

# **Micro/Vickers/Knoop Hardness/Fracture Toughness Measurement Software**

## **USER'S MANUAL**

January 03, 2019

# USER'S MANUAL

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## **1.0 GENERAL INFORMATION**

## 1.0 GENERAL INFORMATION

### 1.1 System Overview

- **Full Automatic:** The Full Automatic version provides the function in auto-focusing by raising/lowering the sample stage at each test point, if the hardness machine is equipped with a sample Z axis motor.

### 1.2 System Requirements

**System:** IBM compatible PC (desktop or notebook) with Windows XP, Windows Vista, Windows 7, or Windows 8/10 32 or 64 bit operating system. At least two USB2.0 ports are required with one for the USB license key and another for the USB camera. An additional USB port is needed for the version With Turret Control and above. If the total number of USB ports is limited on the PC, a high speed USB hub may be used.

**Supporting Software:** MS Office (2003 or higher) with Excel and Word installed for reporting.

### 1.3 Main Features

System provides the below application specific features, in addition to the general standard features which are also listed afterwards.

- **Automatic measurement:** With a mouse click on a button, system automatically measures the indentation.
- **Automatic sample contour scan and indentation pattern set up:** limited to Semi-Automatic and Full Automatic versions only, system can automatically scan the sample contour and generate test points by defined patterns.
- **Hardness curve:** System automatically plots the hardness value vs. test point depth and calculates the hardness depth.
- **Hardness conversion, correction, and validation:** The measured HV value can be converted to other hardness scales such as HB,HR etc . HV can be corrected for non-planar surfaces. System calculates the minimum sample thickness, minimum test point to sample edge distance etc for validation.
- **Statistics:** Statistical values such as average, standard deviation, Cp, Cpk etc are automatically generated, and off the limit values are marked.
- **Data saving and retrieval:** System can save and retrieve the hardness measurement data and images in data files.
- **Reporting:** With a mouse click, the system automatically generates a Microsoft Word or Excel document, with a standard or user provided template, to reports the measurement data, statistical information, the measurement image, and the hardness Case curve.

## 1.4 Standard Features

- **Image/Video capturing:** Capture and save images/videos on DirectShow compatible USB cameras.
- **Camera calibration:** For measurement applications, the camera can be calibrated with a microscope ruler or grid.
- **Calibration management:** System allows save/manage multiple calibrations, load a calibration, rename a calibration, or unload the current calibration.
- **Geometry measurement:** System provides the tools to draw and measure common geometric shapes such as lines, angles, rectangles, arcs/circles, ellipses, polygons, point-to-line, and point-to-arc etc.
- **Image processing:** System provides a rich set of image processing tools for advanced applications, which include adjusting Brightness, Contrast, Gamma, and Histogram Level, and the Sharpen, Smooth, Invert, and Convert to Grey functions. On grey scale images, system provides various advanced tools in filtering and finding edges, as well as some standard tools in morphological operations such as open, close, dilation, erosion, and flood fill, to name a few.
- **Document entry:** On an image, system provides a document editor to enter/edit documents with contents either in simple plain text format or in advanced HTML format with objects including tables, list, and images.
- **Album management:** System allows user manage multiple images in an album which can be saved to and opened from an album file. The images can have the standard geometric shapes and the documents as entered by user as described above.
- **Data saving and retrieval:** System can save and retrieve the geometry measurement data and images in data files.
- **Reporting:** With a mouse click, system generates a Word document for the geometry measurements.
- **Printing with magnification:** System can print the image with user specified magnification.

## **2.0 SOFTWARE INSTALLATION**

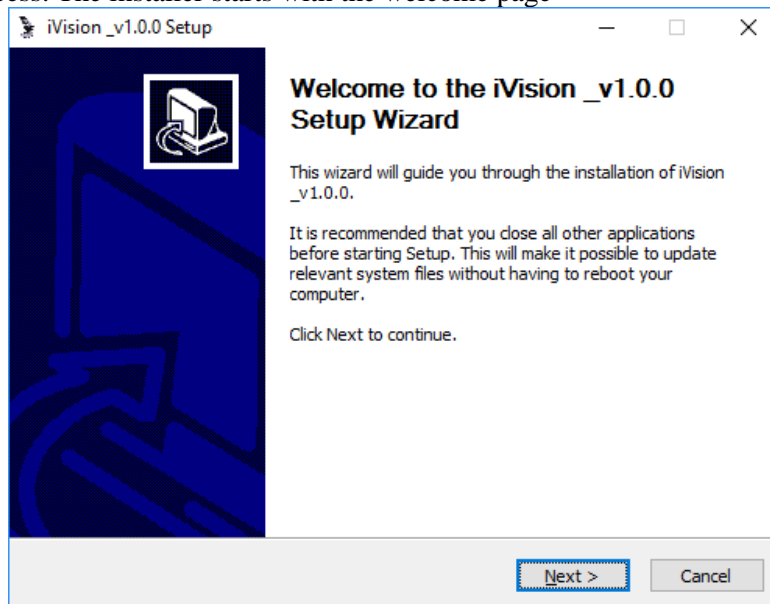
## 2.0 SOFTWARE INSTALLATION

### 2.1 Installation Overview

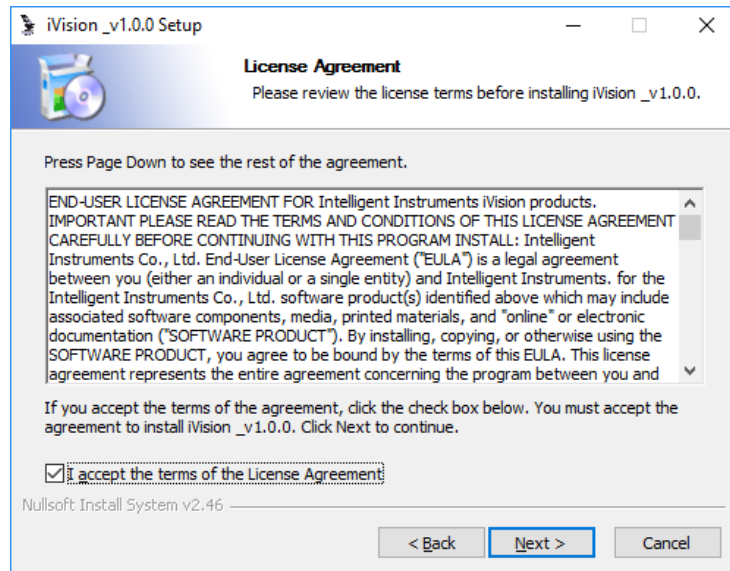
The installation of the system is simple in that the software and its relevant device drivers all come in one installer file. The software is modular in architecture. It consists of the application platform and upon which the application modules. The following components are installed in the system: 1) Microsoft VC++ redistributable package since the software is developed with MSVC; 2) software platform, a general scriptable graphical user interface with built-in image processing functions; 3) Device drivers including USB camera driver and its DirectShow driver, and the motion control card driver if supplied; 4) HV Measurement application modules.

### 2.2 Installation Instructions

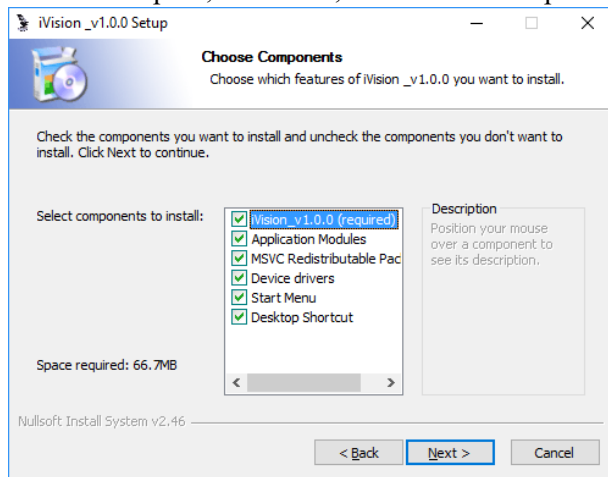
Mouse double-click the installer file iVision\_v1.0.0\_TZXXXXXX\_installer\_yyyymmdd\_en.exe to start the installation process. The installer starts with the welcome page



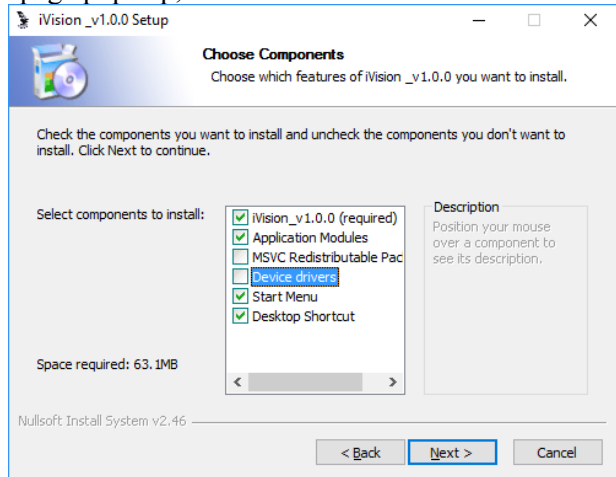
Click Next, the License Agreement page pops up,



Check I accept...,click Next, the Choose Components page pops up,



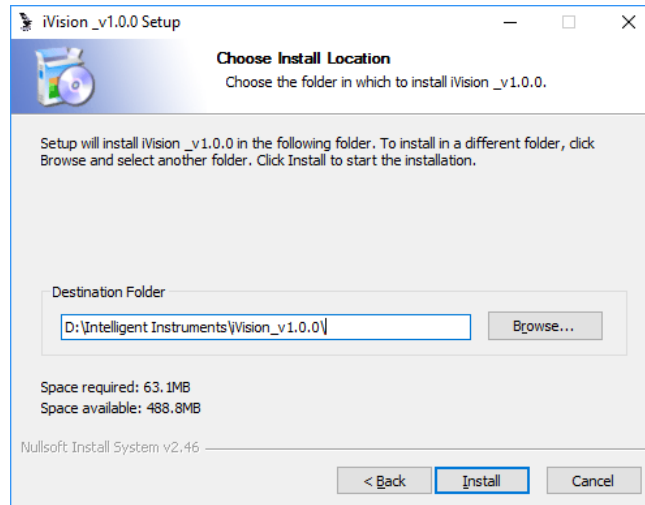
(a) First time installation



(b) Re-installation (overwrite)

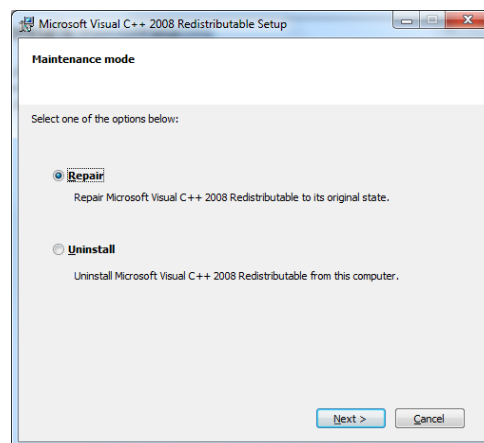
At first installation in the system, choose all the components, or uncheck MSVC Redistributable and Device drivers at re-installation if these two components were installed properly in the previous installation, click Next, the Choose Install Location page pops up,

## 2.0 Software Installation

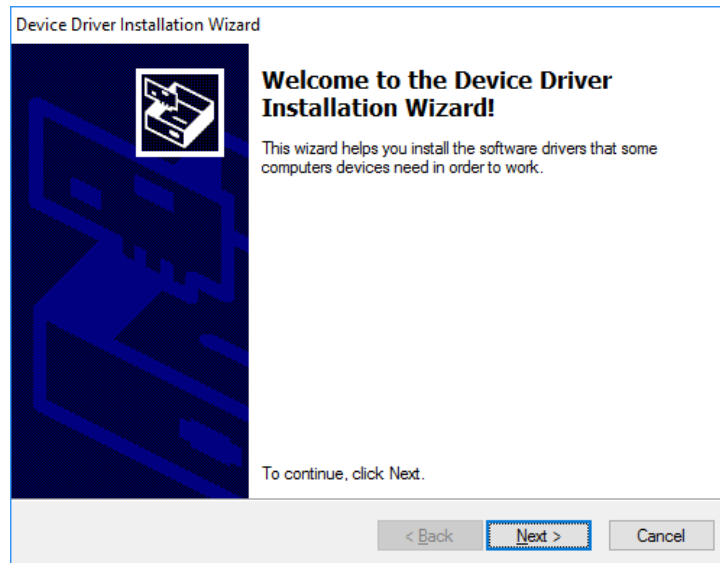


If an installation location other than the default is required, click Browse... to select the location. Click Install to start installation.

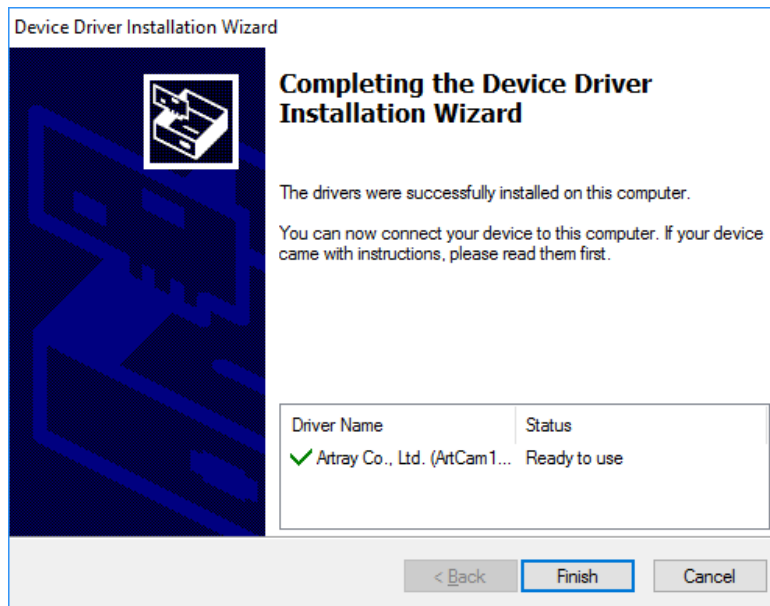
Note that if the MSVC Redistributable component was installed before in previous installation and it is selected for re-installation, its re-installation dialog pops up



Check repair and click Next. Click Finish at its completion to continue. The device driver installation dialog pops up,

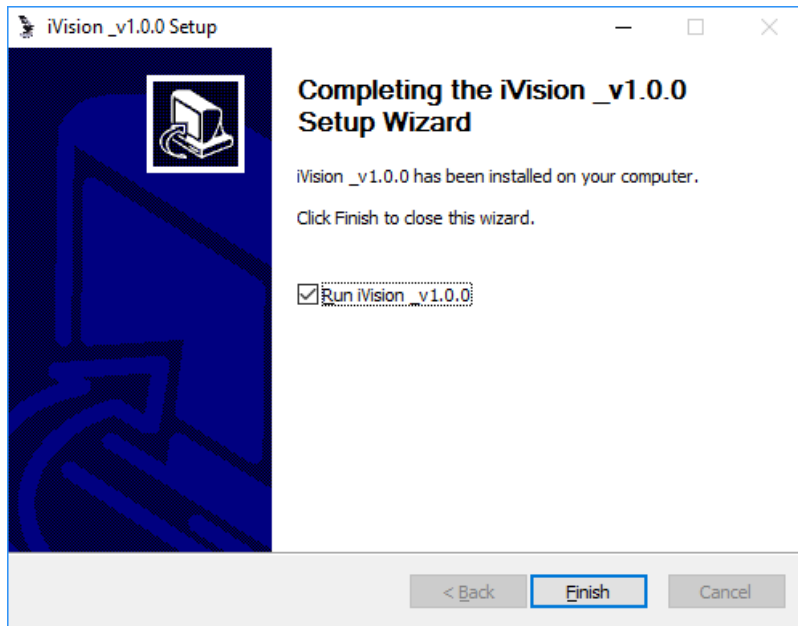


Click Next to start the driver installation,



Click Finish. Repeat until all the device drivers included in the installation package (e.g, the USB camera, USB stepper motor controller etc) are installed. The Setup completion page pops up at the end,

## 2.0 Software Installation



If starting the application is desired, plug in the software USB dongle, and click Finish to start. Otherwise, uncheck Run iVision\_v1.0.0 and click finish to conclude the installation process.

## **2.0 Software Installation**

## **3.0 GETTING STARTED**

## 3.0 GETTING STARTED

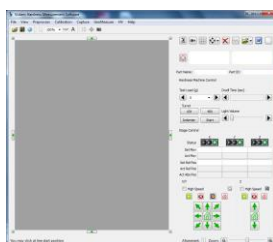
### 3.1 Driver installation

When the USB camera is plugged in at the first time, PC will take a minute to install its driver. If the operating system is Windows XP, when the computer asks to install the device driver either manually or automatically, answer “automatic installation”.

### 3.2 Starting the application



#### 3.2.1 Graphical User Interface (GUI) setup




**GUI Layouts:** At first startup, the GUI will show the HV measurement interface. If user runs other application modules such as geometry measurement and wants to go back to HV measurement module, just select this menu (HV->HV measurement).



(1) Main interface

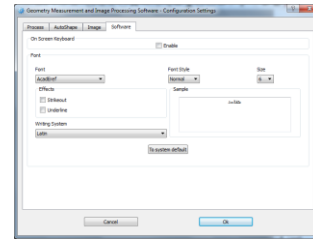
User may adjust the splitter dimensions and the table column widths to his/her preference, and the system will keep the GUI settings at exit. To do so, move the mouse cursor near the invisible separator in

between the two panels of the splitter, when the cursor hits the separator, its shape will become  or  depending on the orientation of the splitter, just drag move the cursor to adjust the splitter sizes. It is the style of this software that the left panel displays the video or image while the right panel displays the user interfaces. The image album may show up automatically on the right at first time, but it can be docked at either of the up/down/left/right side of the main window or it can be dragged out floating.

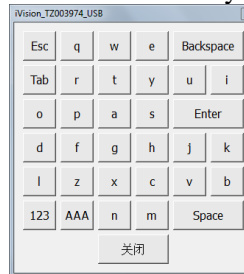
Clicking on the tool button Machine control , Result interface , or Set path  on the upper right will bring the relevant page to the front. On the lower part of the Result interface page lie most of the displays and controls grouped in tabs such as Statistics, Settings, Machine Control, Case Curve, Conversion, Parameters, Correction, and Validation.

### 3.0 Getting Started

**GUI configurations:** Many other general GUI settings such as menu orders, font, pen drawing size, shape selection color, application on-screen keyboard enable, and image grid etc can be configured in the **Configuration Settings** dialog through menu **File -> View/Edit configurations...** If the on-screen keyboard is enabled in the application (by menu File->View/Edit configurations..., under Software tab), the application will use the system on-screen keyboard (suitable for international characters input), or the application on-screen keyboard (alphanumeric characters only), depending on whether “Use System On Screen Keyboard” is checked or not.



(a) System on-screen keyboard




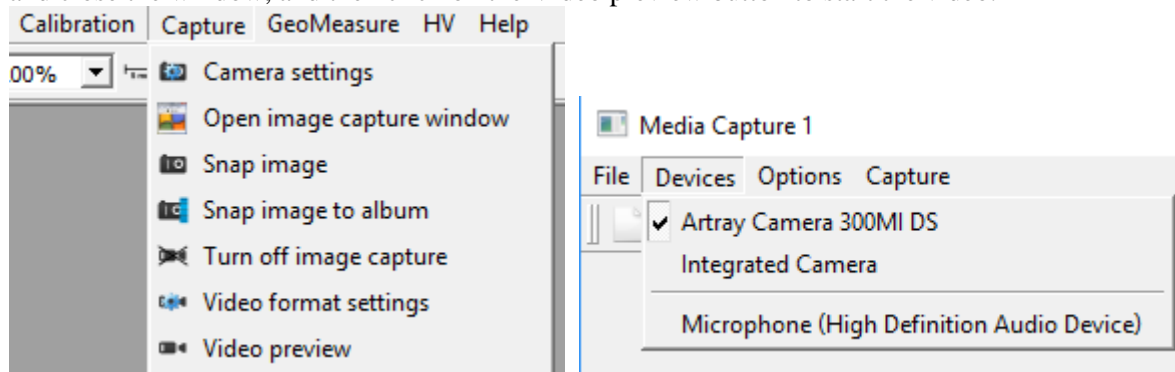
(b) Application on-screen keyboard

**Language:** To choose a different GUI language, go to menu **Help->Language...** Choose the new language and the application will exit. After restarting the application the new language will take effect.

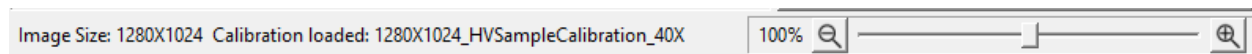
### 3.2.2 Camera setup

Normally it is necessary to set up the camera for video quality at first use after driver installation.


**Start Video:** Plug in the USB camera provided, and wait until its driver is installed if it is the first time plugged in a particular USB port. Clicking on the Video preview  button at the right upper of the user interface should start the video of the camera. If in any case the non system camera on the PC is started, user will need to manually select the camera, to do so go to menu **Capture->Open image capture window**, and in the new window click on menu **Devices**, select the desired camera from there and close the window, and then click on the Video preview button to start the video.



Clicking the Video preview button will set the video at predefined resolution for HV measurement besides starting the video. The video resolution is normally set at 1.3M pixels (1280X1024) resolution which is good enough for HV measurement. The image size (video resolution) normally is displayed on the message bar at the lower left bottom of the application at a mouse entering image event. To fit the image in window, user may need to adjust the Zoom at the lower right bottom of the application. Note that zooming does not affect measurement results.

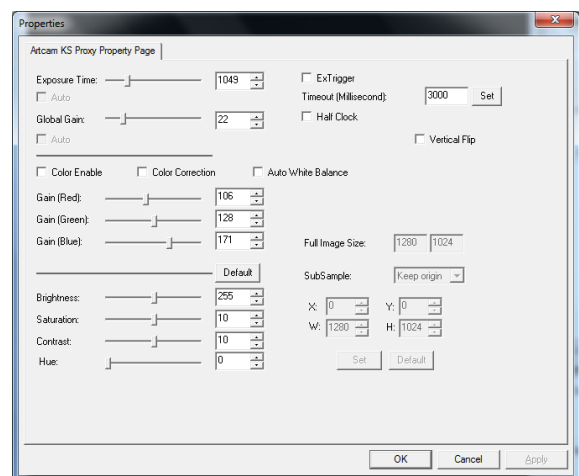


**Note:** If user wants to start the video manually at different camera resolution for purposes other than HV measurement, go to menu **Capture->Video format settings** to set the resolution, and start the video by menu **Capture->Video preview**.



**Camera setup:** On the Result interface page, under the Settings tab, click on the Camera Settings tool button , the camera control dialog will appear.

Different brand cameras have their own sets of control parameters and interfaces. For example, on the right is the control from the camera brand Artray. It is necessary to adjust the Exposure time and Global Gain to get the proper video signals at first use after driver installation. By experience, for the Artray camera, a typical Exposure time is around 1000 while and Global gain is around 50.

**Grid display:** For visual reference, the system provides a



### 3.0 Getting Started

grid display in the video display, toggle click the Display grid tool button  on the tool bar. The XY grid number can be configured in menu File->View/Edit configurations...->Image tab. User may drag move the grid center, and reset the center by clicking on the Reset grid offset tool button  on the tool bar.


**Snap image:** To snap an image, click on the Snap image  tool button on the tool bar.


### 3.2.3 Camera calibration

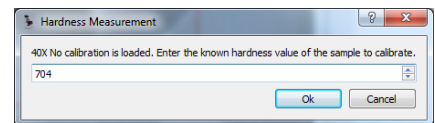
In order to get quantitative geometry measurement (e.g., indentation diagonals) from the camera image it is necessary to calibrate the camera to obtain the conversion from pixel distances to their physical distances. There are two ways to calibrate the camera in the HV hardness measurement: 1) Calibration with a standard test sample; 2) Calibration on a standard calibration ruler or grid

#### 1) Calibration with a standard test sample

**Unload existing calibration:** If no calibration is loaded in the system, after a HV measurement, the system will prompt user to enter its HV value for calibration. To recalibrate after a calibration, unload the calibration first, simply go to menu **Calibration->Calibration viewer**, enter the password if it was set or simply click Ok to pass if no password was set, click button Unload at the calibration viewer dialog. Ensure that the test force is set before the measurement calculation.


**Measure and calibrate:** System provides two ways to measure HV on an indentation image: automatic or manual. To automatically measure, click the Auto measure tool button , the system should find the indentation and mark it with a rectangular box or whatever marking method configured in Settings. To

make a manual measurement, click on the Manual measure tool button  to toggle the mouse in manual measure mode with the cursor in cross hair, click on the 4 vertices of the indentation (in any order). After the measurement, system will prompt user to enter the HV value of the test sample. After user enters the HV value and click OK, the system will automatically load and save the calibration with a default name “HVSAMPLECalibration” or “HVSAMPLECalibration\_1000g” in the case of Basic version, or like “HVSAMPLECalibration\_40X” or “HVSAMPLECalibration\_1000g\_40X” in the advanced versions with lens or with lens plus test load at the suffix depending on if “Auto select calibration by test load” is enabled (refer to Settings for this feature). User may opt to click Cancel at the prompt, and mouse drag move the marking lines to fine adjust to match with the indentation vertices, and enter the HV finally.

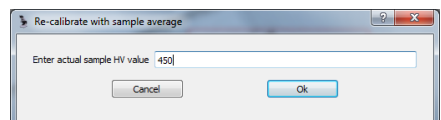



Note that for systems with Turret Control and above, calibration is linked with the lens and test load if “Auto select calibration by test load” is enabled. When lens or test load changes, system will load the linked calibration automatically. See calibration management for details.

**Rename calibration:** To rename a calibration, for example, to distinguish between different lens and different test load in the Basic version, go to menu Calibration->Calibration viewer, select the calibration

and click button rename  to change the calibration name. For example, change the default calibration name “HVSAMPLECalibration” to “HVSAMPLECalibration\_10X” or “HVSAMPLECalibration\_40X”. Refer to **Calibration management** for details.

**Re-calibrate with sample average:** For better calibration accuracy, the system allows user to re-calibrate with the average of the HV values from the calibration sample. To do so, measure HV values on multiple indentations on the same sample to get the average, click




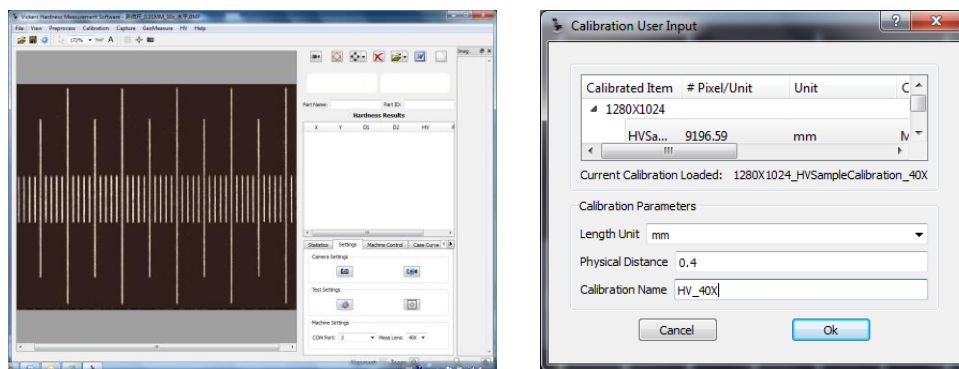
on the Re-calibrate with sample average button  in the Settings tab and enter the sample HV value at the prompt. The calibration loaded is re-calibrated and saved automatically.

#### 2) Calibration on a ruler or grid

User may prefer to calibrate the camera directly with a standard ruler instead of a standard hardness sample, especially when the calibration is used in geometry measurement instead of hardness measurement. The system provides two ways to do calibration with a ruler or grid: a) Manual calibration; b) Automatic calibration.

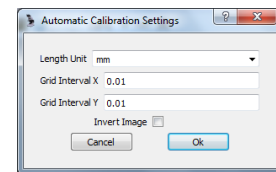
#### a) Manual calibration

Manual calibration simply calculates the linear scale between the pixel distance and the physical distance of two points on image. Place the calibration ruler or grid under the microscope lens, start video preview, move the ruler to make sure the lines are approximately aligned in the XY directions, and snap an image by pressing the Snap image button  on the tool bar. Select menu **Calibration -> Manual calibration**, hold down the mouse and drag from one the center of one line to another line with adequate separation distance and then release mouse. Enter the physical distance between the two lines and a name for the calibration. This calibration will be saved and be loaded later or immediately.

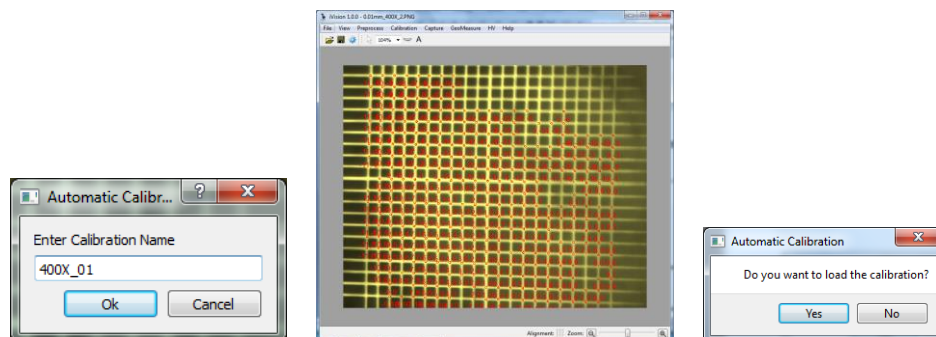


#### b) Automatic calibration

Automatic calibration is much more complex in the algorithms but ironically it is more convenient in usage. It automatically finds the cross points on the grid image, map them to their physically locations and obtain the true 2-D mapping between a physical location and its pixel location via interpolation.

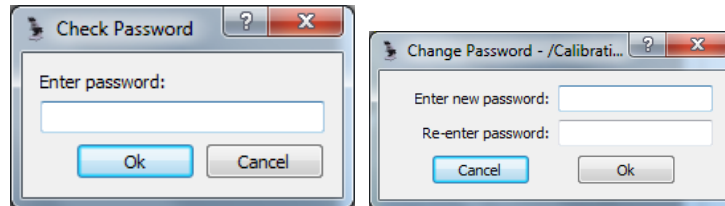


Instead of a calibration ruler, a calibration grid is needed to do the automatic calibration. First select menu **Calibration->Auto calibration settings** to set up the X&Y line distance, unit etc. If the lines in image will be darker than the background then Invert Image needs to be checked. Snap an image with the grid approximately aligned in XY directions. Select menu **Calibration->Automatic calibration**, the system will locate and mark most of the cross points of the grid image.

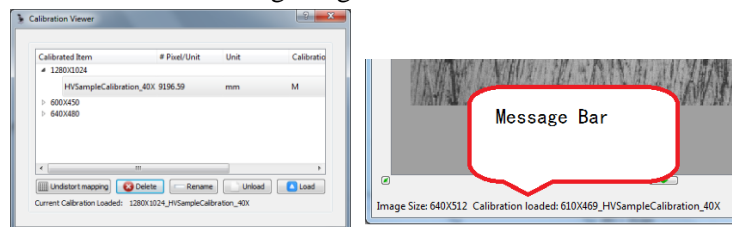


### 3.2.4 Calibration management

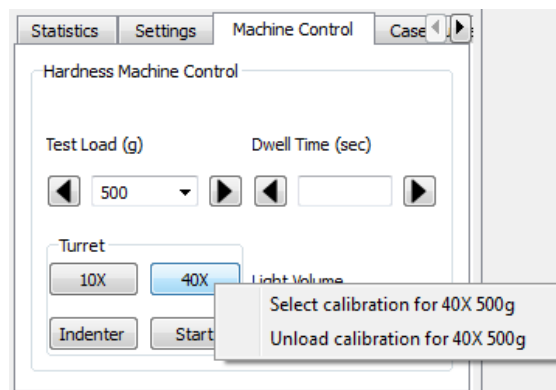
**Set/Change password:** User may set the password to protect the calibration for privileged access only. If no password was set after the installation, user can simply bypass by clicking OK at the password prompt. To set or change the password, go to menu **Calibration->Change password**, enter current password or click OK to bypass if no password was set, and enter and re-enter the new password at the prompt.



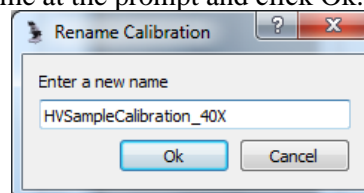
**Load/Unload calibration:** Select menu **Calibration->Calibration viewer** to bring out the Calibration Viewer dialog, click button Load to load a selected calibration or click button Unload to unload the current calibration. Current loaded calibration is normally displayed on the message bar at the lower left bottom of the application at a mouse entering image event.



To select calibration or unload calibration for a lens or for a combination of lens and test load for a system with turret control, user may right click on the lens button and choose the menu to select or to unload.



**Rename calibration:** On the Calibration viewer dialog, select the calibration to be renamed, click on button Rename and enter the new name at the prompt and click Ok.



### 3.2.5 Settings

Click on the Test Settings tool button  under Settings tab to invoke the HV Measurement Settings dialog.

#### 1) Full automatic version

Click on the Auto-focus settings checkbox to expand or collapse the settings which are related to the Z-axis motor control and auto-focusing.

- **Auto-focus enable:** To enable/disable auto-focusing in the automatic test and measure process. If checked, at each test point in the automatic process, auto-focusing will be done before the measurement.

- **Auto-focus setting id (deprecated) :**

Up to 10 groups of auto-focusing parameters (Auto-focus up down range (mm), Auto-focus sharpness threshold, Auto-focus step size (mm), Z-axis backlash (mm)) can be saved under this id. These parameters can be loaded in by select this id. To save the parameters for an id, select the id first and enter the parameter values.

- **Auto-focus up down range (mm):**

The maximum up/down travel distance from the starting point in auto-focusing. Default 0.05.

- **Auto-focus sharpness threshold:** An image processing parameter, default 0.12, normally no need to change. May need to be lower in case of featureless sample surface like a mirror.

- **Auto-focus step size (mm):** Z axis motor move step size in fine tune focusing. Default 0.00125.

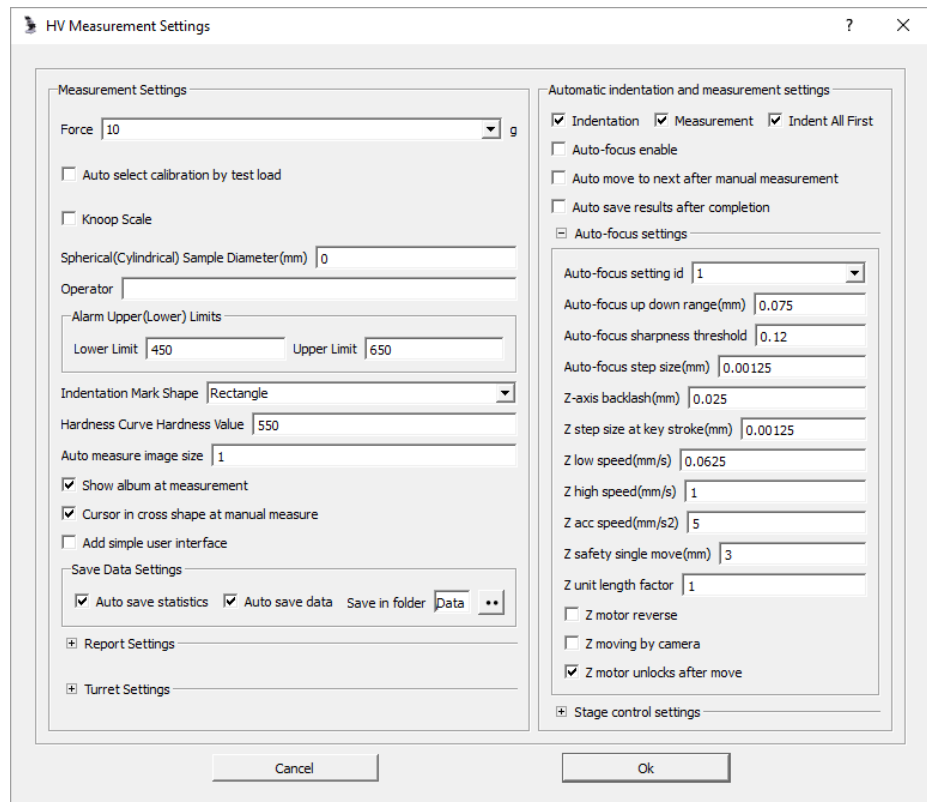
- **Z step size at key stroke (mm):** The amount of move at a single up/down arrow key press. Default 0.00125mm.

- **Z low speed (mm/s):** Z low speed. Default 0.0625mm/s.

- **Z high speed (mm/s):** Z high speed. Default 1.0mm/s.

- **Z acc speed (mm/s<sup>2</sup>):** Z acceleration speed in going to high speed. Default 0.5mm/s<sup>2</sup>. Normally no need to change.

- **Z safety single move (mm):** A safety feature to prevent the Z motor from running in continuous mode in case of communication loss with the system. If set with a positive number, the Z motor will travel at maximum such distance before resuming move. Therefore intermittent stops are observed in





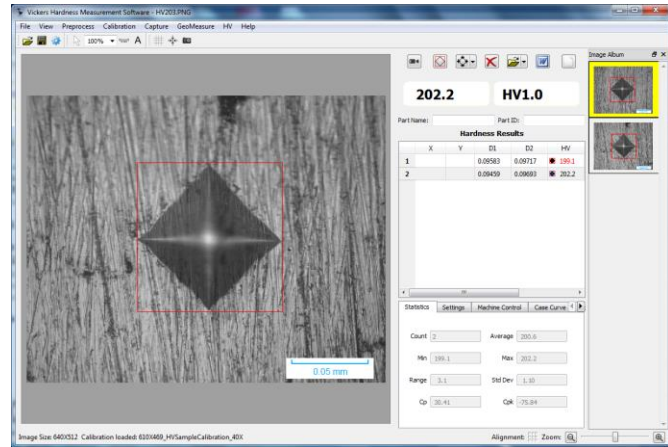
The image shows the 'HV Measurement Settings' dialog box. It is divided into two main sections: 'Measurement Settings' on the left and 'Automatic indentation and measurement settings' on the right. The 'Measurement Settings' section includes fields for Force (10 g), Auto select calibration by test load (unchecked), Knoop Scale (unchecked), Spherical(Cylindrical) Sample Diameter (0 mm), Operator, Alarm Upper(Lower) Limits (Lower Limit: 450, Upper Limit: 650), Indentation Mark Shape (Rectangle), Hardness Curve Hardness Value (550), Auto measure image size (1), Show album at measurement (checked), Cursor in cross shape at manual measure (checked), Add simple user interface (unchecked), Save Data Settings (Auto save statistics and Auto save data checked, Save in folder: Data), Report Settings, and Turret Settings. The 'Automatic indentation and measurement settings' section includes checkboxes for Indentation, Measurement, and Indent All First (all checked), Auto-focus enable (unchecked), Auto move to next after manual measurement (unchecked), Auto save results after completion (unchecked), and an expanded 'Auto-focus settings' section. The 'Auto-focus settings' section includes fields for Auto-focus setting id (1), Auto-focus up down range (0.075 mm), Auto-focus sharpness threshold (0.12), Auto-focus step size (0.00125 mm), Z-axis backlash (0.025 mm), Z step size at key stroke (0.00125 mm), Z low speed (0.0625 mm/s), Z high speed (1 mm/s), Z acc speed (5 mm/s<sup>2</sup>), Z safety single move (3 mm), Z unit length factor (1), Z motor reverse (unchecked), Z moving by camera (unchecked), and Z motor unlocks after move (checked). At the bottom, there are 'Cancel' and 'Ok' buttons.




raising/lowering the stage. If this parameter is set with zero or a negative number, this safety feature would be disabled. Default is 3mm. Of course, to move in long distance, user may enter the amount of move and hit the Go button to move.

- **Z unit length factor:** Used to correct the pitch of the Z shaft lead screw. Default 1. Normally no need to change after set up.



### 3.2.6 Measurement

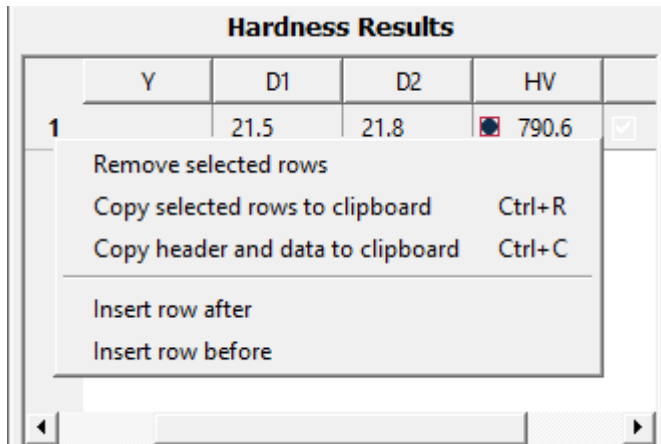
**Automatic measurement:** With an indentation image, click on the Auto measure  tool button, the system should automatically finds the 4 vertices, calculates HV, and updates the statistics and the indentation image in the album. If the indentation in the image appears too fuzzy or the image background is too noisy, the system may not be able to find the indentation or incorrectly locates the four vertices. If the system can't find the indentation, user may try to narrow the search area manually by mouse dragging to select the area that encloses the indentation, and do the auto measurement. If the system still can't find the indentation, then manual measurement is necessary. Note that for the mouse to select an area, it can't be in the manual measurement mode. To put the mouse in selection mode, simply click on the Selection  tool button on the tool bar, or toggle the Manual measurement tool button.



**Manual measurement:** The system provides three methods to manually measure HV hardness on an indentation image: Measure by 4 points , Measure by diagonals , and Measure by four lines . Click on the dropdown arrow button on the Manual measure tool button to select the method, the icon of the Manual measure tool button will change accordingly. Click on the Manual measure tool button will toggle the mouse in either manual measure mode (with cursor being crosshair) or in selection mode (cursor restored). Measure by 4 points is done by clicking on the 4 vertices on the indentation in any order, Measure by diagonals is done by mouse dragging from one vertex on one end of the diagonal to the other end for the two diagonals, while Measure by four lines is simply done by pressing the mouse on the image to bring out the long through cross hair cursor and move the cursor to one location where both the lines are touching the two indentation vertices and then release the mouse, and then press, move and release the mouse on the other location with the cross hair touching the other two vertices. It is up to user's preference to choose either method.

**Measurement correction:** To fine tune the measurement if necessary, mouse move the lines of the marking rectangle to align with the indentation vertices, after the mouse release measurement results (HV, statistics, indentation measurement image etc) will update automatically.

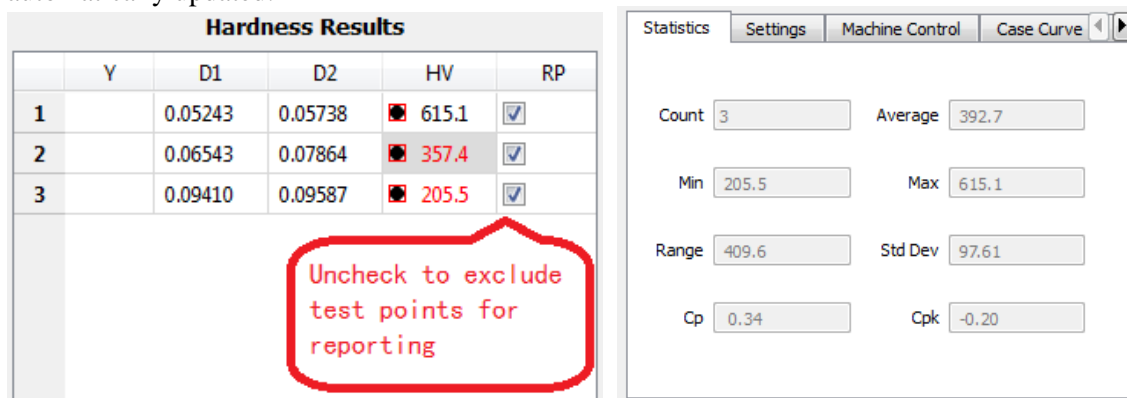
**Delete measurement:** Select one or multiple measurements to delete on the Hardness Results table by click or control-click on the vertical headers, click on the Remove measurement  tool button to delete. To delete all measurements and start new measurements from scratch, click on the New sample  tool button.



**Copy data to clipboard:** User may right click the Hardness Results table row header to pop up the menus, and select to copy the measurement data to the system clipboard which can be pasted in data processing software such as EXCEL etc.

### 3.2.7 Utilities

**Statistics:** After each measurement, the statistical values displayed under Statistics tab are automatically updated.



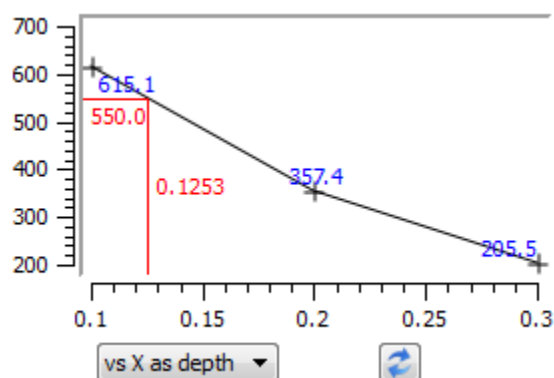
User may uncheck RP column to exclude particular test points for statistics and reporting.

For user's reference:  $C_p = \frac{\text{abs}(\text{UL} - \text{LL})}{6 / \text{StdDev}}$ ;  $C_{pk} = C_p * (1 - \frac{\text{abs}(\text{Average} - (\text{UL} + \text{LL})/2)}{\text{abs}(\text{UL} - \text{LL}) * 2})$ . UL and LL are the upper limit and lower limit set in the Settings.

**Case Hardness Curve:** Case hardness curve is displayed under tab Case Curve. For the Basic version and the With Turret Control version, to plot the hardness Case curve, it is necessary for user to manually enter the depth values for the test points in the X column in the Hardness Results table (Note: Y column is ignored). At each point entry, the curve display is automatically updated. For the Semi-Automatic and Full Automatic versions, the depth values of the test points are automatically entered by the system therefore there is no need for manual entry. The dropdown list at the bottom provides the options to plot the HV vs 1) Seq #; 2) X; 3) X as depth; 4) Y; 5) Y as depth; 6) XY 3D. To obtain the hardness depth, one needs to choose vs X as depth and enter the depth in the X column.

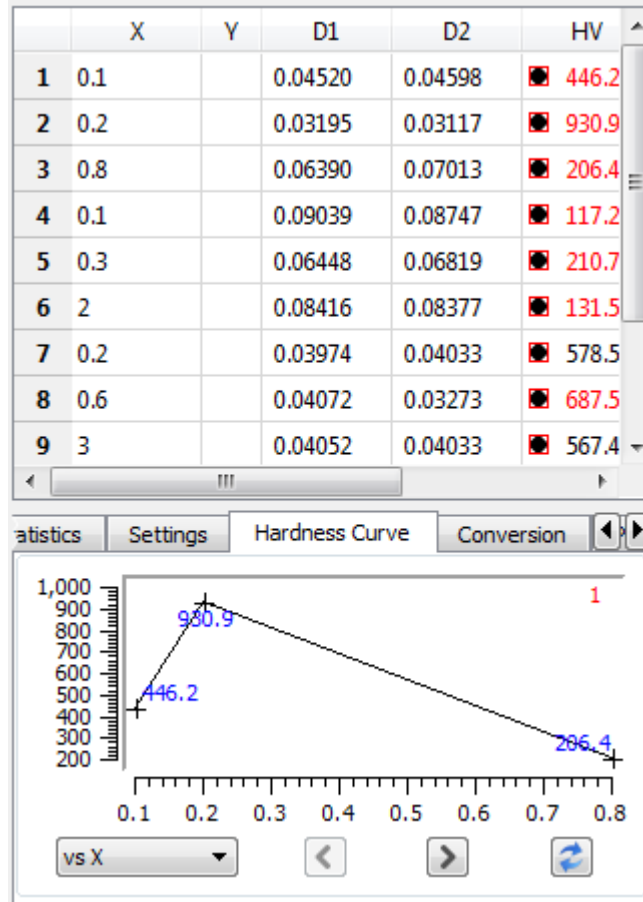
Hardness Results					
	X	Y	D1	D2	HV
1	0.1		0.05243	0.05738	615.1
2	0.2		0.06543	0.07864	357.4
3	0.3		0.09410	0.09587	205.5

Enter depth  
in X column





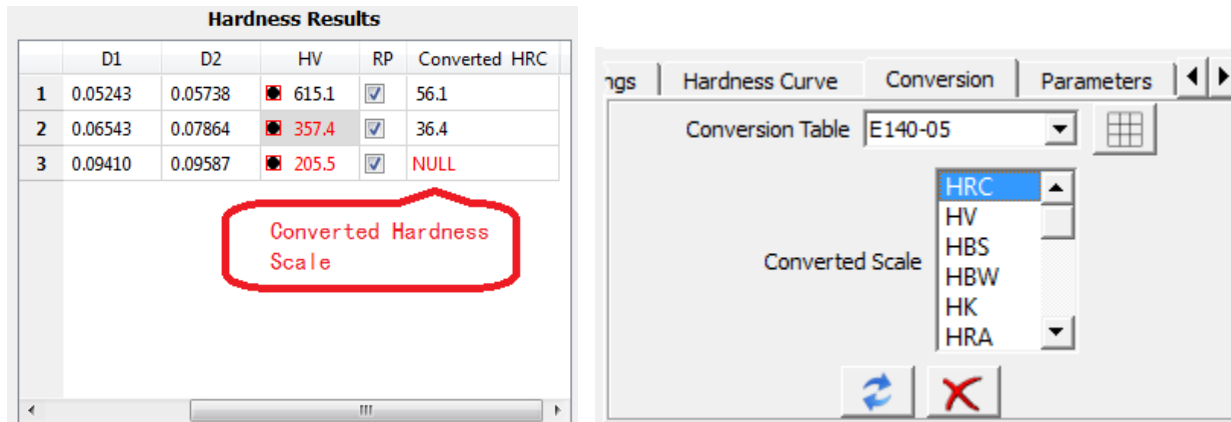
With the option “vs X” or “vs Y”, system may plot multiple hardness curves. When X or Y starts with a lower value in the table which indicates a new test line, the system will start plotting a new curve. User may click the Previous ◀ or Next ▶ button to view all the curves, or check One Page to plot all the curves on one page.


### 3.0 Getting Started





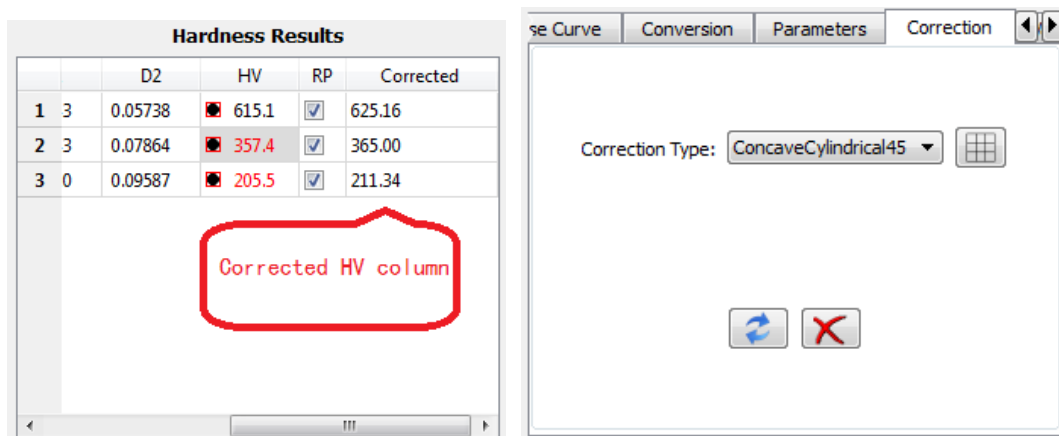
For convenience, if the depth X becomes a pattern, user may prepare a template file with just the X values and load the file for each test so the tedious entry of X at each test can be saved. This feature will be described next in Pre-defined depth table section.


**Conversion:** Converts HV or HK to other hardness scale. Select the Conversion Table (currently E 140-05 for ASTM, and GB T 1172-1999 for the Chinese standard are entered in the application, others can be easily added in) and the Converted Hardness scale(s) in the list, the Hardness Results table automatically adds one or multiple columns for the converted depending on the selection. To delete the converted hardness column(s), click the Delete Converted Hardness tool button  under the Conversion tab. To restore the column, simply click the Update  button or select the Converted Hardness scale(s).





To view the data in the conversion table, click on the Show table  tool button.

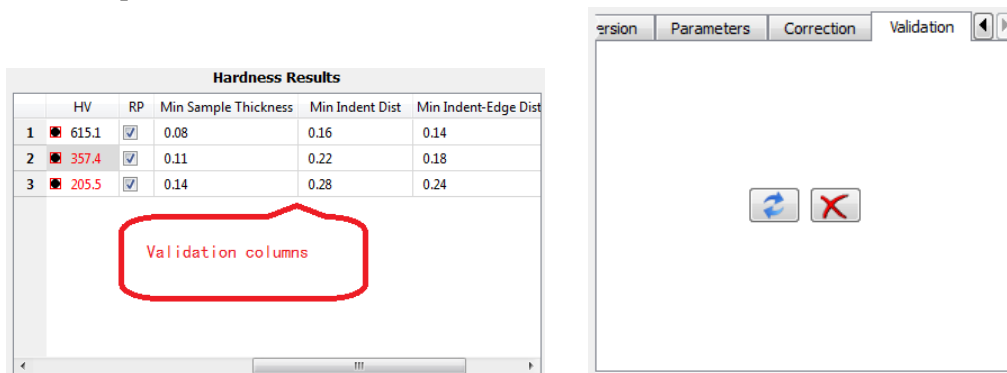
**Correction:** For non-planar sample surface, the system can provide the corrected HV according to standard predefined tables for spherical and cylindrical sample surfaces and the relative orientation of the indentation. To obtain the corrected HV, enter the sample diameter in the Settings, select the Correction Type under the Correction tab, the system will add or update the Corrected column. To remove or restore the Corrected column, click on the Delete Corrected Hardness Column  tool button or the Update  tool button under the Correction tab.






To view the data in the correction table, click on the Show table  tool button.

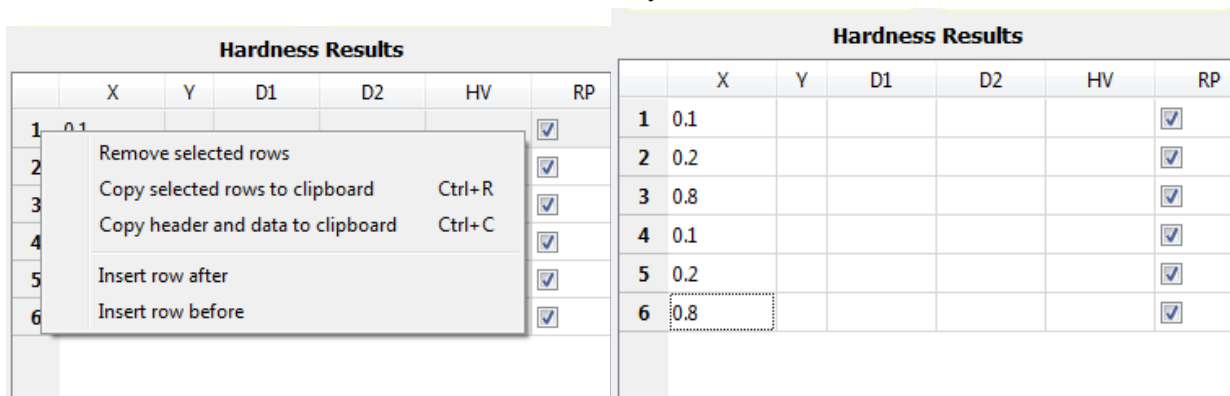
**Validation:** Validation simply calculates the minimum sample thickness, minimum indentation distance, and minimum indentation to sample edge distance for each test points and displays these in 3

columns on the Hardness Results table. Min Sample Thickness (minimum sample thickness) is 1.5 times, Min Indent Dist (minimum indentation distance) is 3 times, and Min Indent-Edge Dist (minimum indentation to sample edge distance) is 2.5 times of the average diagonal length of the indentation. To remove or restore the validation columns, simply click on the Delete Validation Columns  tool button and the Update  tool button.



**Pre-defined depth table:** Often user needs to test at the same pre-defined depths to measure hardness curve. It is convenient to generate a pre-defined depth table as a template. To do so, click the New

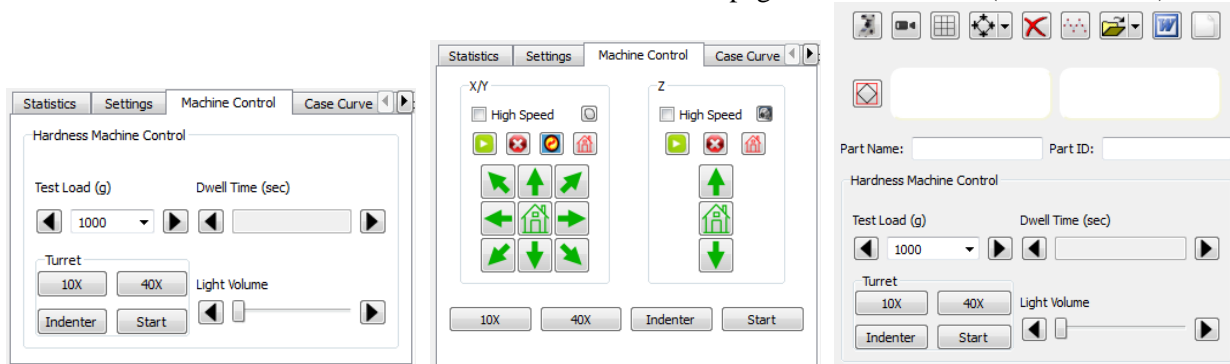
Sample button  to clear the result display if needed, click the same button to generate a blank row in the Hardness Results table. Enter the first depth in the “X” column. To generate more rows for more depth, right click on the vertical table row header, and select menu “Insert row before” or “Insert row after” to generate more rows and enter their depths in X column if needed. Finally click the Save data file button  to save the depth table in a file which serves as a template. To test with this template, click the Open data file button  to load, click on the header on the row with the depth to test, the hardness result will be entered in this row automatically after measurement.



### 3.2.8 Turret Control

This section applies to the With Turret Control version, Semi-Automatic and Full Automatic versions only.

The turret control buttons in the With Turret Control version lie under the tab Machine Control, as shown below in a). In the Semi-Automatic and Full Automatic version, the complete turret control buttons are in the Machine control interface page (as shown below in c), and some of the often used buttons are also shown under the tab Machine Control on the Result interface page for convenience (as shown in b).



(a) With Turret Control version    (b) Semi or Full Automatic    (c) Machine control interface

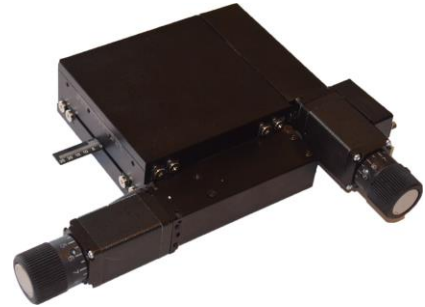
When the machine changes the test load, loading dwell time, or light volume, the new values will be updated in the system. User may change the test load (some models of machines only), dwell time and light volume on the machine through the buttons.

Clicking “Indenter” button will turn the turret to the position only without starting testing, while clicking “Start” will start the load testing.

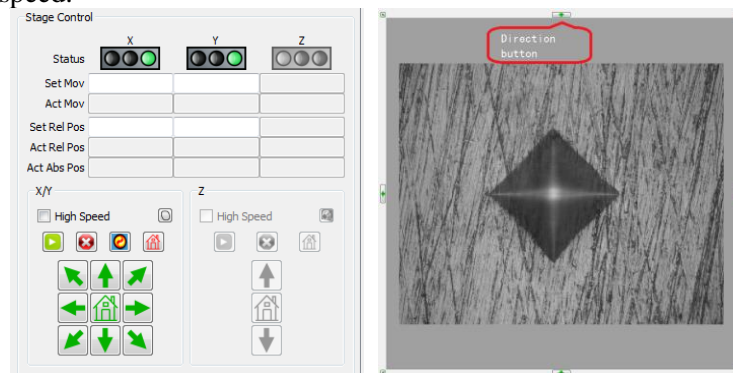
### 3.2.9 Stage Control

This section applies to the Semi-Automatic and Full Automatic versions only.

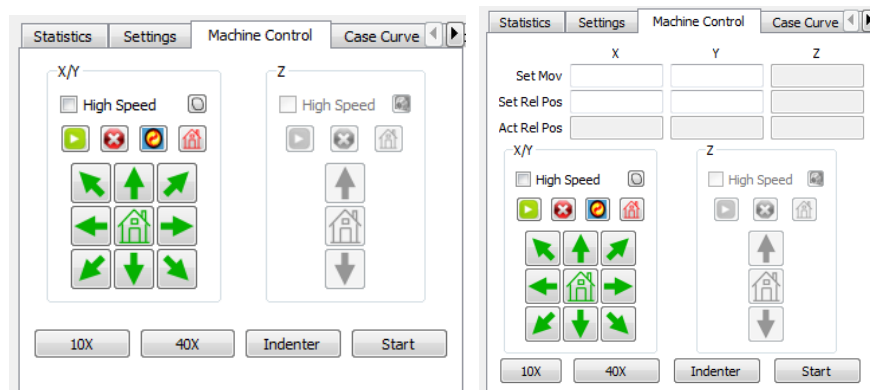
- 1) **Sample stage specifications:** The XY sample stage is an integrated platform with two separate linear motions driven by two 28 stepping motors (mounted with two manual turning knobs with scales). The standard platform dimensions are 100mm X 100mm, with 50mm X 50mm travel range. The linear motion mechanism consists of high precision lead screws with 0.5mm pitch, and stepping motors with standard motion of  $1.8^\circ$  per step. The precision of the stage is normally less than  $2\mu\text{m}$ . The stationary test load of the standard sample stage is larger than 50KG. Non standard stages can be ordered with customized specifications.
- 2) **Sample stage move control:** Refer to settings for stage high/low speed setup.



**Manual move:** To move the sample stage manually by the system, press the direction buttons either on the Machine control page, or the little buttons surrounding the main image panel, or the direction buttons under the Machine Control tab. Check High Speed if to move the stage in high speed, uncheck if in low speed.



Direction buttons on (a) Machine Control interface page; (b) surrounding image panel



Direction buttons under Machine Control tab with the Display move and position input in settings: (a) not set, default; and (b) set

**Fine move:** To move the stage with fine steps, move the mouse over the X/Y control panel and strike the arrow keys on the keyboard. Refer to the Settings section for keystroke step size.



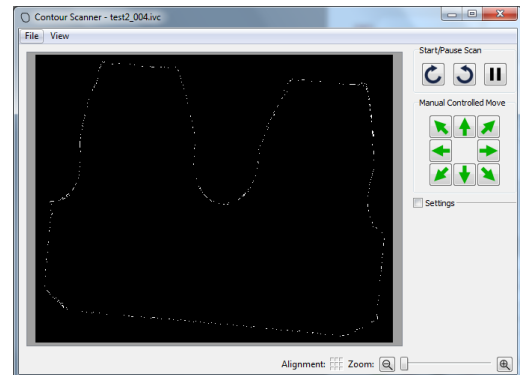
**Home:** To set current position home (for relative position), click on the red Set Current Position Home button . To move the stage home, click the green Move to home button .

**Set Move:** To set the amount of move or set the relative position to move, enter the amount in Set Mov or Set Rel Pos, and click on the Go button to start move.

**Reset:** Occasionally user will need to reset the stage in absolute position by clicking the Reset button to let the stage move all the way to touch the XY limiting switches and move to the stage center and reset the absolute position of the stage.


**Unlock the motors:** When user needs to manually turn the knob on the motors to move, press the Unlock button to unlock the motors.

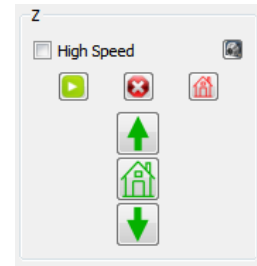
- 3) **Scanning sample edge:** The system provides the capability to automatically move the stage and scan along the sample edge. First, manually move the sample to make its edge appear in the view. Click the Contour Scan button on the stage control panel to show the scan window, and depending on the scan direction click clockwise or counter-clockwise button to start automatic scanning. Note that system should be calibrated before scanning. Click the pause/resume ( or ) button to pause/resume.



After scanning is stopped, to move the sample stage to a specific location on the sample, hold the Ctrl key and mouse press on the scanned image, the sample stage should move the sample location corresponding to the mouse pressed location. To manual scan, uncheck the “Move without scan” check box, manually click the direction arrow buttons to move and scan. If to use the direction arrow buttons to move the stage without scan, then check this check box.

User can specify multiple start/stop points to scan multiple samples. To do so, click button to enter in add point mode, the mouse cursor will become , move the sample stage to make the start point in the field of view, mouse click the sample edge to make the point as start point. Move the sample stage to do the same for the stop point. If no stop point is set, then the start point will automatically become the stop point after the full scan of the sample. Repeat setting the start/stop points for the other samples. To remove a start/stop point, simply click on the point in the scanned window. To clear all the start/stop points, click the button. To exit add point mode, click button, the mouse cursor will be restored. After the start/stop points are set, click or button to start scan depending on the scan direction. To pause/resume scan, click or button.

- 4) **Z axis move and autofocus (Full Automatic version only):** The Z axis control and settings are similar to the XY control. User may use the direction buttons, the arrow keys on the keyboard, or enter the amount on Set Mov or Set Rel Pos to move. To manually start auto-focusing, click the Auto Focus button  and the system will start auto-focusing.



#### 3.2.10 Set Pattern and Path

This section applies to the Semi-Automatic and Full Automatic versions only.

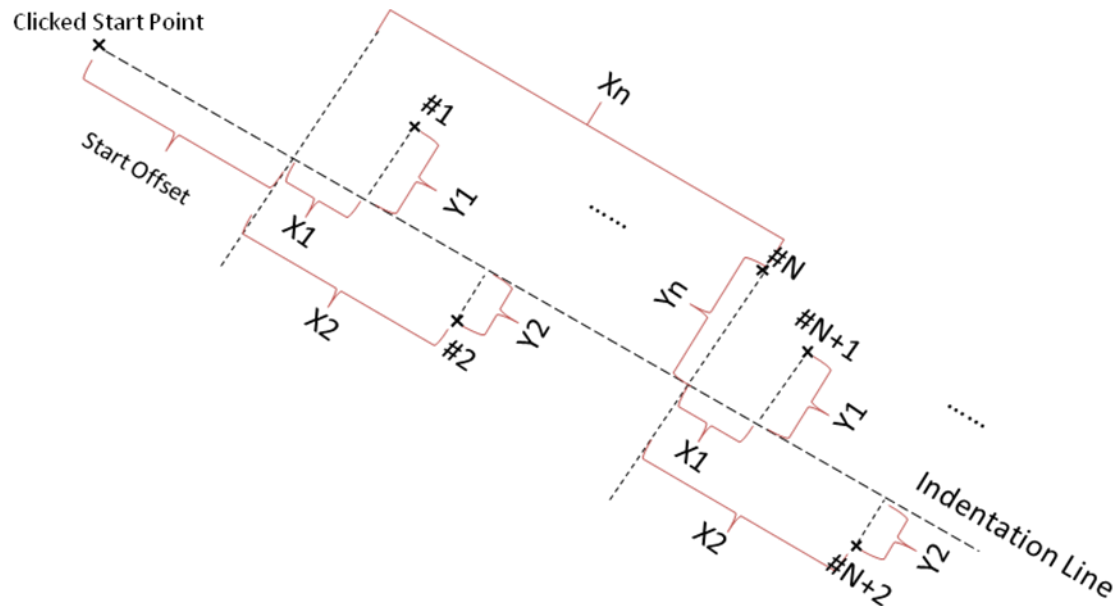
Very often it is necessary to set one or more indentation patterns so user can easily set an indentation path for testing. After the pattern is set, user will just need to set the starting point and the indentation line direction for each test, system will automatically generate the test points according to the set pattern.


Currently the system provides 14 pattern types:

- 1) Line;
- 2) Line Set;
- 3) Free Click;
- 4) Horizontal Line;
- 5) Vertical Line;
- 6) Curve Line Sets;
- 7) Curve Matrices;
- 8) Arc;
- 9) Gear Fillet;
- 10) Gear Top Parallel;
- 11) Auto Line Sets;
- 12) Auto Matrices ;
- 13) Circle Center;
- 14) Curve Gear Top Parallel.

Except 3) Free Click, all others are line oriented, and the Line type provides the basis for all of them. Setting up the Line type is explained in details below, which is a reference to all other types.

Line oriented types require the input of the relative XY coordinates of an indentation period along the indentation line in reference to the start point. And the pattern simply repeats with the period until the last point. The schematic below shows the concept graphically.



Click on the Set path  tool button on the upper right of the main window to bring out the Set path page. Select Measurement Pattern type and select the Pattern ID. After user sets the parameters, they will be automatically saved under this type and ID.

Often it is necessary to have the sample edge scanned to have the indentation pattern and path set because the sample is much bigger than an image frame. For convenience, clicking on the main image window and on the sample edge scan window will have the same effect in setting the pattern and path.

**Line:** Enter the  $X_1, Y_1, X_2, Y_2, \dots$  coordinates for a pattern period in the coordinate table under Line X and Line Y, and enter # Points to Start for the number of test points. User may click on the vertical header to select the popup menu to insert/remove rows. In the case of a simple test with indentations at equal distance and on a straight line, only one point with  $X_1$  (distance) and  $Y_1$  (0) needs to be entered, as shown below in a). For a zigzag pattern, below b) shows an example with 4 points as a period.

**Measurement Pattern 1**

Measurement Pattern: Line, Pattern ID: 1

Origin Position: X'(mm) = -0.0323635, Y'(mm) = 0.0495073

Start Offset(mm): 0

Angle(deg): -46.206

# Points to Start: 8

Offset(mm) to add: 0

# Points to Add: 0

Measurement Lens: 40X

	Line X(mm)	Line Y(mm)
1	0.15	0

**Measurement Pattern 2**

Measurement Pattern: Line, Pattern ID: 2

Origin Position: X'(mm) = -0.0446886, Y'(mm) = 0.0439411

Start Offset(mm): 0

Angle(deg): -44.7091



# Points to Start: 10


Offset(mm) to add: 0

# Points to Add: 0

Measurement Lens: 40X


	Line X(mm)	Line Y(mm)
1	0.15	0
2	0.3	0.2
3	0.45	0
4	0.6	-0.2

To show the test path with test points in a pattern set up, assuming the camera is calibrated, first click on the Reset Starting Points  tool button to reset, click on the image for the start origin, may click a second point on the image to determine the indentation line direction (marked on the image with a green line), then click on the Generate XY Points  tool button, the test points will be generated and they are marked on the image (may be beyond the field of view), and in the XY point schematic view under those tool button. Also the test points are allocated in data rows on the Hardness Results table.

Note that after the start point is clicked, the Enable/disable click to add tool button  will show. This button allows user add the points on the coordinates table by clicking on the image instead of entering by keyboard. To do so, click on this tool button, the mouse cursor will become crosshair, click on the points on the image, and their relative coordinates to the start origin (after the Start Offset) are entered in the coordinates table automatically. To exit the click to add mode, toggle click on the button again and the mouse cursor will be restored.



Start Offset (mm) provides the offset of the start origin to the clicked start point along the indentation line.



The system provides the capability to allow user keep adding more test points, even after testing and measurement. The added points will follow the same pattern, but can be relocated with the parameter Offset(mm) to add. The logic goes this: If the Offset(mm) to add is 0 (by default) or stays the same as previous add action, the added points will be appended after the last generated or added points like normal. If user changes the Offset(mm) to add, then the added points will start at this offset from the start

origin. To add points, specify the # Points to Add, click on the Generate XY Points  tool button, points will be added and displayed.

Measurement Lens specifies the lens to use to measure after indentation in the automation process.




**Line Set:** This pattern is normally used in setting the indentation path perpendicular to sample edge.




Click on the Reset Starting Points  tool button to reset, click on two points on the sample edge, the indentation line will appear with the specified Angle (default 90°) in the middle. User may still click on the edge line to specify a new start point. Click on the Generate XY Points  tool button to generate the test points.





**Free Click:** This pattern allows user simply click on the sample image to get the test points. Click on the Reset Starting Points  tool button to reset, the Enable/disable click to add tool button  will show, click it and the cursor will become crosshair, click on sample image to add points, and toggle click on the button to exit the click-to-add mode.


**Horizontal Line:** This is a special case of Line pattern, with the indentation line in the X direction only.

**Vertical Line:** This is a special case of Line pattern, with the indentation line in the X direction only.

**Curve Line Sets:** This pattern allows generating multiple line sets on a curve. Click on the Reset Starting Points  tool button to reset, click on the Enable/disable click to add tool button , the mouse cursor will become crosshair, click on two points on a section of curve, click the 3<sup>rd</sup> point to specify the start point, the indentation line will appear, repeat on other sections of the curve, toggle click on the Enable/disable click to add tool button to exit the click-to-add mode. Click on the Generate XY Points  tool button to generate the test points.




**Curve Matrices:** Similar to Curve Line Sets, this pattern allows generating multiple parallel line sets (matrices). Click on the Reset Starting Points  tool button to reset, click on the Enable/disable click to add tool button , the mouse cursor will become crosshair, click on two points on a section of curve, parallel lines with line distance specified will show between the two points, repeat on other sections of the curve, toggle click on the Enable/disable click to add tool button to exit the click-to-add mode. Click on the Generate XY Points  tool button to generate the test points. Note that if the distance between the test point to be generated with an existing point is less than the Min Valid Distance, this point will not be generated.




**Arc:** This pattern sets test points on an arc. Click on the Reset Starting Points  tool button to reset, click on three points on the arc, the system will automatically locate the center of the arc, calculates the arc radius and shows the arc. The 4<sup>th</sup> click near the arc will specify the starting origin on the arc. To set more than one indentation line, click on the Enable/disable click to add tool button  to enter in adding mode, then click on the scanned contour or the sample image to add the starting points, the additional indentation lines will appear, don't forget to click  to exit the adding mode. For convenience, an extra tool button  allows moving the sample stage to the other side of the arc. Click

on the Generate XY Points  tool button to generate the test points. Note, if the Arc X values in the coordinate table are all 0, system will automatically determine the test points are to be in radius direction (for additional test points).



**Gear Fillet:** This pattern finds a location relative to the gear fillet along a specified angle from the gear fillet point and with a distance of the maximum of gear module and five times of the hardness depth which can be measured along the path. The gear fillet point should be obtained by scanning the gear edge from the gear top to fillet. The system can automatically find the two gear top points and the gear fillet point in scanning if the “Auto find top and fillet in scanning” option is checked. Or user can manually mark the fillet point in the scan window by clicking the Clear Starting Points first, and followed by clicking the two gear top points, then the system can either automatically mark the gear fillet point or allow user to mark it manually depending on the option “Auto click gear fillet in scan window”. In the measurement process, after the hardness depth is obtained, the system allows user manually correct the measurement and then proceeds with automatically calculating the location, test and measure at the Gear Center position. After the manual correction, user can click on the **Generate XY Points** tool button to generate the Gear Center point for final testing.

**Gear Top Parallel:** This pattern generates test points along a line parallel (or with a specified angle) to the gear top and with a specified separation distance. Check Left Side if the test points start from the left side of the gear or uncheck if at right side. Click two points at the gear top to define the top line. Before the second click, the system will show the start origin and the reference lines on the image at the mouse for visual assistance. If necessary to change the start origin, click the third point to finalize.


**Auto Line Sets:** This pattern works only on scanned sample. Unlike the Curve Line Set pattern, there is no need to click two points to define the directions of the sample edge, the system will automatically calculate by the scanned contour. First click  to enter in the add point mode, the cursor will become , click on the scanned contour, the indentation line will show immediately, click on multiple points if needed to generate multiple indentation lines, click  to exit the add point mode, and the cursor will restore.

**Auto Matrices:** This pattern also works only on scanned sample. Unlike the Curve Matrices, there is no need to break the curve into multiple line sections. First click  to enter in the add point mode, the mouse cursor will become , click two points on the scanned contour, multiple indentation lines with specified separation and specified angle with respect to the sample edge. If needed, click more on the scanned contour to generate indentation lines on multiple sections. Finally click  to exit the add point mode and the mouse cursor will restore.



**Arc Center:** This pattern is very similar to the Arc pattern, except that the coordinate origin is located at the arc center instead of on the arc. Also the tangential coordinate entry can be set either in angle or distance.

**Curve Gear Top Parallel:** This pattern allows generating multiple Gear Top Parallel patterns on a curve, just like the Curve Line Sets pattern for multiple Line Sets. Click on the Reset Starting Points  tool button to reset, click on the Enable/disable click to add tool button , click on two points at a gear top, click on 3<sup>rd</sup> point on the reference line to specify the origin of the indentation line. Repeat the above step for all the gear tops.



### 3.2.11 Automated Test and Measurement

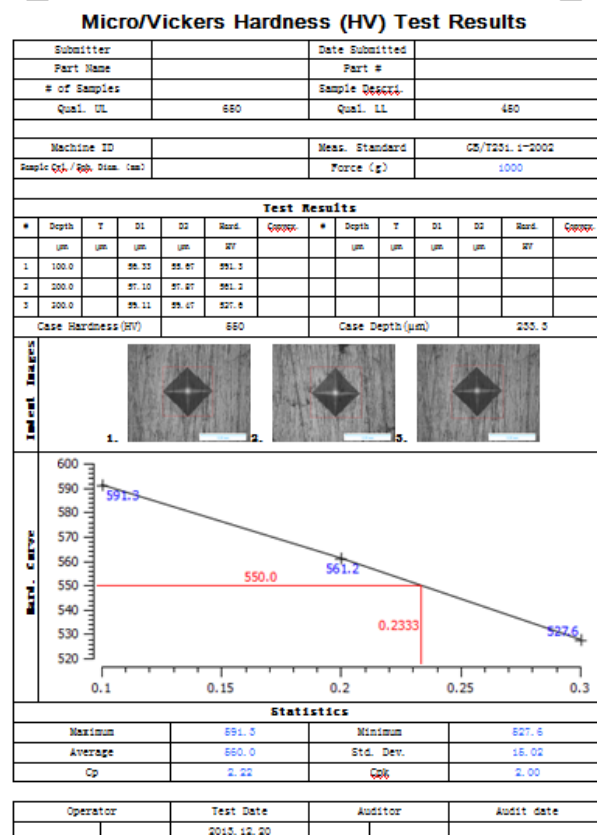
After the test points are generated, click on the Auto Test Measure button  to start the automation process. To pause the automation, mouse click on the image. To resume, click on the Auto Test Measure button.

### 3.2.12 Data Saving and Retrieval

Click on the dropdown arrow on the Open data file  / Save data file  tool button to select Open data file or Save data file to save/restore the measurement results. To save, select the path to store and name the data file.

### 3.2.13 Reporting




Click on the Generate report tool button  or  depending on user's setting, the system will generate a Word or Excel test report with measurement data, indentation images, and the Case hardness curve (all configurable optional). The report template files (hv\_report\_en.doc for Word and hv\_report\_en.xls for Excel) are located in the installation directory. User can customize these files as long as no table cell is added or deleted. For example, user can change the title or add a logo in these templates. If necessary the report format can be totally customized.



### 3.3 Appendix: Using the standard features

For details on geometry measurement, refer to user's manual iVision-PM\_UserManual\_en.

#### 3.3.1 Image/Video capturing

Select menu Capture->Open image capture window, and select the installed camera to use. Start video by menu by clicking the Video Preview button . To snap a image, click on the Snap Image button . To start and save a video in .avi video format, go to Capure->Open image capture window, select menu Capture->Start Capture AV, enter or select the file name to save and the file size limit, click OK at the prompt to start, and click on the Stop Capture Image  button to stop, the .avi video file is saved automatically.

#### 3.3.2 Camera calibration

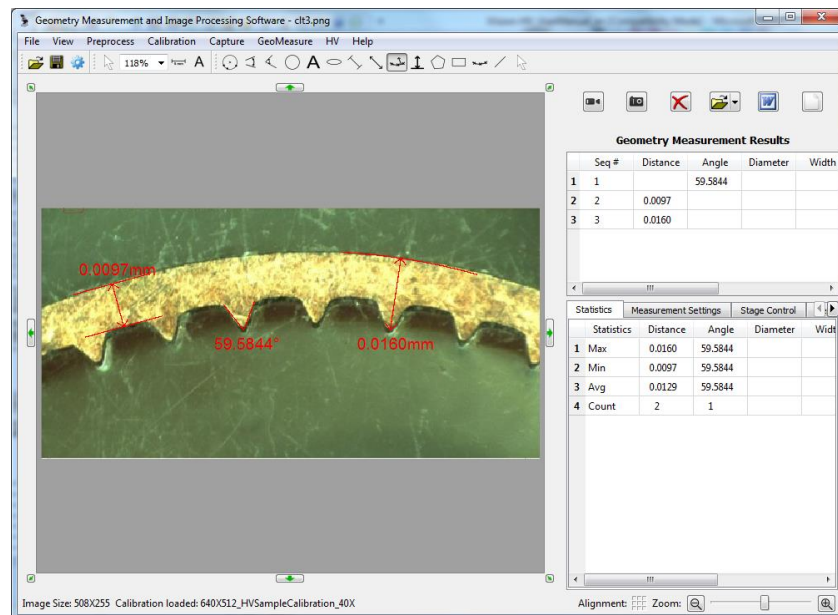
Place a microscope calibration ruler or grid roughly aligned in the XY direction, start the video, snap the image. Select menu Calibration->Manual calibration, mouse dragging from the center of one line to another with adequate separation, enter the physical distances between the two lines and name the calibration.

#### 3.3.3 Calibration management

Go to menu Calibration->calibration viewer, enter password or bypass if no password is set, user can unload the existing calibration, load a calibration, or rename a calibration.

#### 3.3.4 Geometry measurement

Select menu GeoMeasure -> GeoMeasure, the main interface of the geometry measurement will appear. Select the type of geometry measurement on the tool bar, and use mouse to draw and measure. User may edit a measurement by click selecting and mouse dragging on one of the control points on the measurement, and the corresponding measurement results and statistics will be automatically updated.

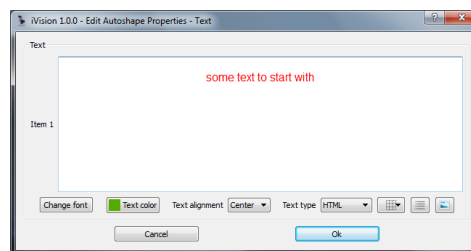


### 3.3.5 Image processing

Select menu Preprocess and its sub-menus to access the image processing tools.

### 3.3.6 Document entry

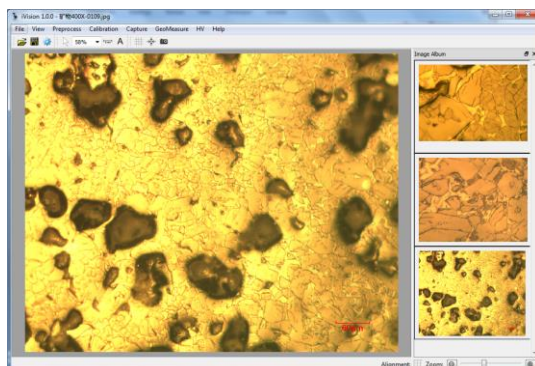
Click on the Document **A** tool button and then on the image, enter text at the small text entry box. To edit the text or to enter complex HTML format documents, double click on the text to invoke the document editor.




To edit the text in HTML format, select HTML on Text type. To insert table, list, or image, click on the tool buttons at the right bottom. The tool buttons to change font, text color, and text alignment lie at the left bottom.

### 3.3.7 Album management


- To view the album, select menu View->Image Album. To change image display size in album, move the splitter. Album can be docked in the main window and it can be floated also.
- Double-click on the image will copy the image into the album, and conversely double-click on the image on the album will copy it to the image panel
- To open/save album file go to menu File
- To reorder the images in album, drag an image with its frame and drop it to position
- To remove an image or images on album, click to select and press the Delete key

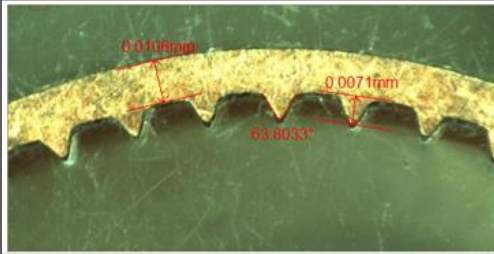


### 3.3.8 Data Saving and Retrieval

Click on the dropdown arrow on the Open data file  /Save data file  tool button to select Open data file or Save data file to save/restore the measurement results. To save, select the path to store and name the data file.

### 3.3.9 Reporting

Click on the Generate report tool button , the system will generate a Word document with the measurement data and measurement images, with the report setting specified under the Reporting Settings tab.

Geometric Measurement Report							
Submitter				Submit Date			
Part Name				Part ID			
Number of Sample				Sample Description			
Equipment ID				Standard			
Measurement Results (µm/mm)							
#	Seq.#	Distance	Angle	Diameter	Width	Height	Area
1	1	0.0108					
2	2		83.8033				
3	3	0.0071					
Statistics							
Max		0.0108	83.8033				
Min		0.0071	83.8033				
Avg		0.0089	83.8033				
Cnt		2	1				
Measurement Images							
							
Tester		Test Date		Approval		Approval Date	
		2013.12.23					

### 3.3.10 Printing with magnification

Connect to the printer first and select menu **File->Print...** to bring up the printing dialog. Select or enter the desired magnification at the bottom, the image print size will change accordingly in preview. User may enter text (can be in HTML format to include tables, lists, images etc) under user input and the text will be saved for next printing. Analysis result tables and statistics summaries can be checked for printing. And all the above elements to be printed have options in printing locations in either top, bottom, left, and right. The textbox widths can be limited by their width inputs.

