid/.

NIWeek continued from page 15 board built by NI. Running real-time NI LabVIEW-based vision programs, the board is capable of processing images, triggering events through digital I/O, and outputting results over an Ethernet interface. Designed for security and rugged industrial applications, these smart cameras are now in operation at the plants of Kansai Electric Power Company (www.kepco.co.jp), where they are being used to monitor the cooling pool for unused nuclear fuel.

FIGURE 1. ORIENT BRAINS' Next-Eye programmable smart cameras use an embedded processor from NI to perform vision tasks. The camera is available in commercial (left), explosion-proof (middle), and IR versions (right).

Display-panel testing was the focus of the Matsuura Denkosha demonstration (http://denkosha.net). There, company president Takahiro Matsuura demonstrated how a GigE-based camera system could be used to calibrate LED panels used in flat-panel display systems.

Many display systems comprise smaller 1 × 1-m panels with up to 4096 × 4096 white LEDs. To ensure each LED is of the correct brightness