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When Trees are Not Green: Recent Developments in an Off-the-Shelf System for Robust Color and Multispectral Based Recognition and Robot Control.

Over the past two decades, machine vision has played an ever-increasing role in industrial automation. The vast majority of vision systems use monochrome (gray-scale) cameras. The relatively few systems using color cameras are generally carefully designed to simplify the inspection scene where objects of interest appear with simple, regular outlines of known orientation and unique uniform colors, or at least unique uniform hue. Great care is usually taken to avoid the presence of shadows and glints. Hours or even days may be available for trainng. Textbooks and vendor literature continue to promote image processing models that assume these simplified properties.

As robot usage expands beyond the factory into the world of agriculture, biological sample processing, reconnaissance and autonomous vehicle control, the need for rapid practical color, multispectral, and even hyperspectral based recognition becomes important. In these environments objects of interest are most likely to appear as mixtures of colors with complicated, variable and ill-defined outlines. Textures may be complex and varying. Shadows and glints may be common and color distributions overlap so the color of any one pixel may not be enough to uniquely determine the object class at that point. Frequent retraining may be required as lighting and scene conditions change. Here traditional color-based machine vision processing approaches geared towards single color items are rarely effective.

While traditional color-based automated recognition approaches struggle with complicated, variable scenes, living creatures, often with modest brainpower and no formal mathematical training, are able to extract color-based identification information rapidly and efficiently.

WAY-2C is a software system for color, multispectral and hyperspectral based recognition founded on a non-parametric statistical model. It is quickly trained by example and provides robust classification, verification, and anomaly detection in the presence of real-world complexities. Under development for well over a decade WAY-2C has been applied successfully in a variety of challenging inspection and industrial control applications where scene complexity and variability cause difficulties for traditional color machine vision approaches. Experience with such applications confirms classification comparable with human observers in accuracy and far exceeding such observers in speed and reliability. WAY-2C runs on both PC’s and smart cameras. Images successfully interpreted now number in the billions.

Because of its unconventional approach to color-based recognition, most WAY-2C real-world machine vision applications have been in areas where other, more established, methods have failed. Based on its demonstrated success in such applications, we hypothesized that the software might be useful in robotic applications where complex scenes are the norm. The purpose of this study was to test that hypothesis.

WAY-2C already had considerable flexibility for control, sensor input processing, as well as text and binary outputs. For example, because of requirements for high speed sorting systems with distributed intelligence, commands in its script language may come from text files or from external devices over a network, serial ports, or a combination of sources. This makes it possible to combine high-level control from external sources with local intermediate-level vision specific tasks. Text and digital output may be routed to a variety of devices including user-written dynamically linked modules. This makes it particularly easy to implement robot control systems where such output may be parsed and translated to appropriate robot specific control commands.

For the tests, we installed WAY-2C on a Sony XCI-SX100C Smart Camera running Windows XPe. The camera and a touch-screen monitor were mounted on an inexpensive iRobot Create®. Network output from the camera was connected to the robot control input port via an Ethernet to serial converter.

For an initial test, we selected two simple, closely related tasks: anomaly tracking and target class tracking. Both involve first training the system by recording reference color distributions in a target free scene. In the first task, the vision system divides the scene into a number of inspection regions and repeatedly scans it checking for regions having anomalous color distributions. If an anomalous region is detected the robot is directed towards it. In the second task, the system is trained additionally on a target color distribution. Again, a search loop is executed and if the specified target is found the robot is directed towards it.

In both cases, the training and search steps use simple WAY-2C scripts to pass text output of scan-position and class-found information to an application-specific robot control interface DLL. The latter takes this information, constructs its own map of the relevant information and uses this map to select motor control commands to pass to the robot. An alternative approach would be for WAY-2C to create and maintain a memory-mapped file of scan information that could be used by a completely independent robot control module. Either of these approaches is applicable to a wide variety of robot control tasks in such areas as surveillance, fruit picking and navigation.

Initial experiments have been very encouraging. The only problems encountered have been in maintaining reliable communications with the inexpensive robot platform we chose.