Integrating Machine Vision and Motion Control

Huntron
System Overview

**PXI Color Vision:**
Cameras, Optics, Lighting, Frame Grabbers and Software

**Serial 3 Axis Motion Control:**
Application Software, Motor Control, Amplifier/drives, Motors, Mechanical elements, and Encoder feedback

**PXI Stimulus and Measurement:** PXI based instruments from simple meters, to complex data acquisition.

**Control Software:** Integrates vision motion and measurement.
PXI Control Software can be written with a number of software packages NI LabVIEW, Microsoft C++, Visual Basic and .NET

PXI Test execution can be called up by test executives such as NI’s Test Stand

EX: Huntron Software development Kit (SDK) LabVIEW application with NI IMAQ Vision
Serial Axis motion control

Application software – You can use application software to command target positions and motion control profiles.

Motion controller – The motion controller acts as brain of the system by taking the desired target positions and motion profiles and creating the trajectories for the motors to follow, but outputting a ±Voltage signal for servo motors, or a step and direction pulses for stepper motors.

Amplifier or drive – Amplifiers/drives take the commands from the controller and generate the current required to drive or turn the motor.

Motor – Motors turn electrical energy into mechanical energy and produce the torque required to move to the desired target position.

Mechanical elements – Motors are designed to provide torque to some mechanics. These include linear slides, robotic arms, and special actuators.

Feedback device or position sensor – A position feedback device is not required for some motion control applications (such as controlling stepper motors), but is vital for servo motors. The feedback device, usually a quadrature encoder, senses the motor position and reports the result to the controller, thereby closing the loop to the motion controller.
Cameras - High-resolution cameras, (CCD and CMOS), line scan cameras, multiple cameras, the camera type is determined by a specific application.

Optics - Use optics with appropriate resolution and distortion properties.

Lighting- LED-based lighting is clearly the trend of the future LEDs make it easier to configure cost effective single application-specific arrangements to optimize performance.

Frame Grabbers - Digital or Analog image acquisition devices for PCI, PCI Express, and PXI share timing signals among devices to synchronize and correlate images with other measurements.

Software Tools- Vision acquisition software, which acquires, saves, and displays images. EX- IMAQ Vision

Control Software - Application of the camera, optics, lighting, frame grabbers, and software tools.
The Product
The Huntron® Access Automated Probing Station is designed to accurately access test points on printed circuit assemblies (PCAs). Its 20 micron accuracy achieved by micro-stepping and linear encoding ensures reliable probing of the smallest surface mounted components.

The elements that make the system work…PXI Color Vision, Serial 3 Axis motion control, PCB CAD data, PXI instrumentation, and Control Software.
The Huntron Workstation Software is designed to bring a high level of efficiency and flexibility to board test creation and troubleshooting. The multiple pane layout of Huntron Workstation allows for fast test creation, quick viewing of component signatures, control of robotic probers and CAD viewing tools that update on the fly.

The Workstation software is an example of an application that is written in Visual Basic.Net. This software application shows the integration of the machine vision, motion control, PCB CAD data, and measurement.
Scaling the camera image is a process that defines the field of view. We start by focusing the camera image at a predetermined distance on the Z axis. Once the camera is adjusted and set a precision ruler is used to measure the field of view (height and width). Having the precise field of view measurements allows for field of view to be converted from pixels to microns. It is now possible to determine the cursor location when clicked on the image in microns. This X-Y location can be sent to the motion control to move the camera to the position clicked. This process is repeated for each separate predetermined Z distance.
Camera to Probe Offset

The Camera and the Probe are physically offset, this process calculates the distance in X-Y of the offset. The X-Y is used when switching between the camera image and the probe.
Alignment points that are selected in opposite corners of the UUT.
- Move the camera over and store two alignment locations and images. If CAD data is used, CAD features are used for alignment locations.
- Move the camera over the same alignment locations on another UUT.
- Calculate offset and rotation between the first UUT position and the other UUT position.

Alignment points are used to compensate for differences in PCB’s (UUT’s) positioned in the probing system to allow the probe to move test points, via’s, or nets on the UUT.

Alignment points are reference points that are physical locations on the UUT.

Two separate points are referenced, at each point store an image along with the X-Y data for that point.

The alignment data will be used each time that type of UUT is placed in the probing system.

When switching UUT on the system there may be some physical differences the alignment data will allow the software to compensate for these differences.
Stored alignment images and the alignment images from the current board.
- Vision comparison algorithms search for a smaller center square of the stored image in the current image.
- Pixel offsets from the comparison to determine position to move the camera and then re-compare images.
- If the image is not found, search adjacent position images for the image.

Auto alignment uses color pattern matching vision tools like IMAQ Vision to compare a stored color image to a new color image. The vision tools will search for a small center area of the new image in the stored image. Pixel offsets are returned when the search is completed. Using the camera image scaling, the camera will move to the new location determined by the pixel offset and re-compare.

Visual comparison algorithms are based on a stored image, the challenge for this to be successful always comes back to lighting. If the lighting changes the new image will change and the comparison may fail. Lighting affects color, glare, and overall image. The key to success is to make sure lighting is consistent.
Align Calculations

Two defined alignment points are for PCB(1) are stored. X-Y test point co-ordinates are stored. PCB (2) is placed in the prober the 2 points may not be positioned in the exact location of PCB(1). The camera is positioned over the 2 alignment on PCB(2), and the X-Y angular difference is calculated. That difference is then applied to all the test points on PCB (2).
The board image is a series of camera images that create a complete and interactive image.

- Set camera to determine the position of the back right corner of board and the front left corner of board.
- Move the camera from back right corner, back and forth, to the front left corner, capturing camera images.
- Insert the captured images into a larger bitmap.
- Clicking the mouse over a point on the image provides a pixel location.
- The pixel location, align data, back right corner position and the image scaling are used to position the camera over the position clicked on the image.

The application is able to stitch together a series of camera images into one composite image. Each small image is scaled, so the composite image is also scaled. This allows the calculation of the location of the mouse cursor anywhere on the composite image.
Example Visual Basic .Net Camera Code

**Camera Initialization:**
```vbnet
Dim niImage As NationalInstruments.CWIMAQControls.CWIMAQImage
NIFrameGrabber.CreateControl()
If NIFrameGrabber.Configure() <> 0 Then
    Return CameraError.InitFailure
End If
NIFrameGrabber.AcquireField = NationalInstruments.CWIMAQControls.CWIMAQAcquireFieldModes.cwimaqAllFields
NIFrameGrabber.ImageRep = NationalInstruments.CWIMAQControls.CWIMAQImageReps.cwimaqRepRGB32
NIFrameGrabber.StillColorMode = NationalInstruments.CWIMAQControls.CWIMAQStillColorModes.cwimaqStillColorModeRGB
NIFrameGrabber.Interface = "huntron"
If NIFrameGrabber.LoadInterfaceDefaults() <> 0 Then
    Return CameraError.InitFailure
End If
NIFrameGrabber.Images.RemoveAll()
niImage = NIFrameGrabber.Images.Add(1)
If niImage Is Nothing Then
    Return CameraError.InitFailure
End If
NIFrameGrabber.AcquisitionType = NationalInstruments.CWIMAQControls.CWIMAQAcquisitionTypes.cwimaqAcquisitionOneShot
NIVision.CreateControl()
```

**Camera Capture Image:**
```vbnet
If iChannel = 1 Then
    NIFrameGrabber.Channel = 1
Else
    NIFrameGrabber.Channel = 0
End If
If (iBrightness >= -50) And (iBrightness <= 50) Then
    NIFrameGrabber.Color.Brightness = iBrightness
End If
If (dContrast >= 0.5) And (dContrast <= 1.5) Then
    NIFrameGrabber.Color.Contrast = dContrast
End If
NIFrameGrabber.AcquireImage()
```

**Example Visual Basic .Net Camera Code**

```
pxl tac.com
HUNTRON
Access Explore Discover
```
Import CAD data from PCB layout packages (PADS, Protel, Mentor Graphics, etc.)
- CAD Data containing component, nets, pins, via’s is used to generate the Test Tree
- The CAD Data contains the XY coordinates of pins, vias, test points, etc.
- The XY data is linked to the Alignment Data, enabling the Prober to move accurately to pins, via’s or test points
- Mousing over a point on the CAD image and clicking will move the probe to the desired pin, via or test point.
- The CAD image will also show all components or nets connected to the selected point

Importing CAD data provides the X-Y data needed for the vision and motion allowing the probe to drive to desired locations. CAD data saves time in establishing probing locations because the X-Y data supplied. Without the CAD data the vision and motion needs to be manually driven to the desired points and stored.
Select Z travel distance (small travel allows for control of the spring loaded probe compression).
Move the probe down in travel distance selected steps
Move probe down to the desired compression of the spring loaded probe and save location.
A Z-up position may be established minimizing up and down travel.

Z Height positioning is used to adjust the position and probing pressure applied to the UUT. This process is done by taking control of the Z motors and stepping down to the desired Z plane.

The Z steps are determined by the motor specifications (steps, micro-steps, and drivers).
Integration of CAD, Vision and Motion allows probe placement with 20 micron accuracy.

The probe is placed on each test point and the TrackerPXI applies sine wave, digitizes the change and displays the signature information graphically.

Reference signature data is stored from a good UUT and then other UUT's can be tested against this baseline model.

Other control software can be used with other PXI instrumentation to capture data using the same motion and vision tools.

Capturing Data is the end result of the vision and motion process, we are able to drive the probe to a point, put the probe down, hold it there long enough to capture the data and then move to the next point.
Robotic Probing provides at least a 10:1 improvement in probing time. This saving is due to the fact that the operator does not have to interrupt the program to look up reference points in a diagram or other documentation. Also, Robotic Probing does not require judgment or manual dexterity on the part of the operator. It eliminates the need for ancillary documentation to identify physical location of the probe points, and it further eliminates errors in probe placement due to operator error and variations in probe pressure.**

*Diagnostic testing of circuit cards with robotic prober, as presented during Autotestcon 1998 0-7803-4420-0/98 ©1998 IEEE
Huntron ProTrack I is a stand alone USB controlled test instrument

Converting the ProTrack I into the TrackerPXI in the PXI format has a number of advantages:

- Small, Compact, Rugged Package
- Open Standard, Multiple Vendors
- Large Selection of PXI Instruments and modules
- Tight Integration
- Low Cost

The process:

- The front panel replaced with software
- Uses PXI chassis power supply
- Change the USB interface to PXI (Drivers created)
- Remaining circuits compressed to fit on the smaller board
### PXISA Vision and Motion Vendors

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<th>Vendor</th>
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<tr>
<td>Conduant Corporation</td>
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<td>Huntron</td>
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<td>MEN Mikro Elektronik</td>
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