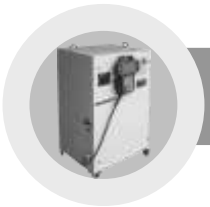
WARNING

INSTALLATION SHOULD ONLY BE PERFORMED BY QUALIFIED INSTALLATION PERSONNEL AND MUST CONFORM TO ALL NATIONAL AND LOCAL CODES

Hi5HN25D131201FMEN1



Hi5 Controller Function Manual

HRVision 2.5D

HYUNDAI
HEAVY INDUSTRIES CO.,LTD.

HYUNDAI
HEAVY INDUSTRIES CO.,LTD.

Printed in Korea – Dec. 2013 1st Edition

HYUNDAI
HEAVY INDUSTRIES CO.,LTD.

Contents

Contents

1 Introduction

1.1. About HRVision 2.5D

HRVision 2.5D is vision software for robot guidance based on the PC for Hyundai robot and Hyundai Hi4a/Hi5 controller.

HRVision 2.5D provides color graphic operating buttons and intuitive user interface so that it is convenient for the user to operate. With the data communication protocol for Hyundai robot controller installed, any Hyundai robot controller user can easily use this software.

Just one camera, the distance between the workpiece and the camera can be measured.
By applying pattern-recognition that utilizes multiple pattern registration and geometric shape information, it is possible to measure position and rotation information of work targets rapidly and correctly.

HRVision 2.5D is the optimal tool to execute the 2.5-D location recognition work easily and stably when apply the workpiece handling using the Hyundai Robot.

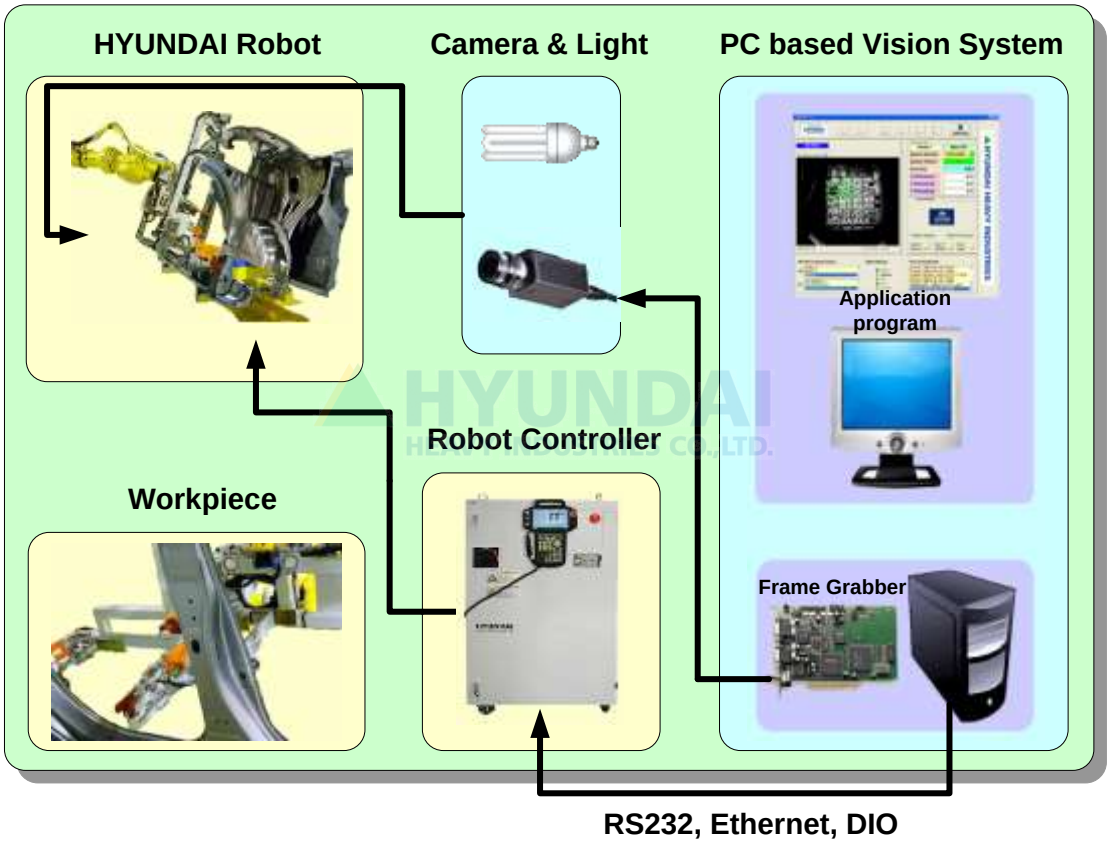
HRVision 2.5D provides the following convenient functions.

Simple operation	You can set and operate the vision system easily by using the operating button.
Obtain distance information	Using only one camera, the distance information between the workpiece and the camera can be obtained.
Multiple pattern support	You can add multiple numbers of patterns for one model and enable various pattern additions depending on the light and surrounding environment.
Geometric pattern score	By executing the pattern score by using the geometric shape of the workpiece, you can execute the pattern recognition work strong to environmental changes.
Tool function	You can easily set and manage various types of data including camera calibration, pattern addition, communication setup etc. by using the tool by each function. Additionally, with the data communication protocol installed for Hyundai Robot controller, the interface with the Hyundai Robot is simple.
Monitoring function	You can monitor process sequence, communication sequence with Hyundai Robot, pattern recognition result etc, and manage the error history and data history. Additionally, you can save the image of the time of the error.

1.2. System Configuration

The following figure is a simplified diagram of the vision system for robot guidance using HRVision 2.5D. The vision system for robot guidance is composed of the robot system part and the vision system part. The vision system is composed of the hardware including PC, Frame Grabber, camera, lighting device etc., and the software of HRVision 2.5D.

The user can use the HRVision 2.5D program to set and operate the vision system, communicate with Hyundai Robot using the exclusive Hyundai controller communication protocol. Hyundai robot executes the logistics handling work depending on the location recognition result of the vision system.



1.2.1. Hardware Configuration

The recommended H/W of HRVision 2.5D is as follows.

H/W	Item	Recommended specifications
PC	CPU	At least 2GHZ Multi-core Processor 512KB or more L2 cache
	OS	Windows XP
	RAM	2GB or above
	Video	PCIe x16 Video Card
	HDD	80GB or above
	CD-ROM	X48
Lighting	Light	florescent light
Vision system	Frame Grabber	8511VX or 8514VX (COGNEX)
	Camera	XC-HR70 (SONY) or MV-BX30A (CREVIS)
	Lens	H1214-M(PENTAX) Can be changed depending on installation environment and usage.
	Cable	20m

If you would like to use HRVision 2.5D by adding multiple numbers of patterns, use a PC with high performance CPU and sufficient memory.

The detail specifications of the installed vision system are as follows.

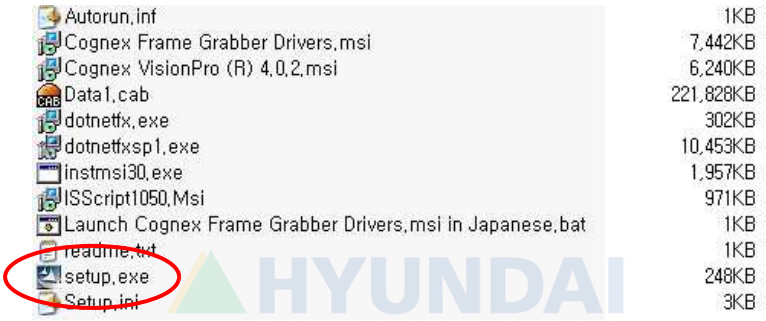
Model name	Exterior	Specifications
MVS-8111VX **MVS-8514VX**		High speed Frame Grabber Number of camera that can be connected: Maximum of 4 units Connection method: RS170, CCIR 1/2 slot PCI
XC-HR70, **MV-BX30A**		1/3" CCD 1024(H)×768(V) C Mount DC 12V 29(W)×29(H)×30(D) mm
H1214-M		Focal Length : f12mm Format Size: 1/2", 1/3" Mount : C-mount Filter Screw Diameter(mm) : M27 P0.5 Weight : 55g Focus & Iris Lock Screws

1.2.2. Software Configuration

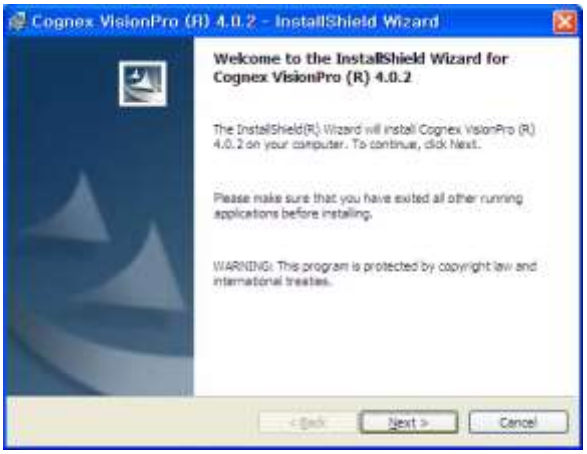
The software is composed of VisionPro 4.0.2, 8510 Support SW and HRVision 2.5D.
VisionPro 3.0.2, 8510 Support SW is a software that provides the driver for Cognex Frame Grabber and various application tools.
HRVision 2.5D is a PC-based 2.5D robot vision software dedicated for Hyundai robots, and it is possible to use this software after installation and license registration.

1.2.2.1. VisionPro Installation

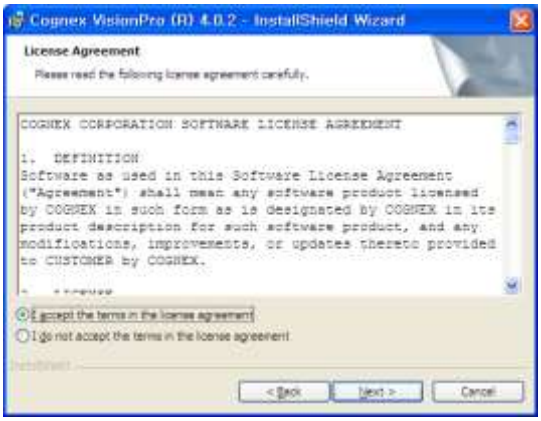
End all application softwares on the system.
Insert the installation CD of VisionPro into the CD-ROM drive. If it is not automatically executed, execute the setup.exe file among the installation files.

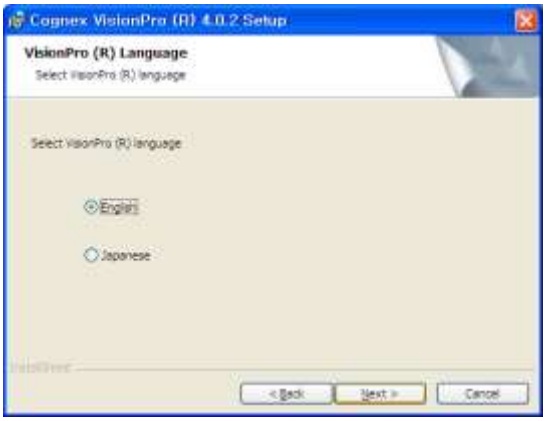


When the following installation appears, follow the installation procedure and direction as the general Windows program.

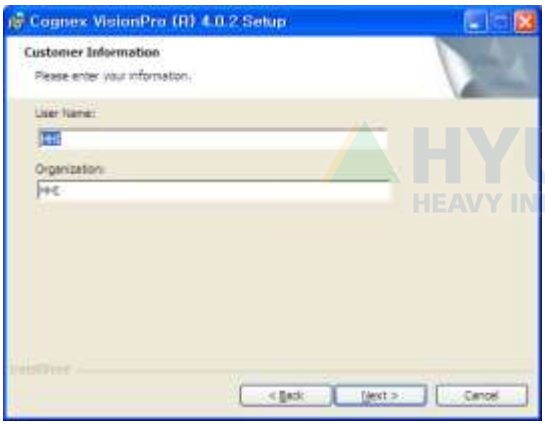


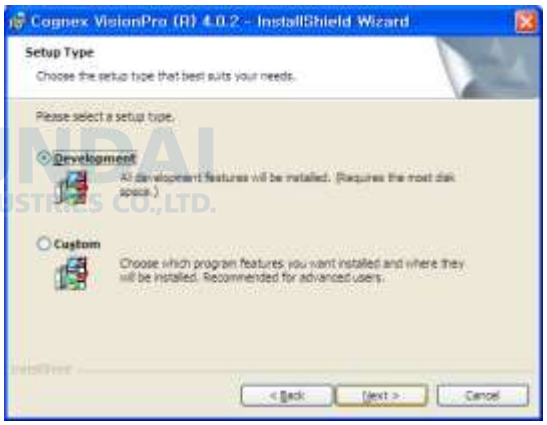
Agree to the license use as follows and select the language.



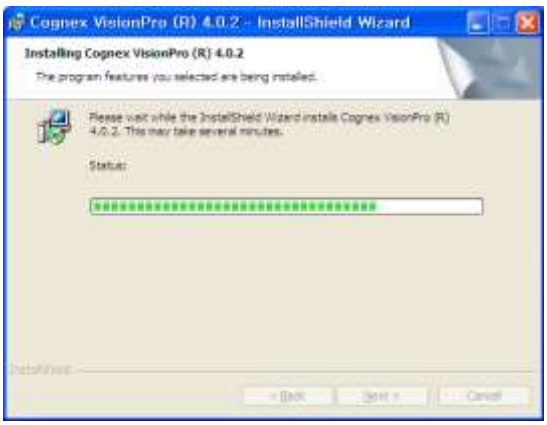


Enter the user information and select the installation type as shown below.

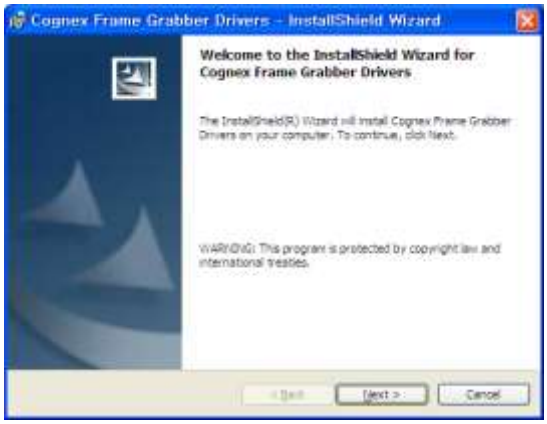




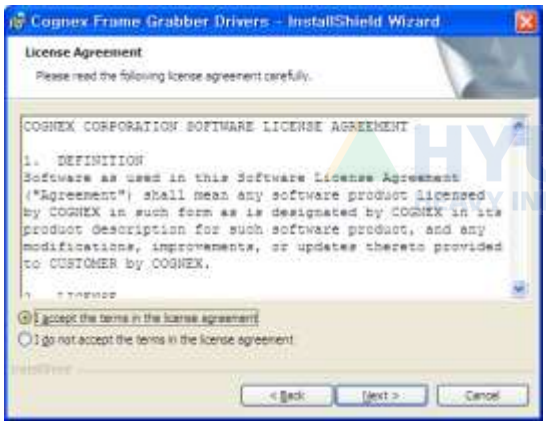
Follow the direction and the Cognex VisionPro Documentation and Cognex VisionPro(R) will be automatically installed.

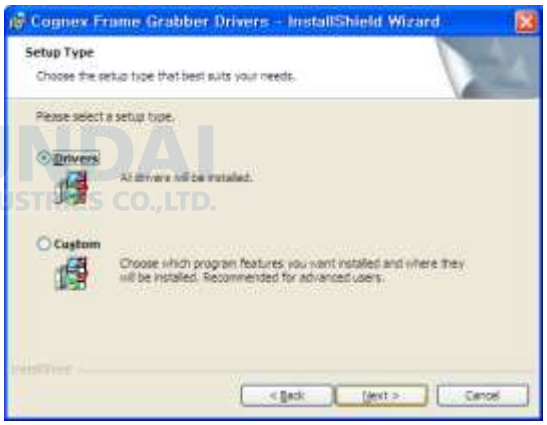


When the VisionPro 4.0.2 is installed, it installs the Cognex Frame Grabber driver..

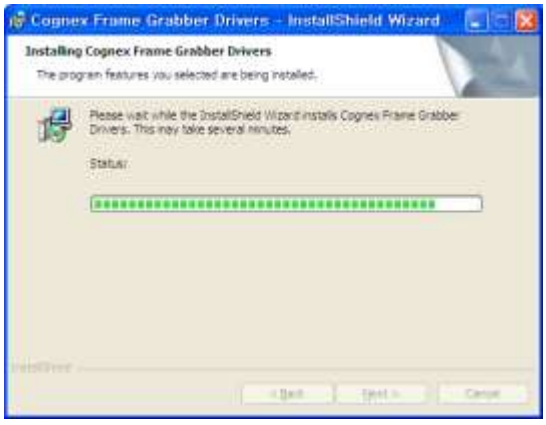


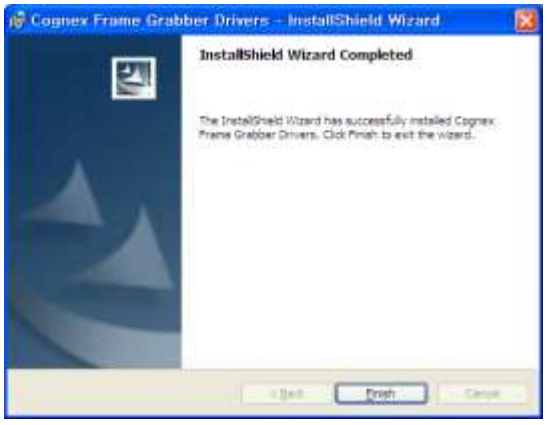
Agree to the license use as follows and select the installation type as shown below.





When the driver installation is complete, restart the computer.



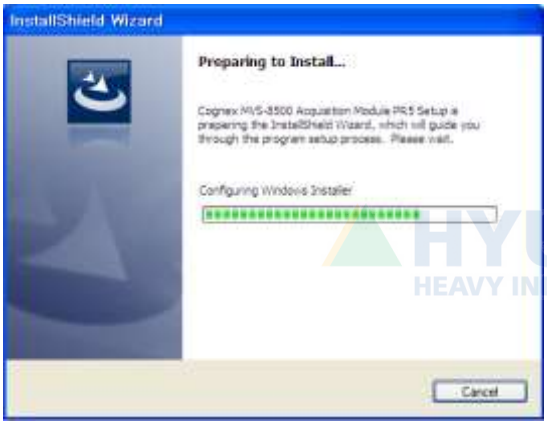


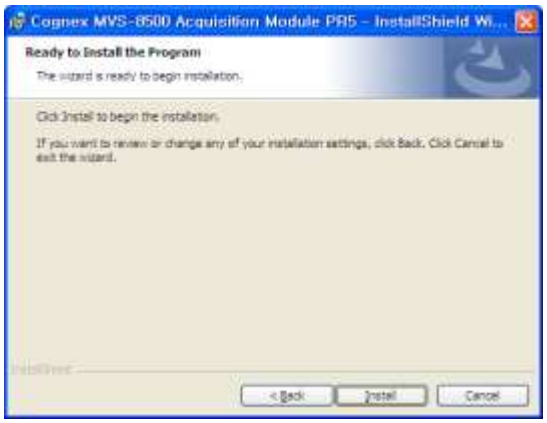
When you follow the direction, the software installation related to Cognex Frame Grabber will be completed.

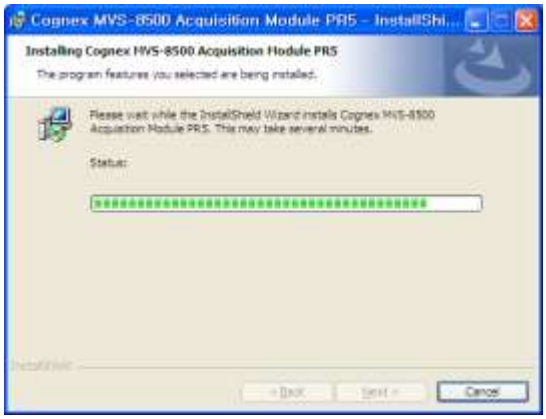
1.2.2.2. 8510 Support SW Installation

After completing installation of VisionPro SW, install 8510 Support SW. 8510 Support SW supports boards of COGNEX 851X series. Run "setup.exe" in the 8510SupportSoftware folder.

When the following screen appears, follow the directions as the installation procedure of general Windows program.







If VisionPro 4.0.2 is not installed, and you try to execute the HRVision 2.5D program, the following warning window will appear

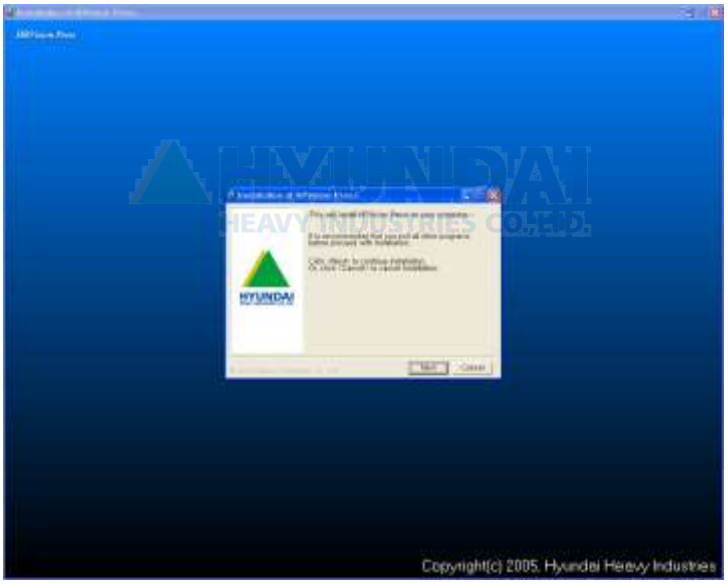
The user checks whether “C:\Program Files\Cognex\VisionPro” is installed and reinstalls the program.

1.2.2.3. HRVision 2.5D Installation

HRVision 2.5D program installation procedure is as follows.

Close all application softwares on the system.
Insert the installation CD of HRVision 2.5D in the CD-ROM drive and execute the "HRVision_2.5D_V200_Setup.exe" file among the installation files.

When the following screen appears, follow the directions as the installation procedure of general Windows program.



The HRVision 2.5D execution files are copied to the “C:\Program Files\HHI Robotics\HRVision 2_5D” folder and the user cannot change directory arbitrarily.

The program is restarted after copying the files.

When the restart process is completed, the following window appears. The installation of HRVision 2.5D program is completed.

1.3. HRVision 2.5D Execution

To execute HRVision 2.5D use one of the following methods.

- Method 1

  1) Click on the Start.

  2) Select HRVision 2.5D as follows.

- Method 2

  Double click on the HRVision 2.5D icon on the desktop.

HYUNDAI
HEAVY INDUSTRIES CO.,LTD.

2
License Entry

To use HRVision 2.5D, you must enter the license key.
You cannot execute any work in the condition without the license key entered.

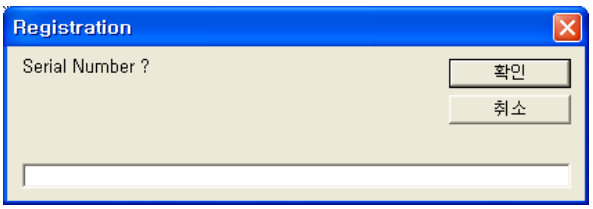
2.1. HRVision 2.5D License

To use HRVision 2.5D, you must enter the license key number that fits the Cognex Frame Grabber of the PC with the S/W installed.
To purchase the user license of HRVision 2.5D from the supplier, you must notify the “System Serial No” for the Frame Grabber of Cognex to use.
The key code that fits the number provided by the customer will be notified to the user.

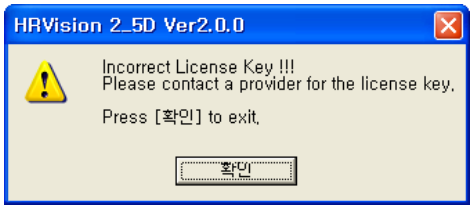
After the HRVision 2.5D installation, execute the HRVision 2.5D in the method described in 1.3. If Cognex Frame Grabber is not installed or is not operating normally, the following warning window will be displayed and the program will be ended.

The user should check whether the Frame Grabber is normally installed.

When the Frame Grabber is normally installed, the following input window will be displayed.
The user enters the license key received from the supplier and click OK.



When the license code is entered incorrectly or when the Frame Grabber installed on the PC is different from the Frame Grabber of which the information is provided to the supplier, the following warning window will be displayed and the program will end.



Because the license key is saved in the Windows registry, you only need to enter it once and do not need to enter it again.
But when you uninstall HRVision 2.5D program from the PC, reinstall the operating system or format the hard drive, the entered key code information will disappear and you need to re-enter during the reinstallation. Therefore keep the key code in a safe location.

3
Basic Function

3.1. Screen Configuration

HRVision 2.5D supports Korean and English and the language can be changed in the Option tab of setup mode when the program is running. This manual describes English Windows OS only.

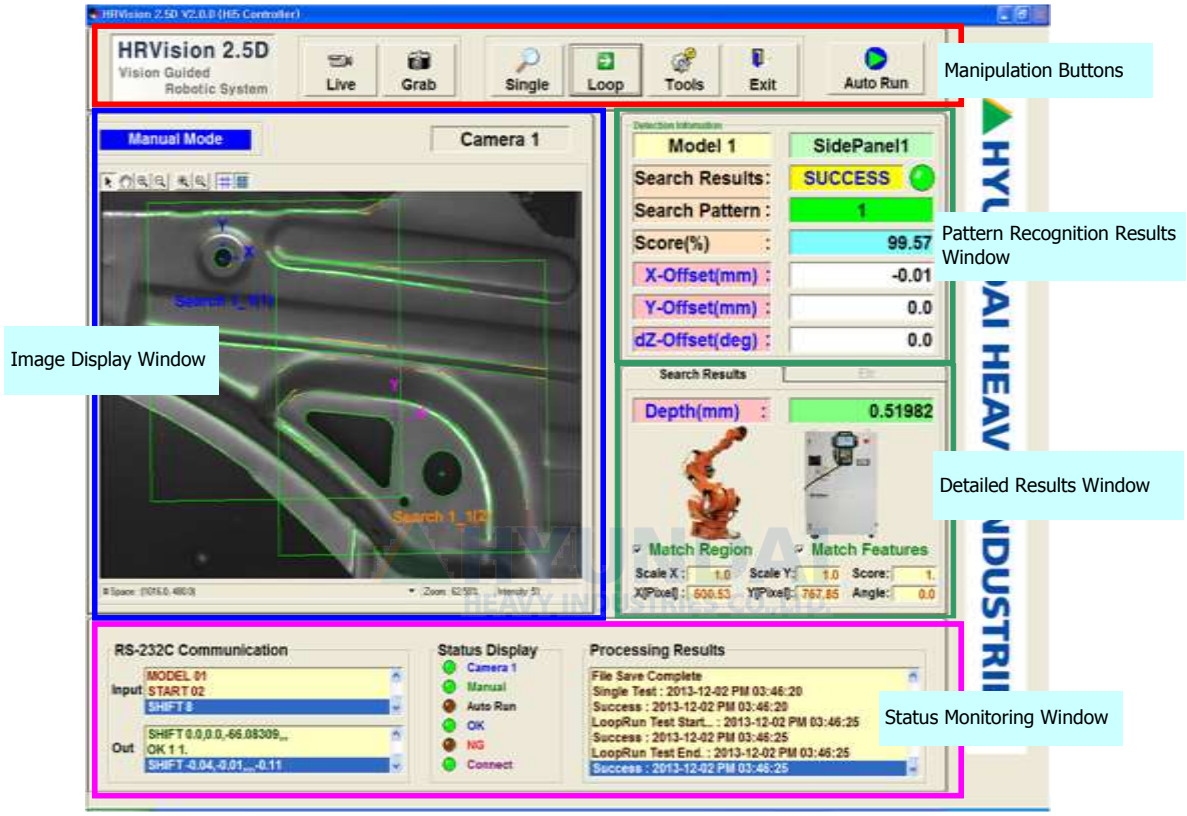
3.1.1. Splash Screen

When the serial key is entered accurately after executing the program, the following splash screen will be displayed to execute the HRVision program. The splash window displays HRVision 2.5D version information and the robot controller information to be used. This function manual is described by the Hi5 controller.

HRVision 2.5D can be applied to the Hi4a controller. If you want to apply the Hi4a controller, please contact our staff.

3.1.2. Main Screen Configuration

The screen of HRVision 2.5D is composed of 6 windows and is displayed in 2 screens depending on the “Display/Tools”. The following picture shows you the result display screen configuration during inspection and auto operation.

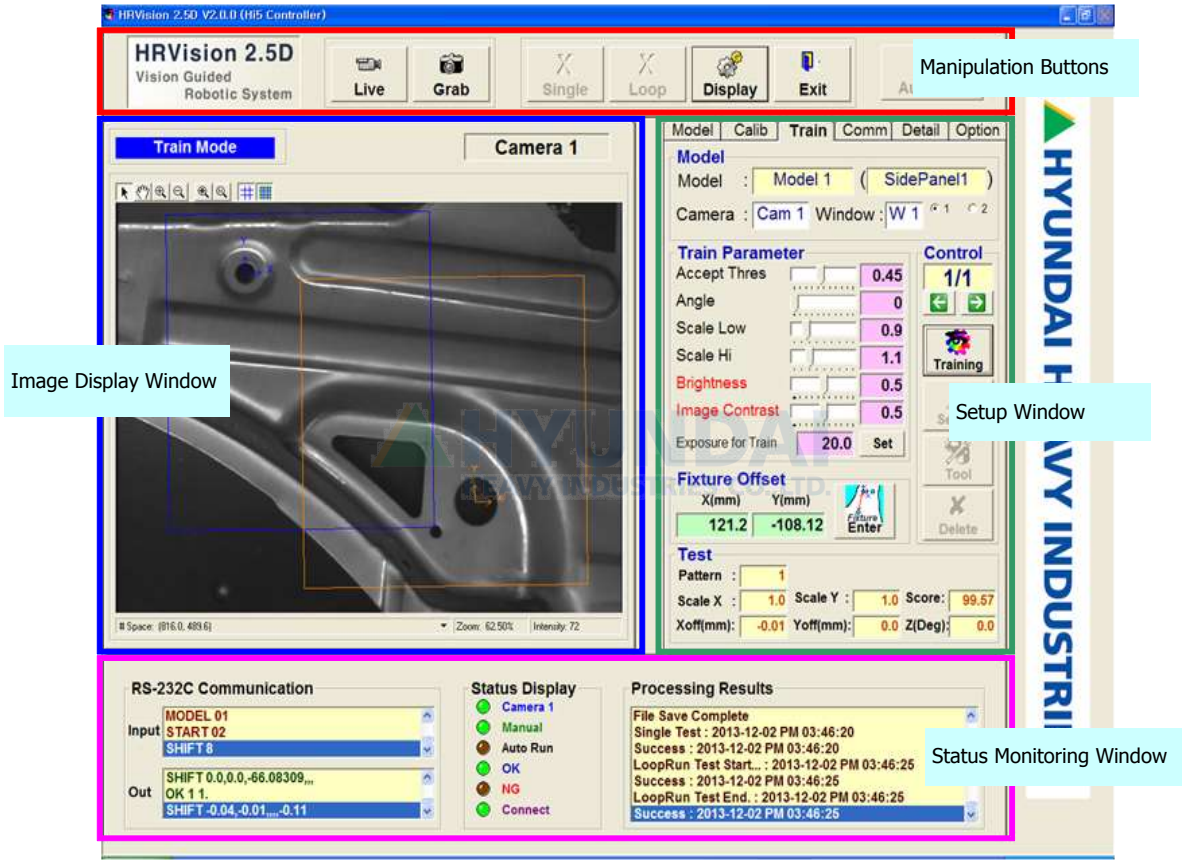


The key function of each window is as follows.

Manipulation Buttons	This provides the operating buttons to operate HRVision 2.5D including grab image, inspection, various setups, auto operation etc.
Image Display Window	This displays the current live or grabbed image.
Status Monitoring Window	This displays the communication details with the Hyundai Robot, various status display, progress details etc.
Pattern Recognition Result Window	This displays the detected results of inspection/continuous inspection and auto operation.
Detailed Result Window	This displays the detail results of the searched patterns of inspection/continuous inspection and auto operation.
Setup Window	When you click on the Tools button of the operating button, this window appears which executes all setups to process the image.

The following picture shows the screen configuration of HRVision 2.5D changed to setup mode by clicking on the “Tools” button. With the setup mode, you can setup the vision and manage files. Access is only possible after logging in. The setup window password is notified to the user at the time of purchase for the license of HRVision 2.5D. The user logs in and changes the password in the “option” tab of setup window. Refer to [3.7.6 “Option” tab.

For the setup mode screen, the result output window and detail result output window disappears in the result display screen and the setup window is added for arrangement.
There are 6 configuration modes: “Model”, “Calib”, “Train”, “Comm”,” Detail”, and “Option”.



3.2. Manipulation Buttons

As the button operating the key function of HRVision 2.5D, each function is as follows.

- Live
  This displays continuous image from the installed camera.

- Grab
  Every time you click, it captures currently shown image.

- Single
  When the pattern is added, it executes the pattern recognition work once from the currently shown image.

- Loop/L-Stop
  - This is a toggle button that when you click on this button, it becomes “L-Stop” and when you click again it becomes “Loop”.
  - When the pattern is added, the pattern recognition work is executed for the input image until “L-Stop” is clicked

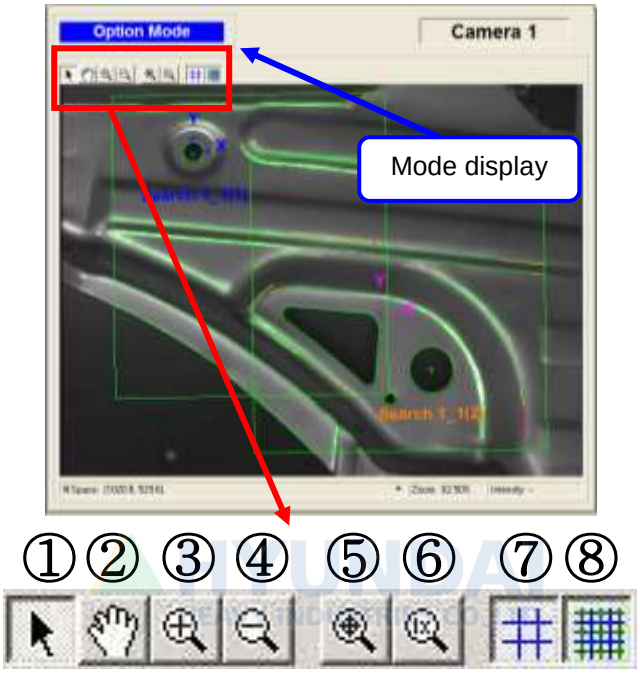
- Display/Tools
  This is a toggle button that when you click on it once, it becomes “Display” and when you click again, it becomes” Tools”.
  - Tools
    You can set the model to execute image processing, camera calibration, communication, other data files etc.
    The setup mode is set so that only the administrator can access the functions. Refer to “3.7.6 Option” tab on how to change the password.
  - Display: This displays the pattern recognition result and location movement.

- Exit
  This ends the program.

- Auto Run/Auto Stop
  This is a toggle button that when you click on this button, it becomes “Auto Stop” and when you click on this button again, it becomes “Auto Run”.
  In accordance with the communications standard with the robot, until “Auto Stop” is clicked “Auto Run” will be executed.
  In order for Auto Run to operate normally, the pattern addition, camera calibration, communication setup with robot and robot work program preparation must all be completed.

3.3. Image Display Window

Image window is a window to display continuous image or currently grabbed image.



Within the image window, there is the mode display window that shows you all the currently executed modes, and the operating tool mode that will help you efficiently view the grabbed image.

The function by each button of image operating tool is as follows.

① Pointer
② Move
③ Zoom In
④ Zoom Out
⑤ Fit Image
⑥ Zoom 100%
⑦ Grid On/Off (Can be seen when expanded)
⑧ Sub-Grid On/Off (Can be seen when expanded)

3.4. Status Monitoring Window

Monitoring window can be divided into 3 parts, communication details with robot and HRVision 2.5D, status display and work progress status.

- Communication
  The details of the communication with Hyundai Robot are monitored.
  - Input : It displays the input data from Hyundai Robot to PC.
  - Output: It displays the output data from PC to Hyundai Robot.

If the system is connected to the Hyundai Robot via Ethernet, the description of the communication monitoring window can be set as follows.

Ethernet Communication

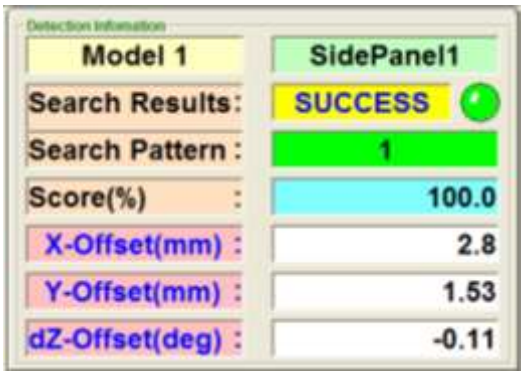
- Status Display
  It displays auto/manual run condition, OK/NG recognition status, communication connection etc. with LED.

  - Manual : LED is turned on green for Manual Mode.
  - Auto Run : LED is turned on green for Run Mode.
  - OK : When pattern recognition is successful, LED is turned on green.
  - NG : When pattern recognition is unsuccessful, LED is turned on orange.
  - Connect:
    When connected to Hyundai Robot via RS-232 or Ethernet, LED is turned on green. In case of a communication error, the LED is turned on red.

- Processing Results
  It displays the work in progress by HRVision 2.5D in order.

3.5. Pattern Recognition Result Window

It displays pattern recognition and location calibration result during manual inspection and auto run.



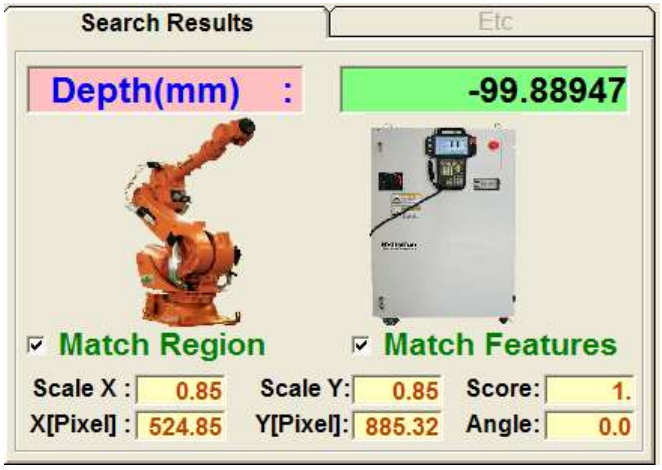
The details of each item are as follows.

- MODEL : It displays the model name and ID of the pattern recognition process.
- Search Results :
  It displays the pattern recognition result in SUCCESS/FAILURE. For SUCCESS, the green LED is turn on and for FAILURE, the red LED is turn on.
- Search Pattern : It displays the result and number of search pattern.
- Score(%) : As the result of search pattern, it displays the score in percentage.
- X-Offset(mm) : As the result of search pattern, it displays the offset in X axis direction of the robot.
- Y-Offset(mm) : As the result of search pattern, it displays the offset in Y axis direction of the robot.
- dZ-Offset(deg): As the result of search pattern, it displays the angle of rotation based on the Z axis of the robot.

  * Note:
  In the result display window, the shift amounts of X, Y, and dZ are automatically changed and displayed according to the coordinates system that is decided during calibration work.
  (e.g., if the coordinates system is configured as YZ-Coord (RX-) during the calibration work, Y shift amount, Z shift amount, and dX shift amount will be displayed automatically.

3.6. Detailed Result Window

It displays the detail results of image processing.



The detail description of each item is as follows.

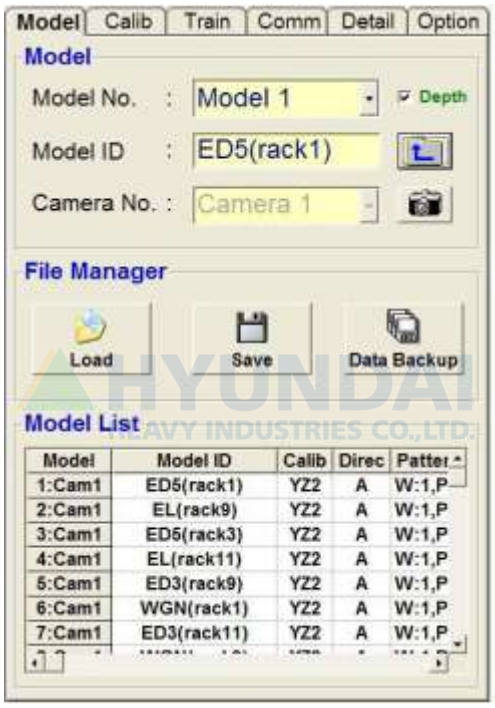
- Depth(mm) :
  When the depth detection function is enabled, information on measured distance will be displayed.
- Match Region :
  When this checkbox is checked, it displays the search window area when executing pattern recognition.
- Match Features :
  When this is checkbox is checked, it displays the matched features when executing pattern recognition.
- Scale X : As the result of search pattern, it displays the changes in X axis direction.
- Scale Y : As the result of search pattern, it displays the changes in Y axis direction.
- Score : As the result of search pattern, it displays the score in a decimal between 0 and 1..
- X(Pixel) : As the result of search pattern, it displays the X coordinate of the image.
- Y(Pixel) : As the result of search pattern, it displays the Y coordinate of the image.
- Angle:
  As the result of the search pattern, it displays the rotation angle of the image coordinate.

3.7. Setup Window

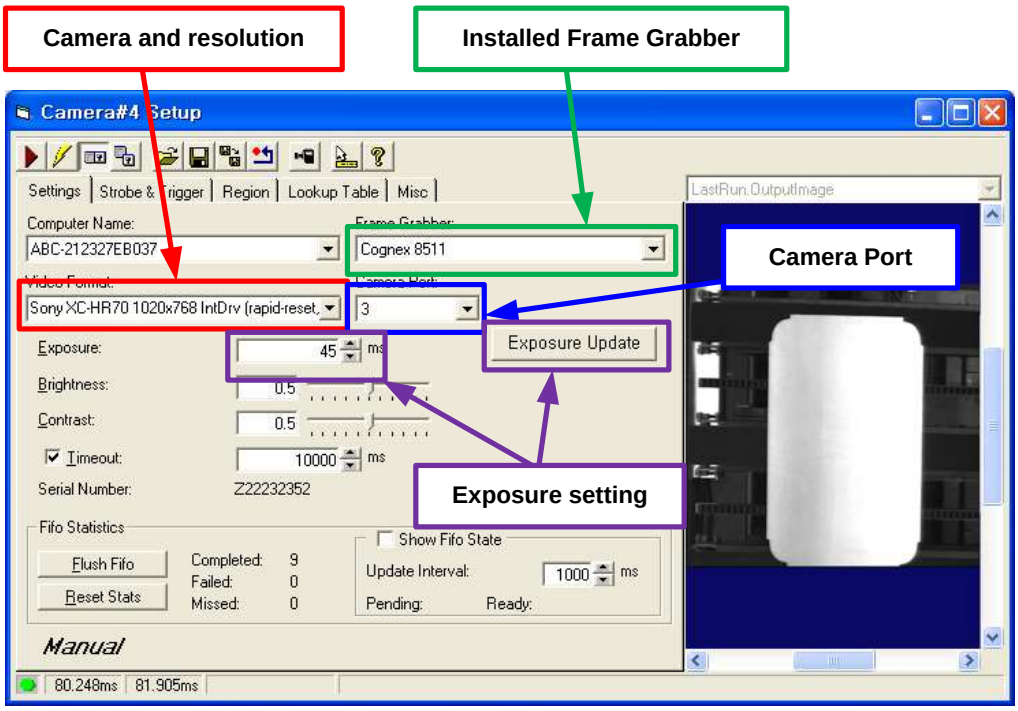
You can use the setup window after clicking the “Tools” of operating button and logging in successfully.
When the setup window appears, the “Pattern Recognition Result Window” disappears.
The setup window is composed of total of 6 tabs, and each component is as follows.

3.7.1. Model Tab

This mode sets the camera and model to add the pattern and manage the data file.



- Model No. : It sets the model to add the pattern.
- Depth :
  When the checkbox is selected, distance information of the applicable model will be measured.
- Model ID : It sets the model name.
-  Button : It saves the entered model name.
- Camera No. : Cameras that will process images will be displayed by model.
- When you click on the  button, the following camera setup window appears.
  Check the Frame Grabber installed on the PC, and set the camera, resolution and camera port to use.



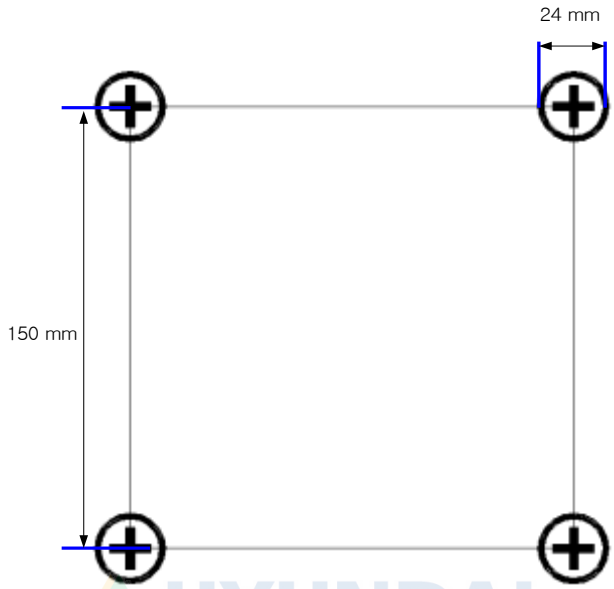
- Load : Load the data file.
  Load the HRVision_2_5D_V200_init.vpp data file in the “C:\Program Files\HHI Robotics\HRVision 2_5D” folder.

- Save : Save the data file.
  Save the HRVision_2_5D_V200_init.vpp data file in the “C:\Program Files\HHI Robotics\HRVision 2_5D” folder.
  In addition, in saving, the previously saved data file will be saved as the HRVision_2_5D_V200_init_bak.vpp file, which can be utilized as the data file for recovery.

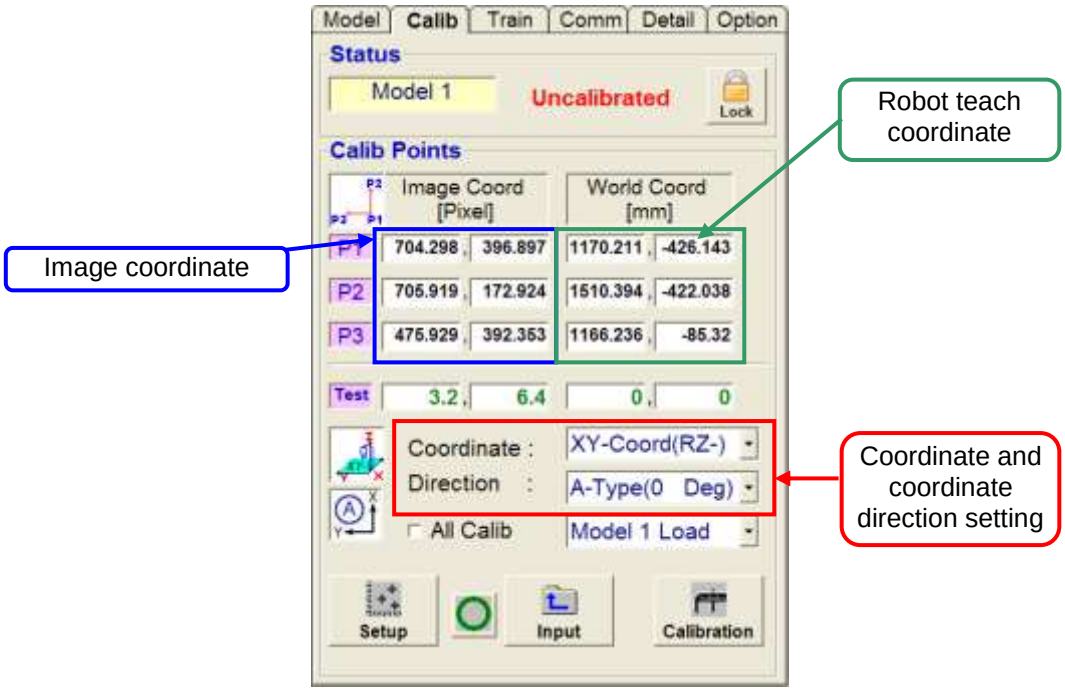
- Data Backup : Backup the data file.
  Backup the HRVision_2_5D_V200_init.vpp file and the HRVision_2_5D_V200_init_bak.vpp file in the selected folder as shown in the following figure.
  The default data file backup folder is created as “HRVision 2_5D Backup_DateTime” under “C:\Program Files\HHI Robotics”.
  The data file that is backed up can be utilized as one for recovery.

3.7.2. Calib Tab

This mode executes the camera calibration to align the image coordinate and camera coordinate. HRVision 2.5D executes the calibration using the following calibration board.



The calibration board is the form of setting the circle with a diameter of 24mm at the corners of a square with a length of 150mm. Refer to the “2D calibration board.dwg” file in the installation CD. Here the 4 circles are called the calibration points, and the calibration work is executed by teaching the central point of this circuit from the image coordinate and the location from the robot coordinate.



The detail description of “Calib” tab is as follows.

- Status : It displays the model, whether there is calibration etc.
  - Model : It displays the model executing the calibration.
  - Calibration condition : It display whether the calibration is executed or not as shown below.

Status	Display	Description
Uncalibrated	Uncalibrated	Calibration has not been performed.
Calibrated	Calibrated	Calibration has been performed.

- 

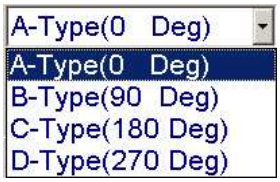
Lock button: This locks all buttons related to calibration.

- Calib Points
  Enter the image coordinate and robot teach data for the Calibration Points.
  The positions of calibration points in the image coordinates can be configured either through performing pattern recognition by clicking the "Setup" button, or performing elliptical fitting by clicking the  button. The positions of calibration points in the robot coordinates system can be configured through directly inputting positions of calibration points. Note that the inputted coordinates are subject to selected "Coordinate".

- Test
  When calibration has been performed, the position of the current mouse point based on the image coordinates and the robot coordinates system (or calibration coordinates system) will be displayed.

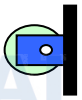
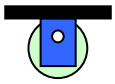
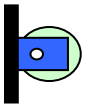
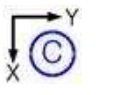
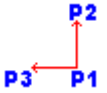
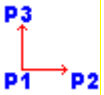
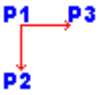
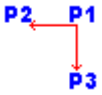
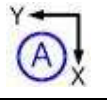
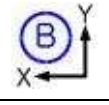
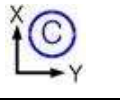
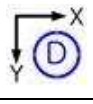
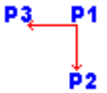
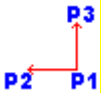
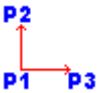
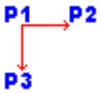
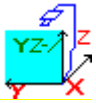
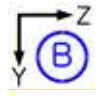
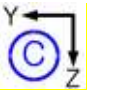
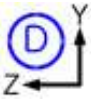
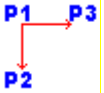
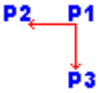
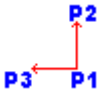
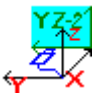
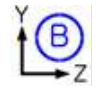
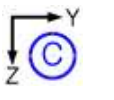
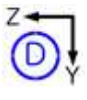
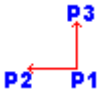
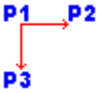
- Coordinate
  Configure robot coordinates system according to the camera operation condition.
  There are 6 configurable coordinates systems are available according to camera operation conditions (installation and orientation direction).

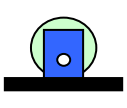
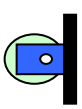
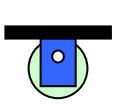
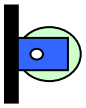
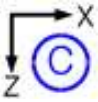
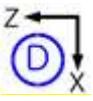
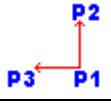
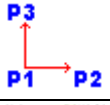
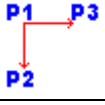
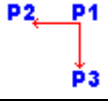
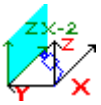
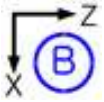
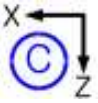
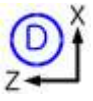
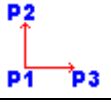
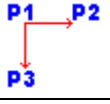
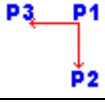
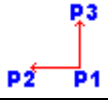
■ Direction
Setup the coordinate axis direction of calibration.
When you select the combo box, the direction changes to fit the coordinate axis direction of the selected picture of the status window.



※ For the method of configuring "Coordinate" and "Direction" by the working condition of the processes that utilize an Hi5 controller, refer to Table 1.
※ When an Hi4a controller is used, note that XY Coord will be displayed differently from Table 1.

<Table 1. Hi5 Configuration of Coordinates System and Direction Based on Camera Operation Condition under Hi5 Controller >

Camera operation condition		Setting positions of image-based robot coordinates system and calibration points	Direction of camera orientation			
			A-Type	B-Type	C-Type	D-Type
						
XY-Coord (RZ-)		Robot coordinates system				
		Setting positions of calibration points				
XY-Coord (RZ+)		Robot coordinates system				
		Setting positions of calibration points				
YZ-Coord (RX-)		Robot coordinates system				
		Setting positions of calibration points				
YZ-Coord (RX+)		Robot coordinates system				
		Setting positions of calibration points				

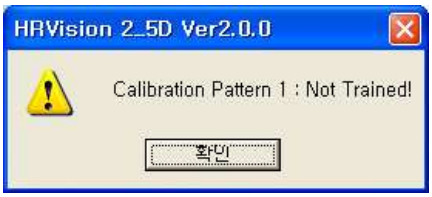
Camera operation condition		Setting positions of image-based robot coordinates system and calibration points	Direction of camera orientation			
			A-Type	B-Type	C-Type	D-Type
						
ZX-Coord (RY-)		Robot coordinates system				
		Setting positions of calibration points				
ZX-Coord (RY+)		Robot coordinates system				
		Setting positions of calibration points				

- All Calib
  When you select check the checkbox, the same calibration data is applied to all the models.
  When you uncheck the checkbox, you can copy specific calibration data or calibrate applicable models separately.

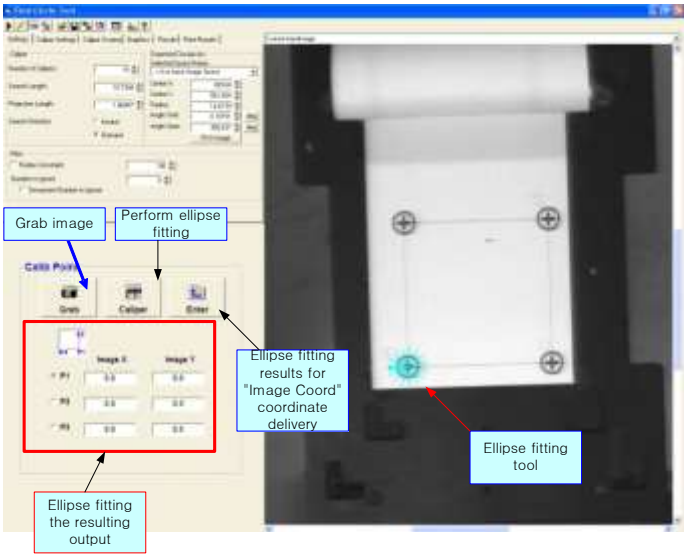
- Setup
  This button is of toggle type: Clicking it once enables "Search", and clicking it for the second time enables "Setup".
  If you click the "Setup" button, 3 search windows and coordinate axes of search windows will be displayed.

  Arrange the 3 search windows properly so that 3 calibration points can be recognized, and place each coordinate axis on the center of each calibration point. For detailed description, refer to "4.4.2.4.1 Method of Calibration Pattern Recognition".
  When the arrangement of each search window and coordinate axis is completed, click on the “Search” button.

  If the search process fails, the failed calibration point is provided as output in the following window. Retry the “setup” and “search” process so that the failed calibration point can be easily distinguished.

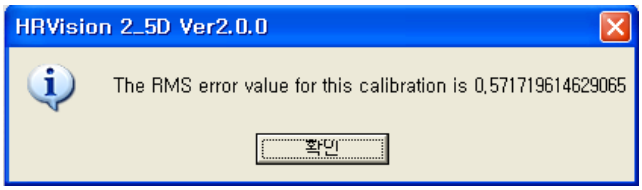


- 
  This is the method of measuring a circle center, which exists on the calibration board, based on elliptical fitting. Place the elliptical fitting tool on the points of P1, P2, and P3 that are set based on the "Coordinate" and "Direction" information selected in the "Calib" tab, and click the "Caliper" button. For detailed description, refer to "4.4.2.4.2 Method of Elliptical Fitting".

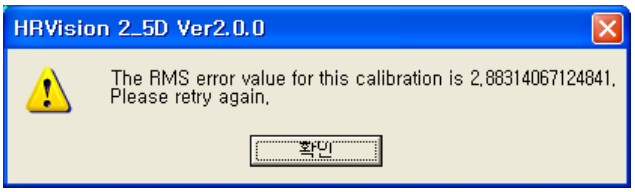


- Input
  When you have directly entered the calibration points or copied specific calibration data, it functions as data entry to the actual memory to execute the calibration.

- Calibration
  When the image coordinate and robot coordinate of calibration points are entered, click on this button to execute the camera calibration. If the RMS value of executed calibration is lower than the “RMS Error Limit”, the following window is provided and the camera calibration is completed. Refer to 3.7.5 “Detail” tab for “RMS error limit” setup.



If the RMS error is higher than the “RMS Error Limit”, the following warning window is generated. Reset the image coordinate and robot coordinate to execute the calibration again.



3.7.3. Train Tab

This manages (Add/Modify/Delete) the pattern by model and executes the training function.

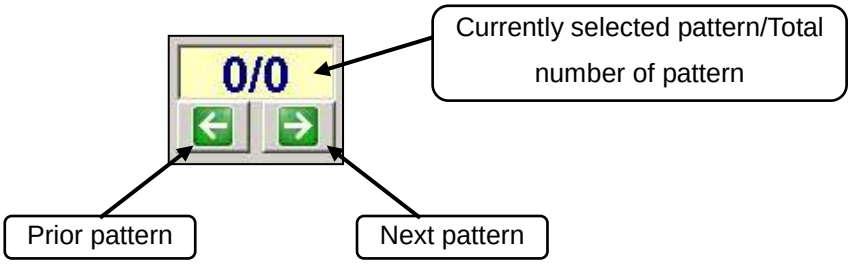
- Model
  The model name, model ID set in the “model” tab are displayed

- Window
  If the "Depth" checkbox of the "Model" tab is clicked, you have to register 2 patterns to acquire distance information. The "Window 1/2" button is a radio button that allows selection of one pattern to be registered out of two.

- Train Parameter
  Use this parameter to train the pattern.

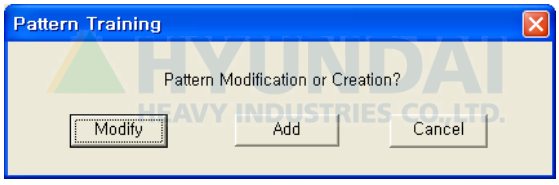
  - Accept Thres : This sets the score threshold for pattern recognition.
  - Angle : This sets the angle range that can be recognized.
  - Scale Low : This sets the minimum change that can be recognized.
  - Scale Hi : This sets the maximum change that can be recognized.
  - Brightness : This sets the brightness of the image.
  - Image Contrast : This sets the image contrast.
  - Exposure for Train :
    Set Shutter Speed for the exposure to be used for pattern registration.

- Control
  Execute the work to add/modify/delete/search the pattern.



You can select specific patterns from the whole pattern.
For example, [2/5] means that you have selected the 2nd pattern among total of 5 patterns.

- Add/Mod.
  When you click on this button, it toggles between “Training” and “Add/Mod”.
  You can add the pattern, modify the added pattern or train the pattern.
  When you click on the “Add/Mod” button, the following window appears. Click on “Modify”, “Add” or “Cancel” depending on the purpose.



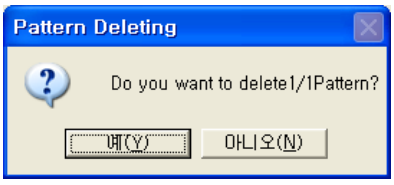
When you click on the “Add” button, the search window and coordinate axis are displayed in the image window.
Arrange the search window and coordinate axis in the pattern area to add and execute the pattern addition process. If the "Depth" checkbox of the "Model" tab is clicked, you have to register 2 patterns.

Modify button modifies the added pattern. If you have click on the “Modify” button without any added patterns, the following warning message will be displayed.

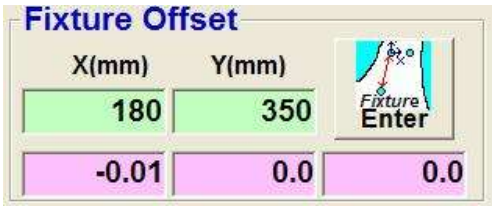
- Search
  Use the added patterns to execute the pattern recognition work.
  Even when multiple number of patterns are detected, the pattern with maximum score will be displayed.

- Tool
  Call the "Edit PatMax Setting Dialog" tool for advanced pattern setting.

- Delete
  When you click on “Delete” button, the following window appears. When you click on the Y button, the added pattern will be “Deleted”.

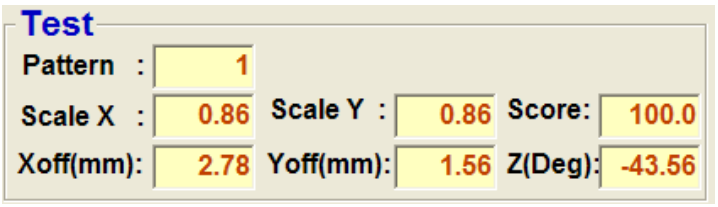


- Fixture Offset
  Change the center position of the model pattern by the given Offset amount so that it can be outputted.
  This function can be assigned only when the center position of the model pattern is different from that of the robot tool, or when the model pattern is registered or modified through clicking the "Add/Mod." button.
  To use this function, input the relative distance between the center position of the model pattern to be assigned for the work target and the position of the robot tool to grip the work target, based either on the CAD information of the work target or on manual measurement.
  If you click the "Add/Mod." button, the Fixture Offset input window will be activated.
  In the activated input window, enter the the measured Offset amount, and click the "Enter" button.
  When the dialog window, which asks whether you want to set Fixture Offset, is displayed, click "Yes (Y)".



Assign a model to be newly registered or to be modified and registered; and click the "Learn" button to finish the "Fixture Offset" setting.
"Fixture Offset" of the patterns that are additionally registered for a same model should be the same with one another.

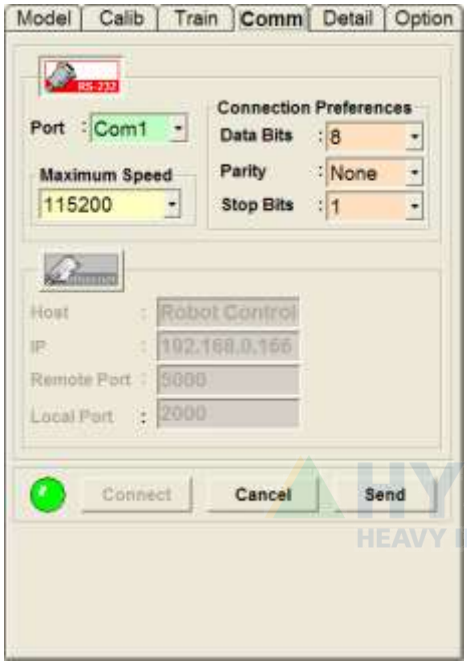
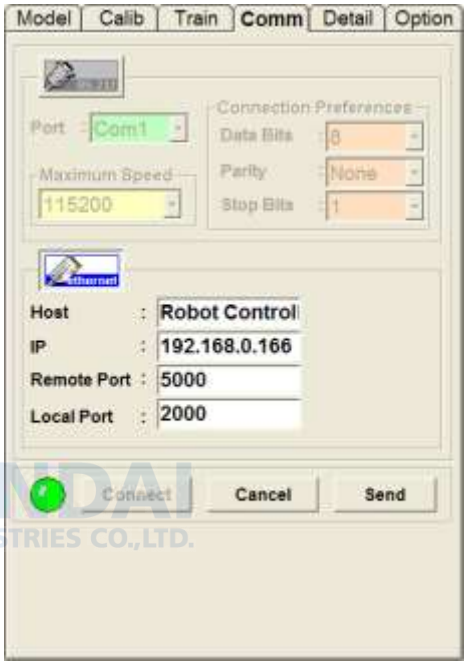
■ Detection results
Detail detection information is displayed for “Training” and “Search” process.



- Pattern : This displays the detected pattern number.
- Scale X : This displays the X axis direction size ratio of recognized pattern.
- Scale Y : This displays the Y axis direction size ratio of recognized pattern.
- Score : This displays the score of detected pattern between the value of 0 and 1.
- XOff(mm) : This displays the location offset in X direction.
- YOff(mm) : This displays the location offset in Y direction.
- Z(Deg) : This displays the rotating angle based on the Z axis of the robot.

3.7.4. Comm (Communications) Tab

This sets the communication method with the Hyundai Robot controller.
You can select one between the RS-232 communication and Ethernet communication.

RS-232C Serial	Ethernet
	

When you click on each communication method, it is activated and the color changes to the following color.
When deactivated, the color changes to gray and you cannot set the internal parameter.

Communication method	Active	Deactivate
RS-232		
Ethernet		

- RS-232
  It communicates with the Hyundai Robot controller with the RS-232C serial communication method.
  - Port : This selects the communication COM port.
  - Maximum Speed : This sets the communication speed.
  - Data Bits : This sets the data bit.
  - Parity : This sets the parity bit.
  - Stop Bits : This sets the stop bit.

- Ethernet
  HRVision 2.5D utilizes UDP/IP. This function cannot be utilized by an Hi4a controller.
  - HOST : Enter the host name to connect.
  - IP : This sets the IP address of the server to connect.
  - Remote Port : Configure the port for the robot controller.
  - Local Port : This sets the port of the PC.

- Connect
  This executes the communication connection with the Hyundai Robot controller with the selected communication method.

- Cancel
  This cancels the connected communication.

- Send
  To check the connection with the Hyundai Robot controller, this sends the character string of “Connected” to Hyundai Robot controller.

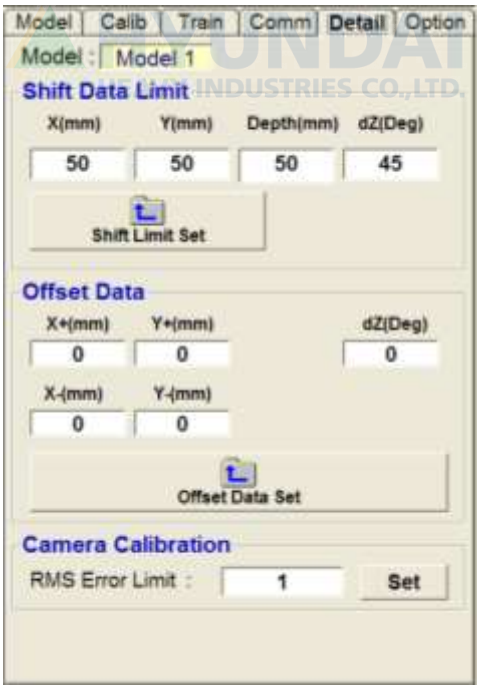
3.7.5. Detail Tab

This mode sets the various detail parameters.

- Shift Data Limit
  This sets the permitted limit of the shift movement (X, Y, ThetaZ) to transmit to the robot controller.
  Enter the permitted range for the X, Y and ThetaZ, and click on the “Shift Limit Set” button for the setup.

- Offset Data
  Change the location shift by the offset data (X+/X-, Y+/Y-, ThetaZ) to transmit to the Hyundai Robot controller.
  Enter the shift to X+/X-, Y+/Y- and ThetaZ, and click on the “Offset Data Set” button for the setup.

- Camera Calibration
  RMS Error Limit :
  RMS Error Limit: Set the RMS error limit to execute camera calibration.
  Enter the permitted value in decimal format in the edit window and click on the Set button.
  Execute the camera calibration for the RMS error within the entered permitted value. When it exceeds the permitted value, a window appears to re-execute the calibration.

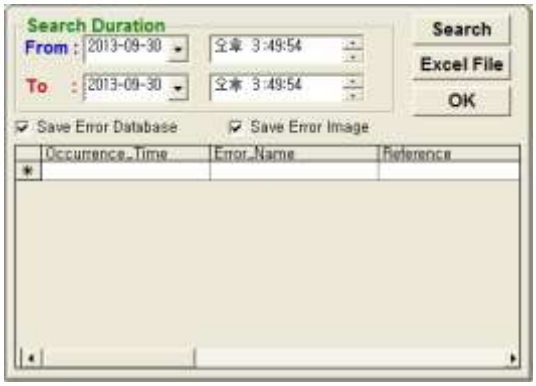


3.7.6. Option Tab

This is a mode for configuring error and detected data management, password management, language change, Depth Caliper function, etc.

- Management
  This manages the error, data record, user password change, and data file auto loading setup.

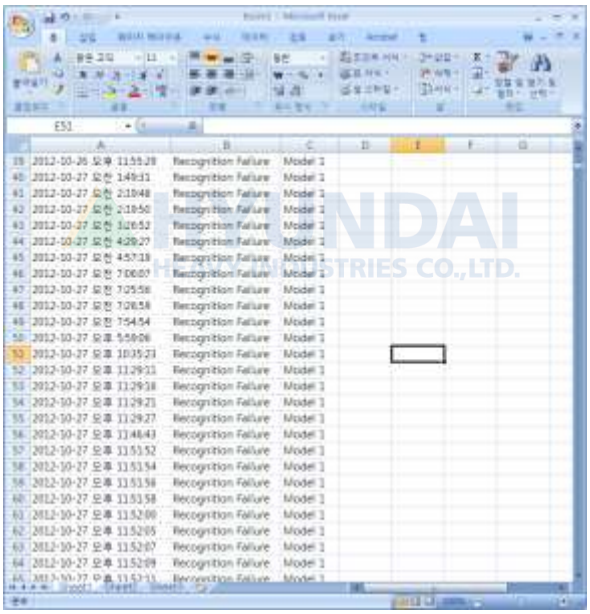
- Error History
  It manages the error record that occurs during Auto Run.
  The error database is composed of Occurrence Time, Error Name and Reference, and managed in the ErrorDB.mdb file in the “C:\Program Files\HHI Robotics\HRVision 2_5D”



  - Search Duration : This sets the search duration.
    Initially this sets the time to execute HRVision 2.5.
  - Search : This searches the error history that satisfies the search duration set.
    The search result is displayed in the data grid.

Below picture is the result of the error history search by setting the search duration.

- Excel File : Call the searched result in Excel file.



- OK : This ends the error history management.
- Save Error Database :
  In case of an error, this saves the error history to the database. When the checkbox is unchecked, the error history is not saved.
- Save Error Image :
  Images having errors of pattern recognition will be saved in folders under “C:\Program Files\HHI Robotics\HRVision 2_5D \Images” by date, and they will be automatically deleted after a period of one month has elapsed.
- When the checkbox is unchecked, the error image is not saved.

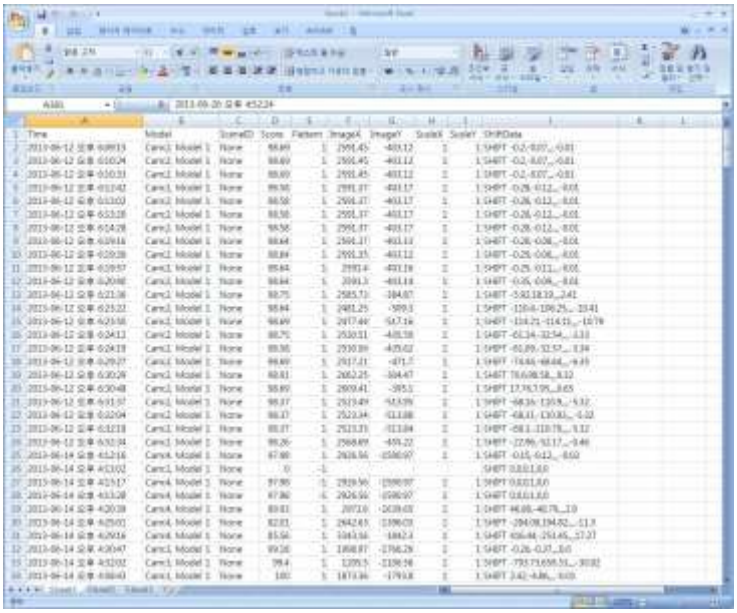
■ Data History

It manages results of pattern recognitions acquired during automatic operation, and the history of position shift amounts. The database consists of Time (pattern recognition time), Camera Model (model name), SceneID (model ID), Score (matching rate), Pattern (pattern no.), ImageX (X coordinate of the image of the detected pattern), ImageY (Y coordinate of the image of the detected pattern), ScaleX (change of dimension in the direction of X axis), ScaleY (change of dimension in the direction of Y axis), and ShiftData (amount of position shift).

- Search Duration : This sets the search duration.
  Initially this sets the time to execute HRVision 2.5.
- Search :
  This searches the error history that satisfies the search duration set.
  The search result is displayed in the data grid.

Below picture is the result of the error history search by setting the search duration.

- Excel File : Call the searched result in Excel file.



- OK : This ends the pattern recognition result history management.
- Save Data Database:
  This automatically saves the pattern recognition result history to the Database.
- When the checkbox is unchecked, the pattern recognition result history not saved.

- Change Password
  Change user password to enter the setup mode.
  Enter the Previous Password and the New Password, and the click on the “OK” button.

If the Previous Password is accurate, the following window will be displayed and changed to the New Password. The characters in the “[ ]” in the below window is the newly changed password.

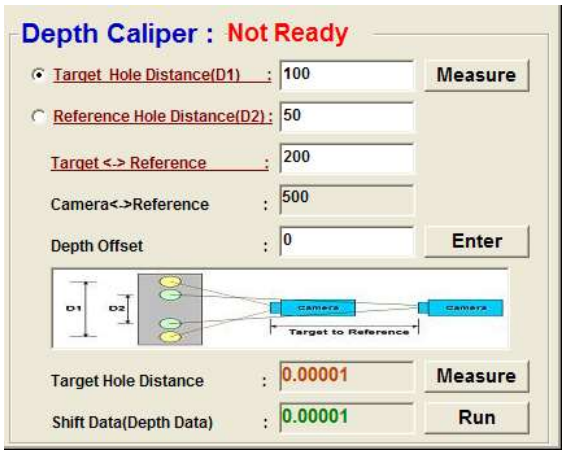
But if the Previous Password is incorrect, the following warning window will be displayed.

- AutoFileLoading
  When executing HRVision 2.5D, the data file (HRVision_2_5D_V200_init.vpp) is automatically loaded.
  When the checkbox is unchecked, the initialization file is not automatically loaded. You must load the initialization file by clicking the “Load” button from the “Model” tab in the Setup window.

- Language
  Select the language to be displayed on the main menu, pop up menu, window, message etc. HRVision 2.5D supports Korean and English, and the default is English.
  If you want to change the language, select the language you want to use and click on the “Select” button.
  The changed result is saved on the registry, and the changed language is applied from the next execution. End and restart the program.

■ Depth Caliper

If you have clicked the "Depth" checkbox of the "Model" tab, and registered 2 patterns in the "Train" tab, you can measure distance information with the "Depth Caliper" function.



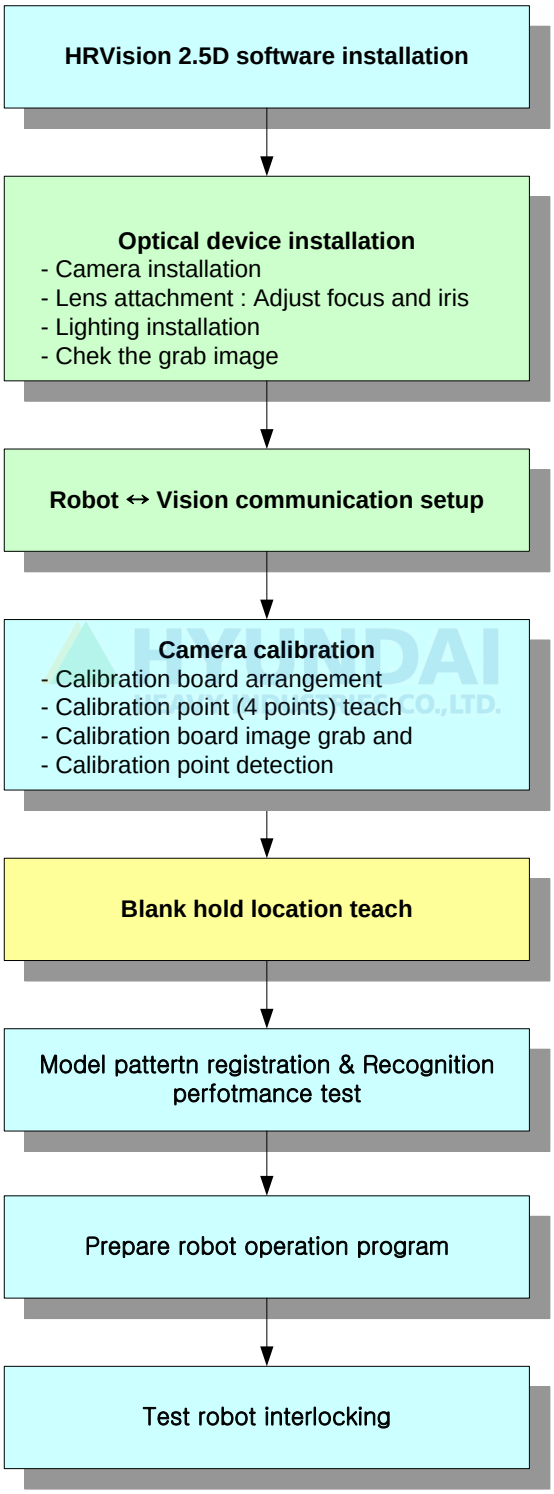
- Target Hole Distance (D1): This is the distance between the images of the two patterns that is measured at the reference image measurement position.
- Reference Hole Distance (D2): This is the distance between the image pixels of the two patterns when pattern recognition is performed at a given distance from the reference image acquisition position.
- Measure: This allows measuring of the pixel distance between the two patterns in image.
- Target<->Reference: This allows entering of actual distance between the target and the reference.
- Camera<->Reference: This displays actual measured distance between the camera and the reference.
- Depth Offset: When measured distance values have a constant error, "Depth Offset" setting compensates distance values.
- Target Hole Distance: This displays the current measured pixel distance between the two patterns in image.
- ShiftData (Depth Data): This displays shift amount of the distance between the current measurement position and the Target Hole Distance (D1).

HYUNDAI
HEAVY INDUSTRIES CO.,LTD.

4

Work Procedure

The work procedure of the HRVision 2.5D is as follows.
The detail description of each procedure is provided in the following sections.



4.1. HRVision 2.5D Software Installation

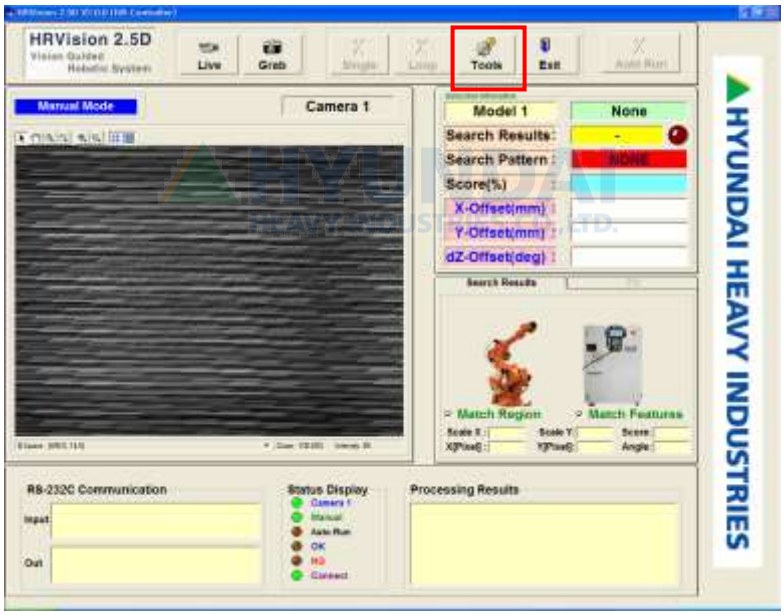
Install VisionPro 4.0.2, 8510 Spport SW and HRVision 2.5D software in accordance with 1.2.2, and register the license key in accordance with 2.1.

This work procedure describes the process of installation/operation of HRVision 2.5D. Interlocking procedure with an Hi4a controller is the same except for a few parts including camera calibration and robot operation program.

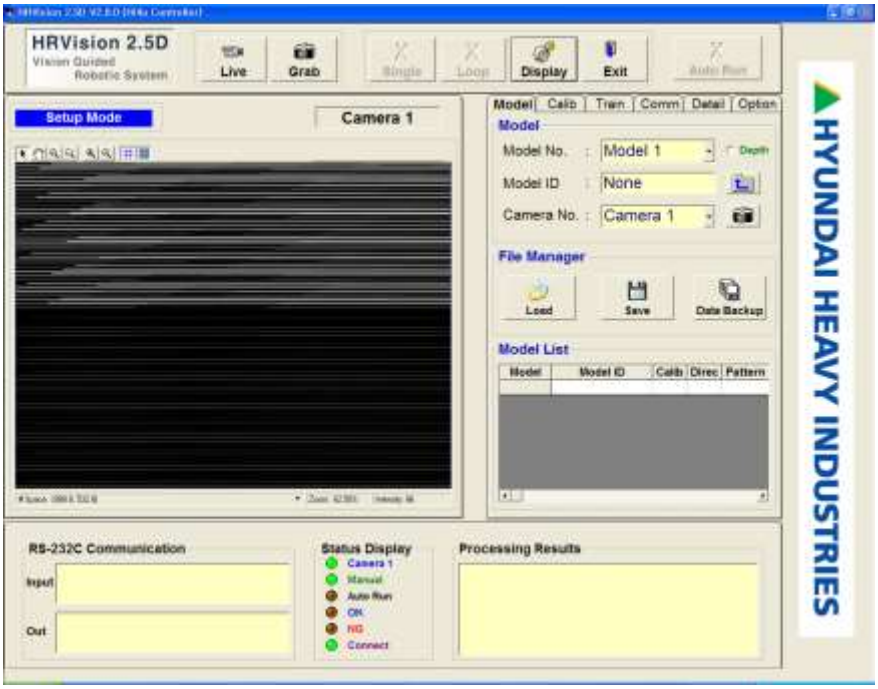
4.2. Optical Device Installation

Install the camera and lighting according to the using purpose.

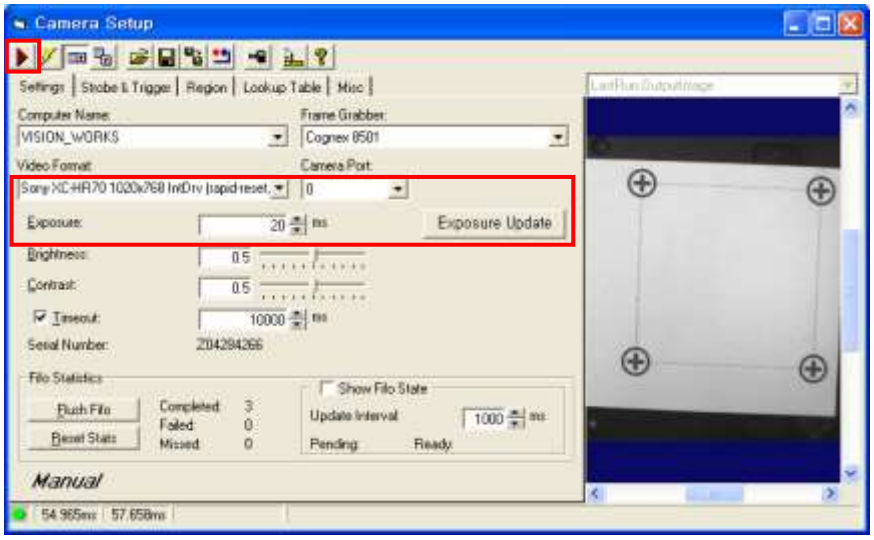
The following picture is the initial screen when executing the HRVision 2.5D after installing the optical device and HRVision 2.5D program. In the first execution, since camera type is not configured, normal image acquisition is not possible.



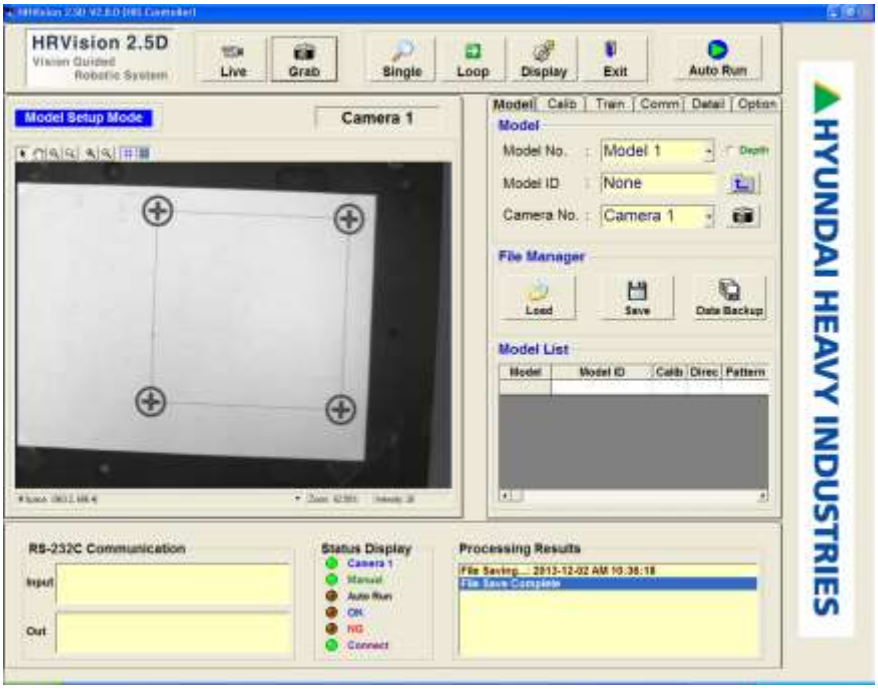
Click the "Tools" button among the manipulation buttons to switch the system to the setup mode. At this time, input password to enter the setup mode.



Clicking of the  button creates the following "Camera Setup" dialog. Configure "Video Format", "Camera Port", and "Exposure" to fit the installed camera, and click the "Exposure Update" button. If images are not acquired, check the connection of the camera cable and the setting of the camera DIP switch.



After properly setting the camera, click the  button of the "Camera Setup" dialog, and check whether images are normally acquired in the image window placed on the right.



By clicking the "Grab", and the "Live" buttons to check for normal image acquisition, click the "Save" button of the "Model" tab to save the current setting.

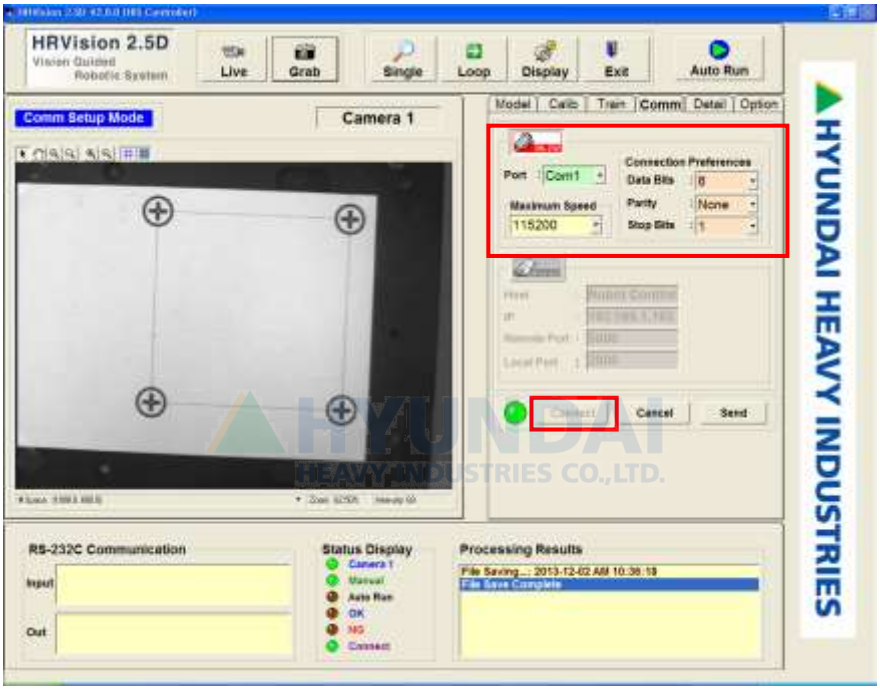
Set the distance between the work target and the camera, and the lens focus and aperture to fit the condition.
Fix the camera so that gap cannot be formed. Check the lens focus ring and the aperture ring.
After completing vision installation, check whether images are normally acquired while the adjacent equipment are operating. If image noises occur, check on the insulation condition of the camera and the cable.

4.3. Communication Setup of Robot and Vision

4.3.1. HRVision 2.5D Communication Setup

When image acquisition is completed, configure communication of HRVision 2.5D.

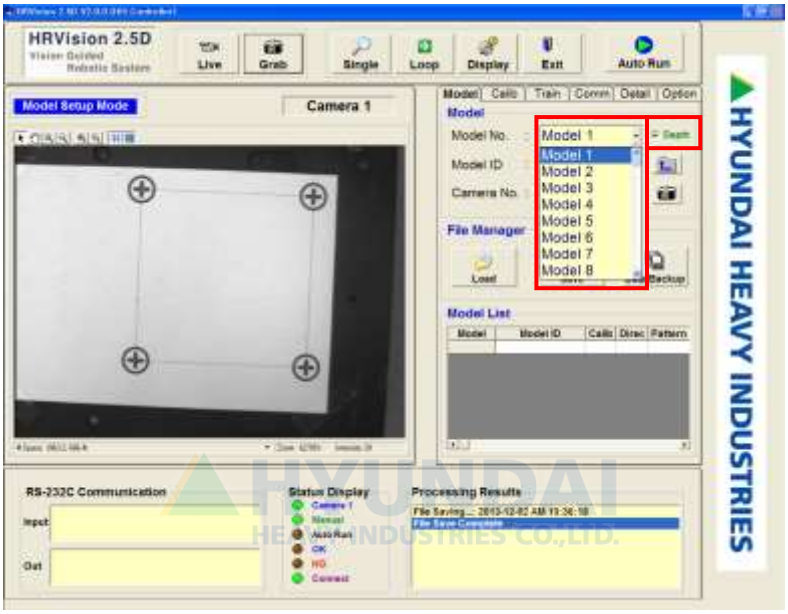
In the setup mode, click the "Comm" tab. Click the communication method to be connected, configure various parameters, and click the "Connect" button. The following figure shows a screen in which connection is made with Comp port 1, and Baud Rate 115200 through RS-232.



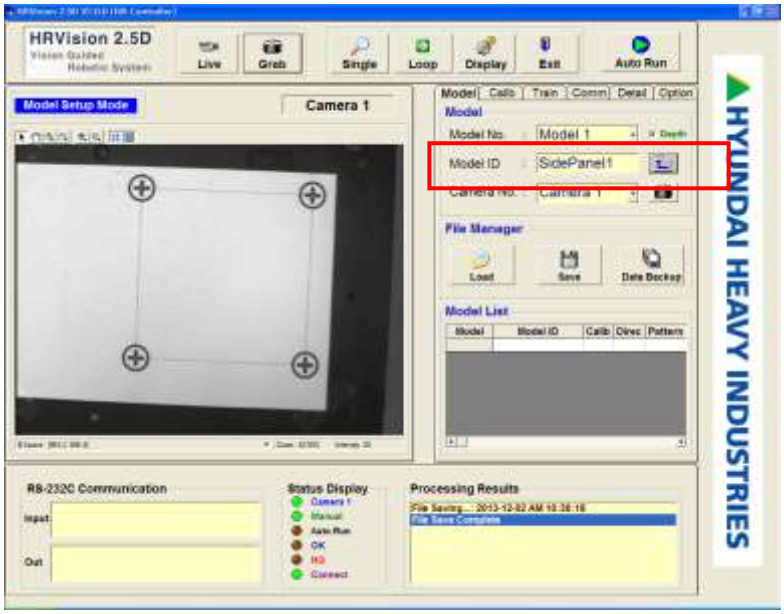
4.4. Camera Calibration

4.4.1. Model Setup

Pattern recognition result and calibration data is managed by model.
First of all, click the "Model" tab in the setup mode, and select "Model No." in the combo box.
If you want to measure distance information, click the "Depth" checkbox.



Enter the model ID and click on the  button. In this example, I have entered “SidePanel1”.



4.4.2. Camera Calibration Parameter Setup

Camera calibration to align the camera coordinate and robot coordinate is executed. The camera coordinate uses the pixel units and the robot uses the mm units. Therefore, in order to use the measured results from the camera coordinate and execute the work in the robot coordinate, it requires a process to change the results of the camera coordinate into the robot coordinate. This is called camera calibration and HRVision 2.5D uses the calibration board described in 3.7.2 and executes the calibration.

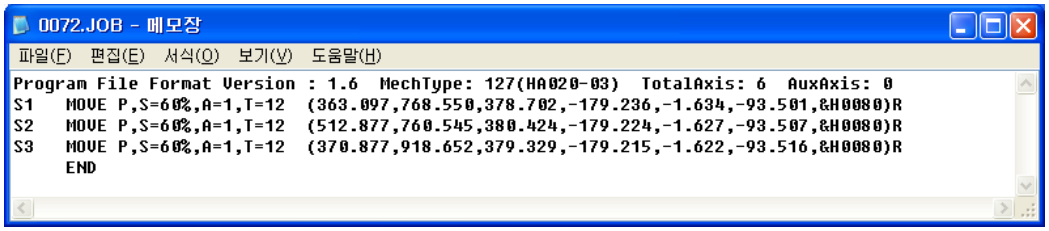
4.4.2.1. Calibration Board Arrangement

Considering first the lens specification, workpiece arrangement, pattern recognition accuracy etc., set the distance between the camera and the workpiece (Grab image location). The distance between the camera and the workpiece is not only used for camera calibration but also for pattern recognition. Therefore you must set it consistently. If the distance between the camera and the workpiece has to be modified start resetting all the setup of HRVision 2.5D including the camera calibration.

Set the calibration board on the pallet where the workpiece will be put. The pallet must not be tilted but it must be maintained for perfect leveling. There should not be any camera calibration work.

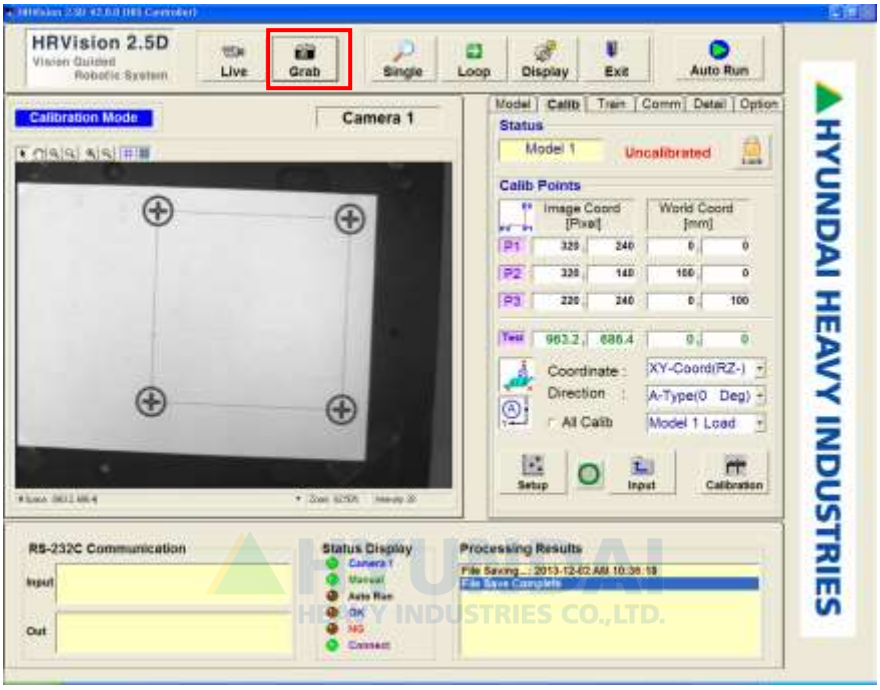
4.4.2.2. Teach Calibration Point

Attach a tip at the tool end of the robot and teach the 3 calibration points of the calibration board.
At this time, enter the tool parameter of the robot and enter the tool parameter of the attached tool.
Record the positions of the calibration points in the robot work program.

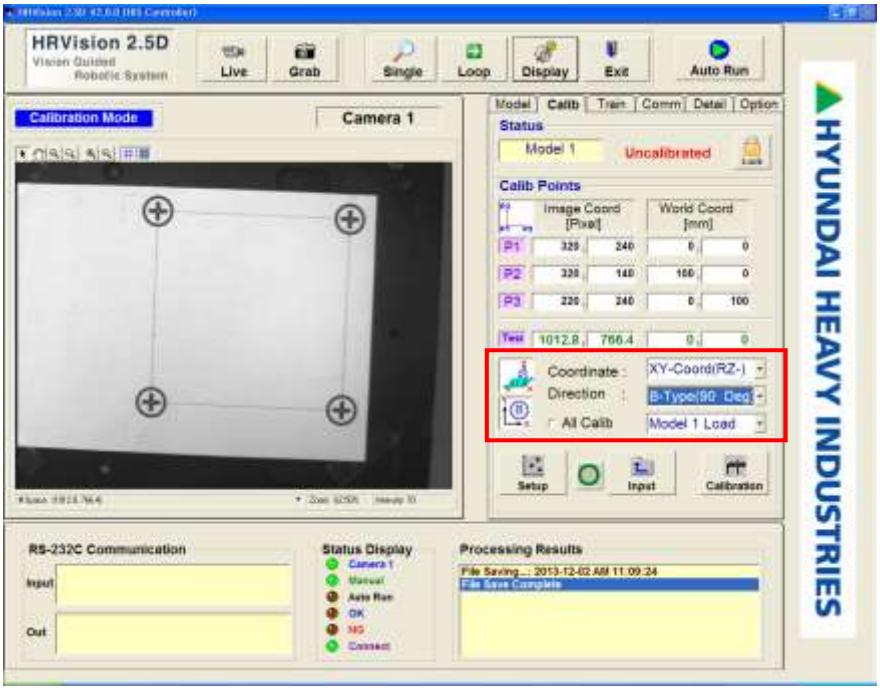


4.4.2.3. Grab Calibration Board Image

Click the "Calib" in the setup mode.
Click the "Grab" button among the manipulation buttons to acquire images including the calibration board.



Enter the camera direction for the robot coordinate. Refer to 3.7.2 “Calib” for details.

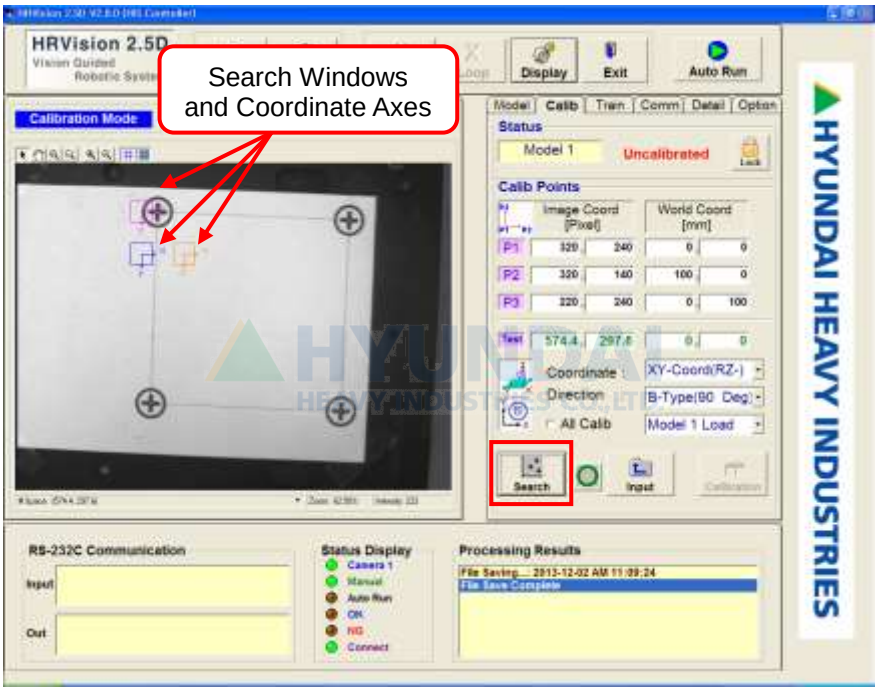


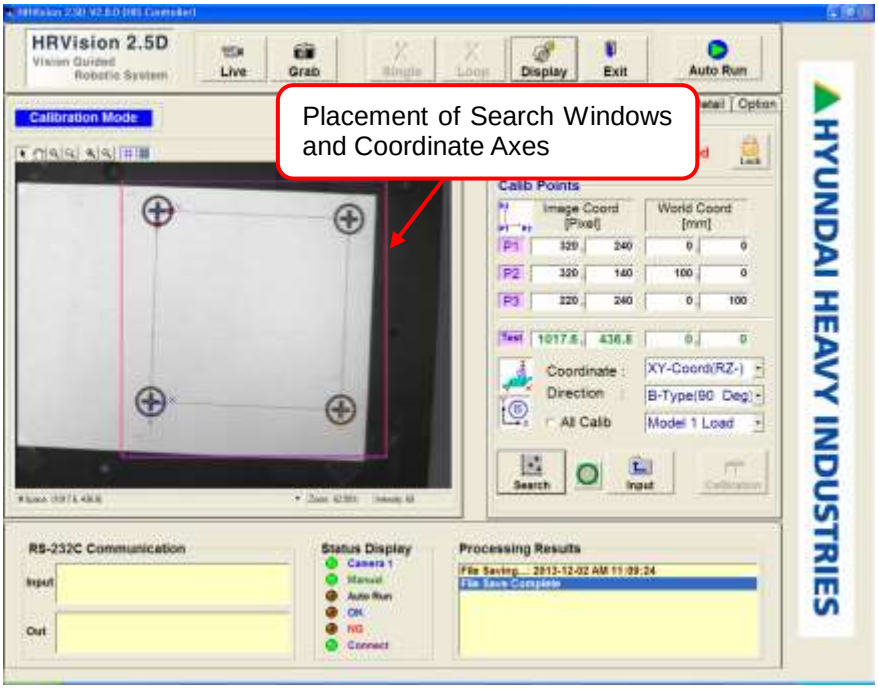
4.4.2.4. Detect Calibration Point and Enter Coordinate

To detect positions of calibration points from images, methods of calibration point pattern recognition and elliptical fitting can be used. Select either of the methods to fit the working condition, and set positions of image coordinates of the calibration points.

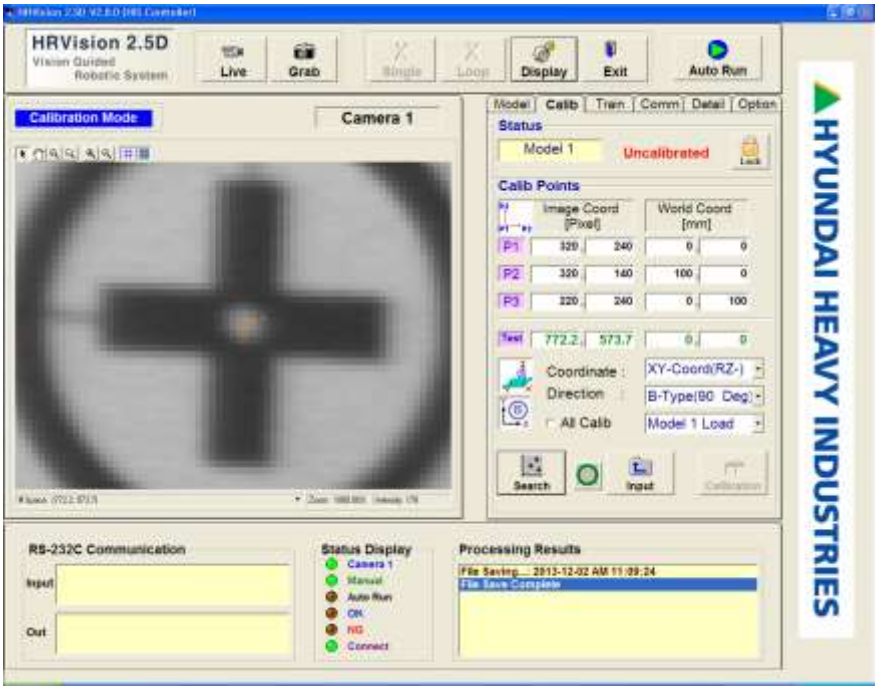
4.4.2.4.1. Method of Calibration Point Pattern Recognition

Click on the “setup” button of the “Calib” tab. In the image window, 3 search windows and coordinate axes are created, while the "Setup" button is changed to the "Search" button. Place the search windows and coordinate axes on the 3 points of the calibration board. At this time, the positions of the 3 points should be placed to fit the "Coordinate" and the "Direction" that have been set in advance.

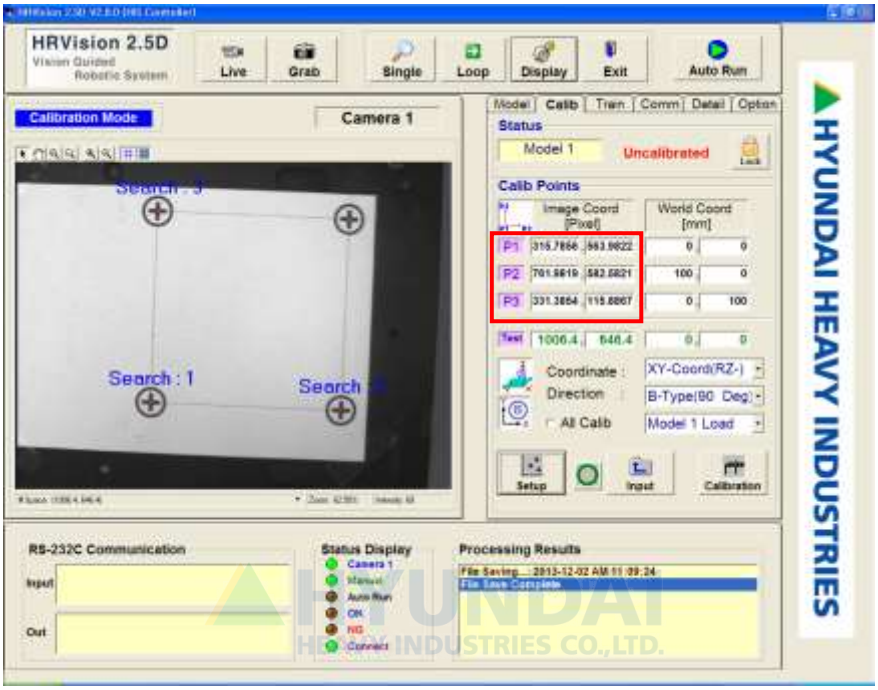




Click on the  (Zoom in) of the Image window to expand the calibration board image that has been grabbed.
Set the coordinate axis accurately at the center of the cross in the zoomed image. Click on the  (Move button) of the Image window to accurately set the coordinate axis for the remaining calibration points.

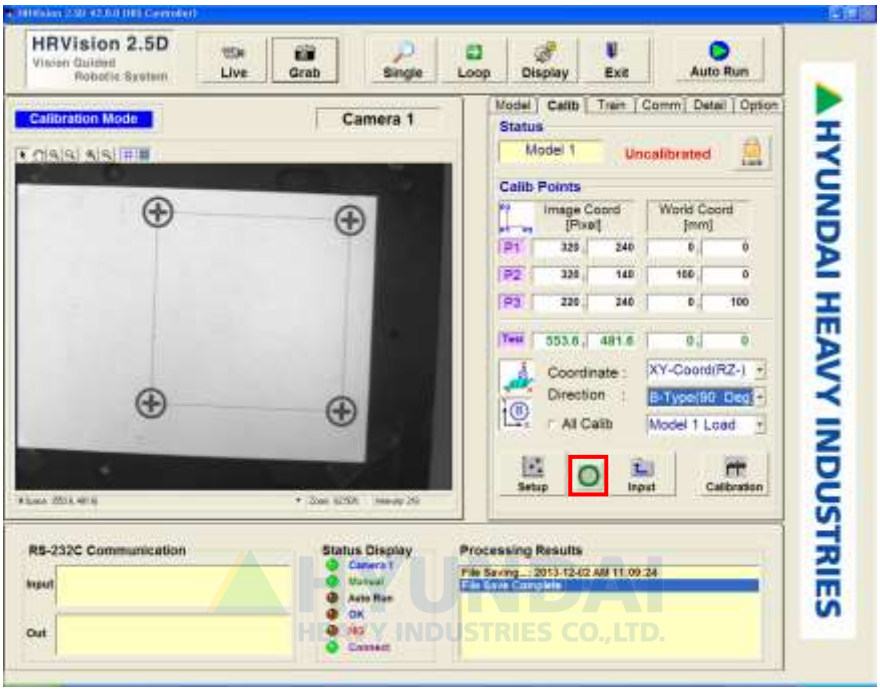


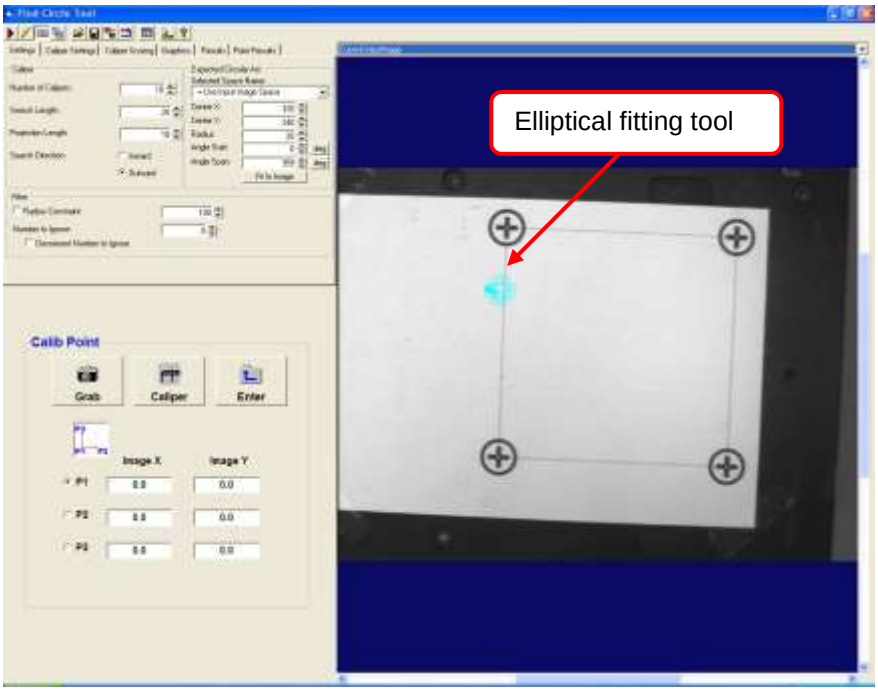
When the search window and coordinate axis are accurately set, click on the “Search” button of the “Calib” tab. The searched results are displayed in the Image window as follows. The “Search” button changes to the “Setup” button. If the search was unsuccessful, re-execute the 4.4.2.4.1 Calibration point detection process



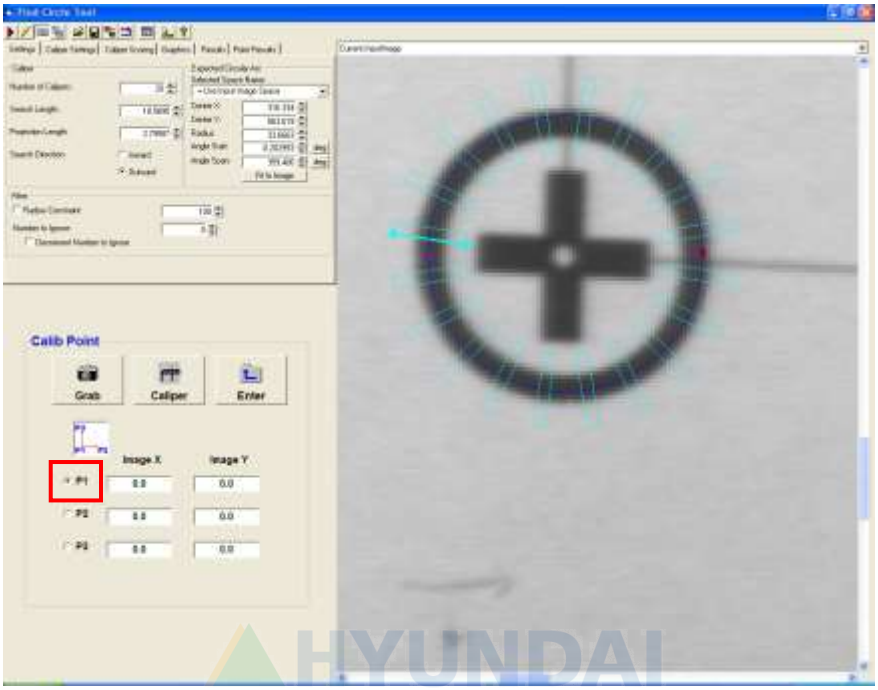
4.4.2.4.2. Elliptical Fitting Method

If you click the  button in the "Calib" tab, the "Find Circle Tool" dialog will be created as follows:

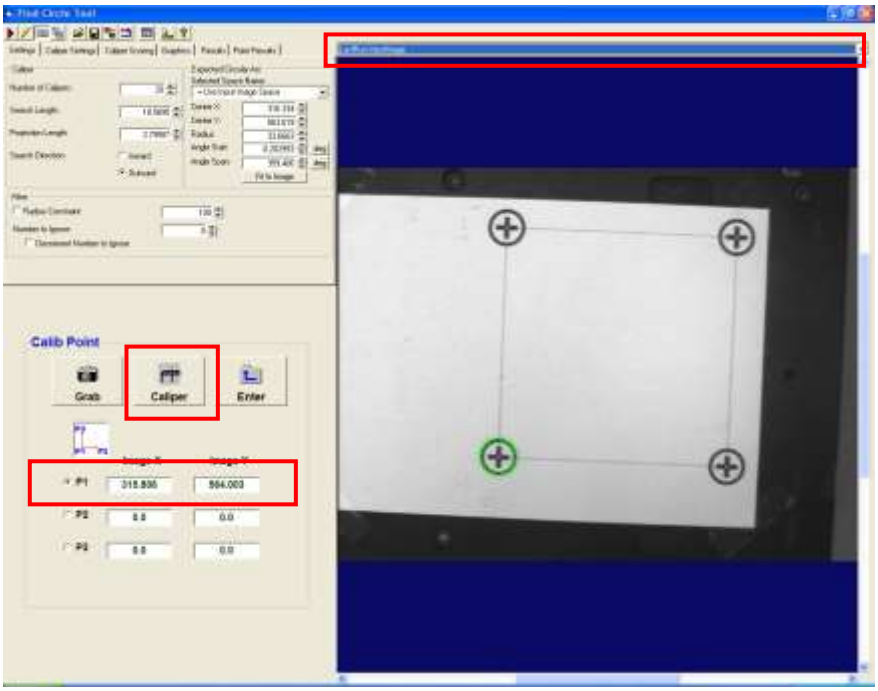




First of all, move the elliptical fitting tool to the P1 position of the image. Right-click on the image to enlarge it. move the correction position



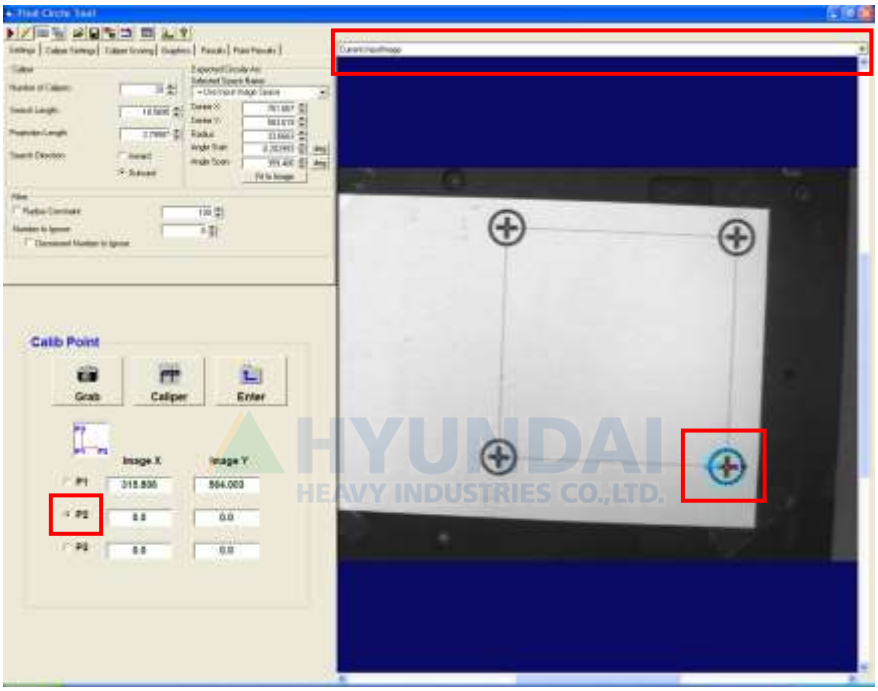
Click the "Caliper" button. The origin point of the measured ellipse is inputted in the X and Y editing box of P1.



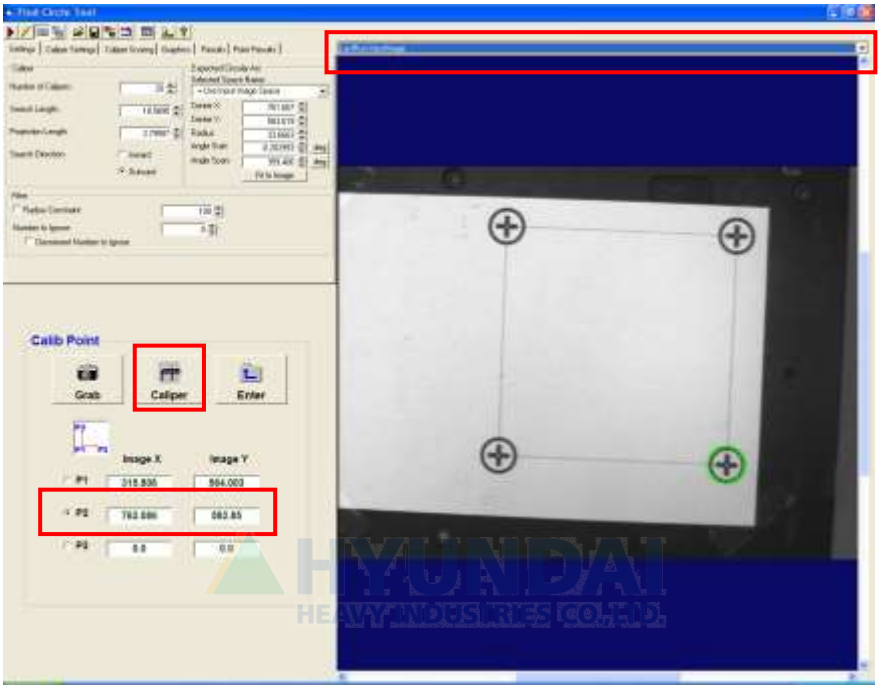
Click the combo box at the upper right part of the "Find Circle Tool" dialog, and select the "LastRun.InputImage". Check whether the outer points of the P1 circle, which are used for elliptical fitting, are correctly detected. If they are not correctly detected, configure the elliptical fitting tool again.

After completing elliptical fitting for the P1 position, perform the same process for P2, and P3.

First of all, click the radio button that corresponds to P2, click the combo box at the upper right part of the "Find Circle Tool" dialog, and select the "Current.InputImage".
Move the elliptical fitting tool to the circle that corresponds to P2 of the image.

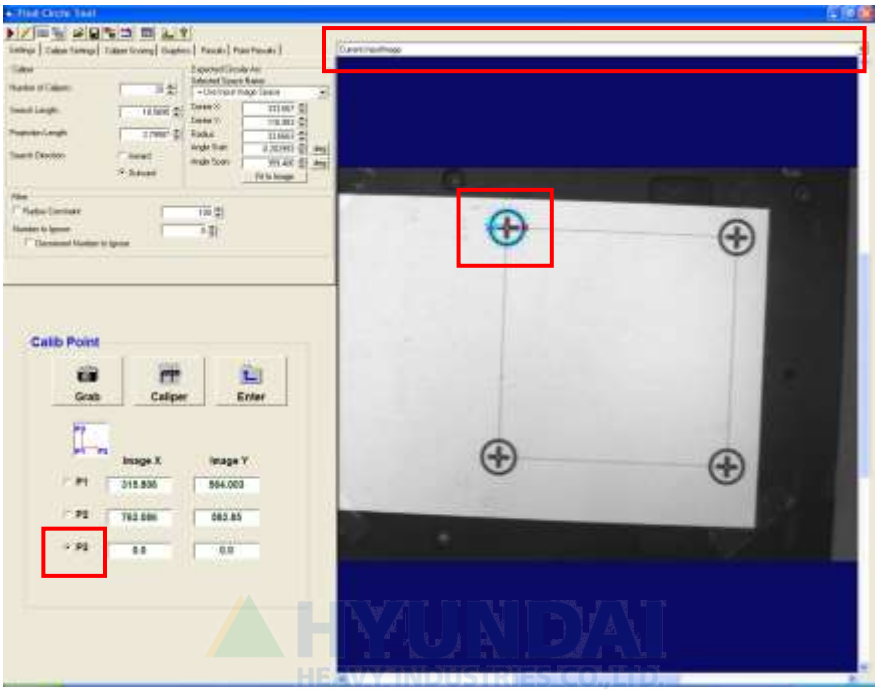


Click the "Caliper" button. The origin point of the measured ellipse is inputted in the X and Y editing box of P2.
Click the combo box at the upper right part of the "Find Circle Tool" dialog, and select the "LastRun.InputImage". Check whether the outer points of the P2 circle, which are used for elliptical fitting, are correctly detected.

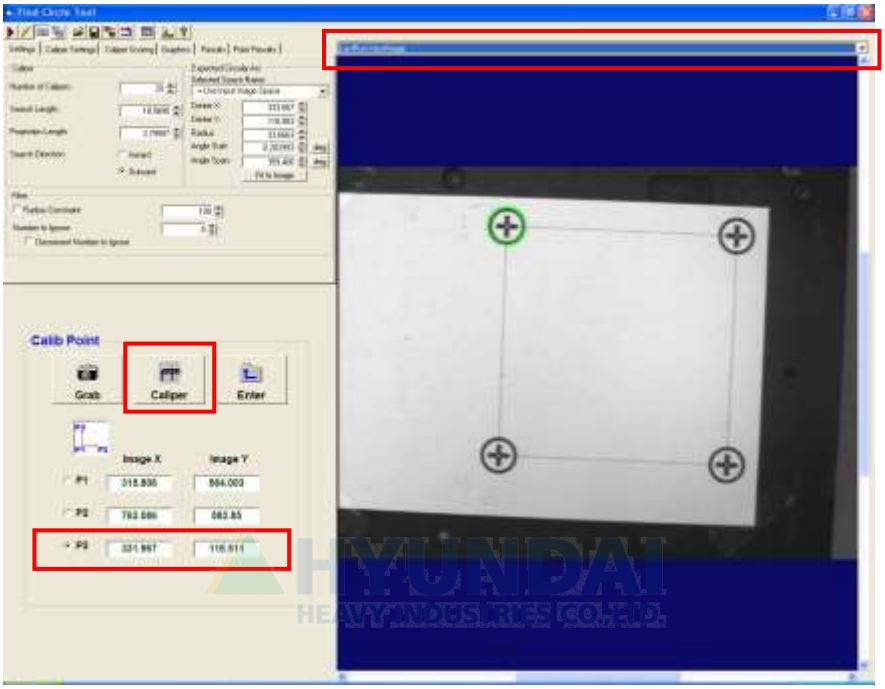


After completing elliptical fitting for the P1 and the P2 positions, perform the same process for P3.

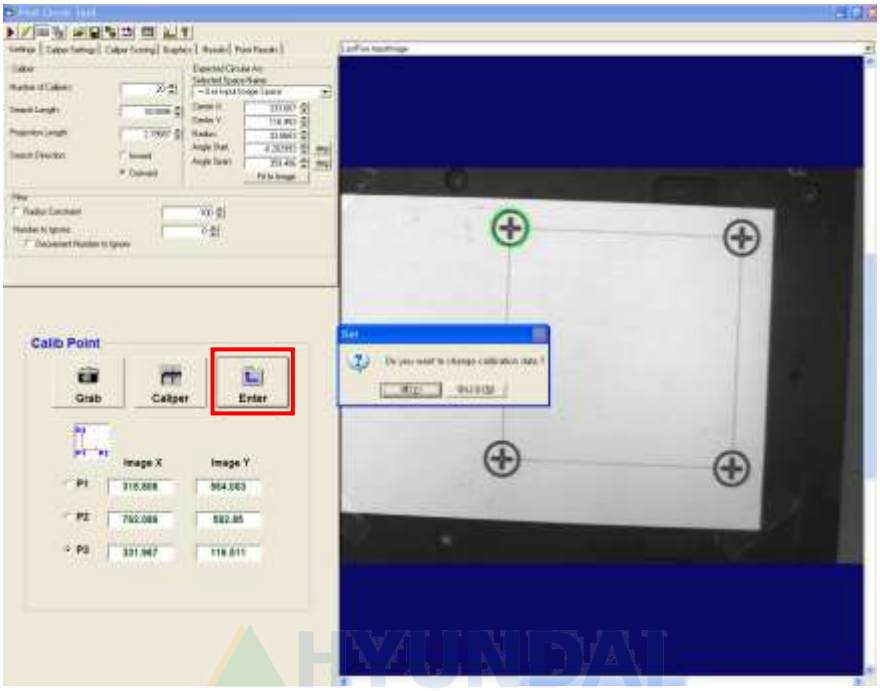
First of all, click the radio button that corresponds to P3, click the combo box at the upper right part of the "Find Circle Tool" dialog, and select the "Current.InputImage".
Move the elliptical fitting tool to the circle that corresponds to P3 of the image.

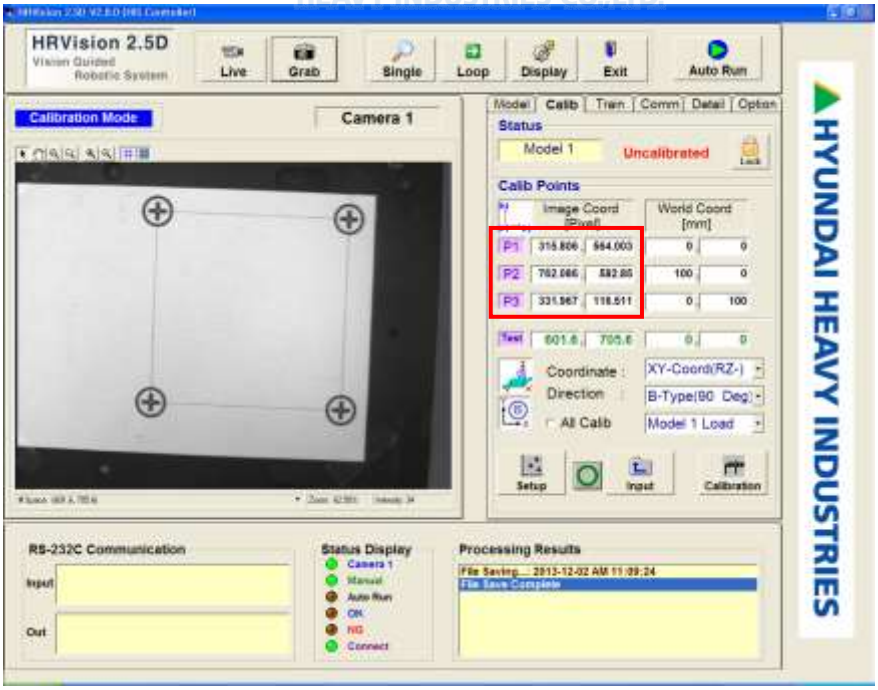


Click the "Caliper" button. The origin point of the measured ellipse is inputted in the X and Y editing box of P3.
Click the combo box at the upper right part of the "Find Circle Tool" dialog, and select the "LastRun.InputImage". Check whether the outer points of the P3 circle, which are used for elliptical fitting, are correctly detected.



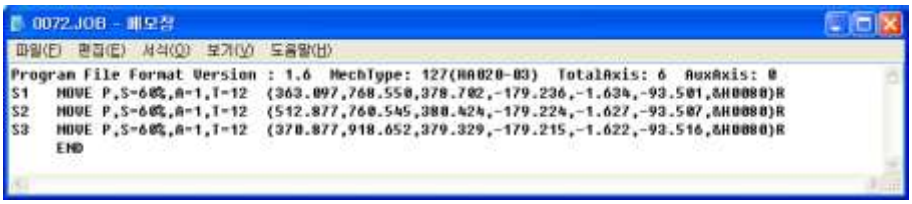
After completing elliptical fitting for P1, P2, and P3, click the "Enter" button, and input data in the "Image Coord" item of the "Calib" tab.

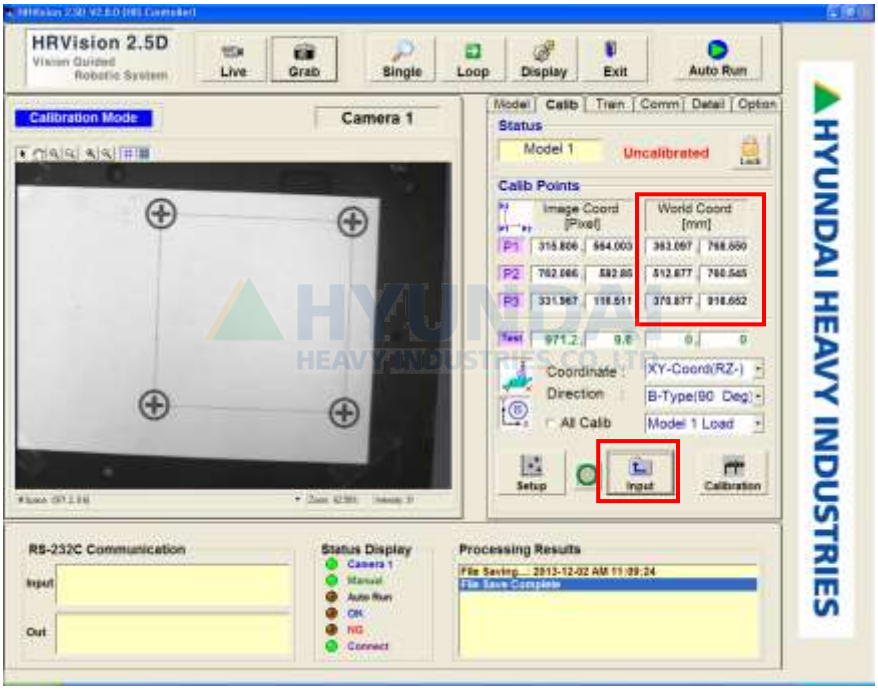




4.4.2.5. Robot Coordinate Setup

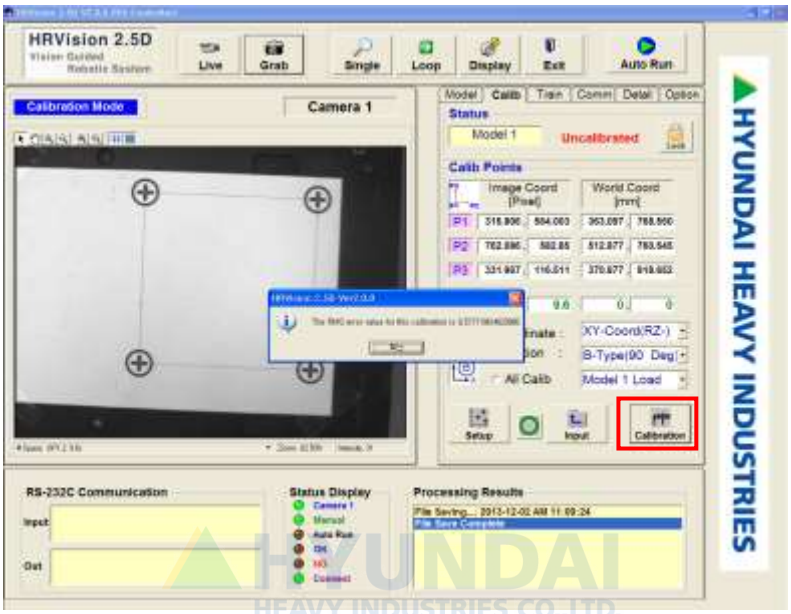
If the positions of the calibration points have been entered in the robot operation program under 4.4.2.2, input data for P1, P2, and P3 with the keyboard in the "World Coord" item of the "Calib" tab, and click the "Input" button of the "Calib" tab. The next figure shows an example of the robot coordinates input under XY Coord (RZ-), and B Type (90 deg).



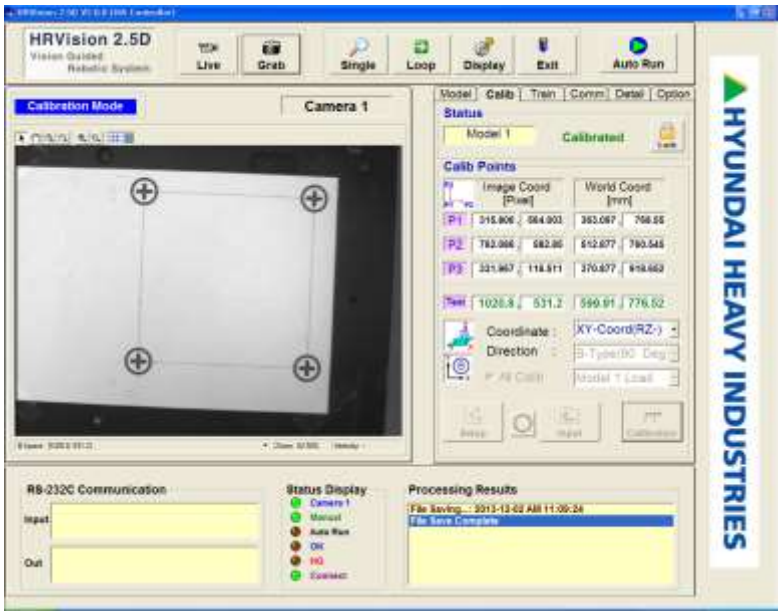


4.4.3. Camera Calibration Execution

If both the image coordinate and camera coordinate of the calibration points are all entered, click on the “Calibration” button of the “Calib” tab. This shows the RMS results after executing the camera calibration.

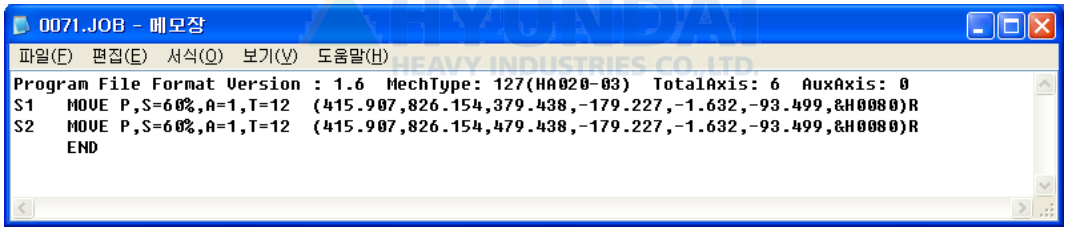


If RMS error is smaller than the "RMS Error Limit" of the "Detail" tab under 3.7.5, the "Setup", the "Input", and the "Calibration" buttons will be activated, and the calibration will be completed.
If RMS error is bigger than the "RMS Error Limit" of the "Detail" tab under 3.7.5, a warning dialog will appear and direct the user to perform camera calibration again. Typically, the "RMS Error Limit" is set at 1.



4.5. Blank Hold Location Teach

Place the workpiece on the palette, calibrate the Hyundai robot, and enter in the robot operation program the position to grip the target.

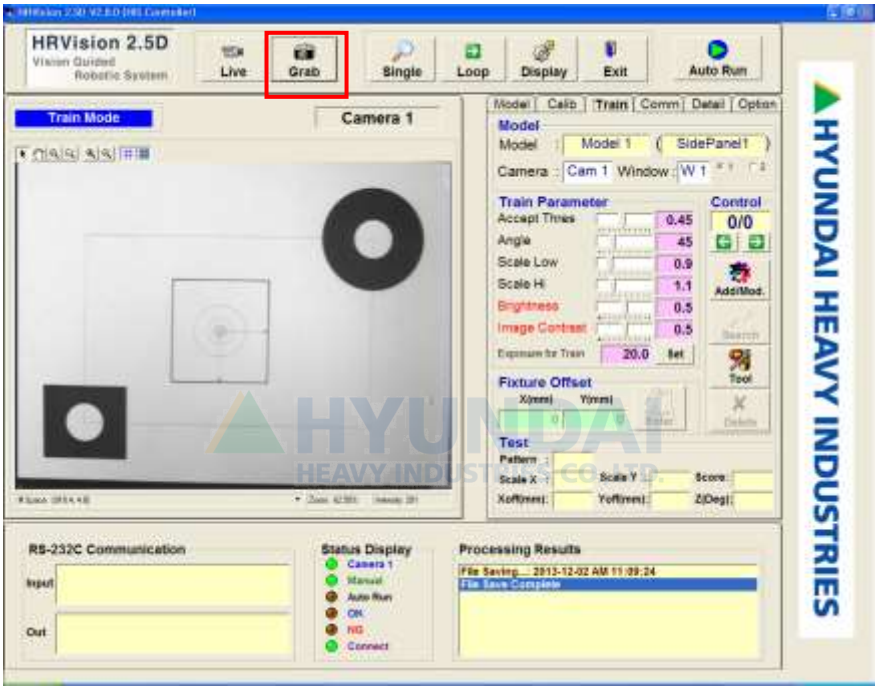


4.6. Model Pattern Addition and Pattern Recognition Test

Register all patterns for pattern recognition and execute the pattern recognition test.

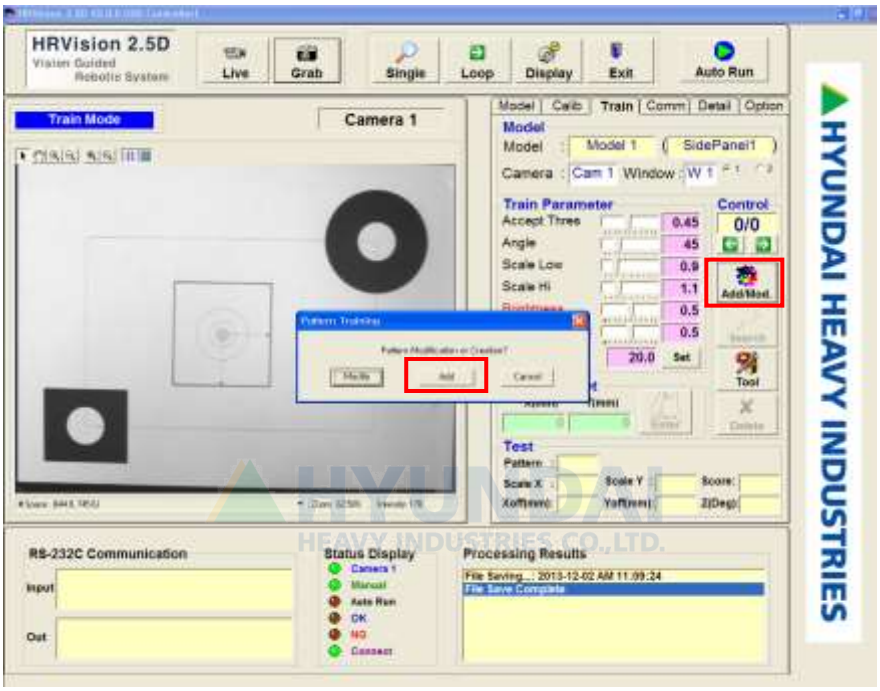
4.6.1. Grab Image

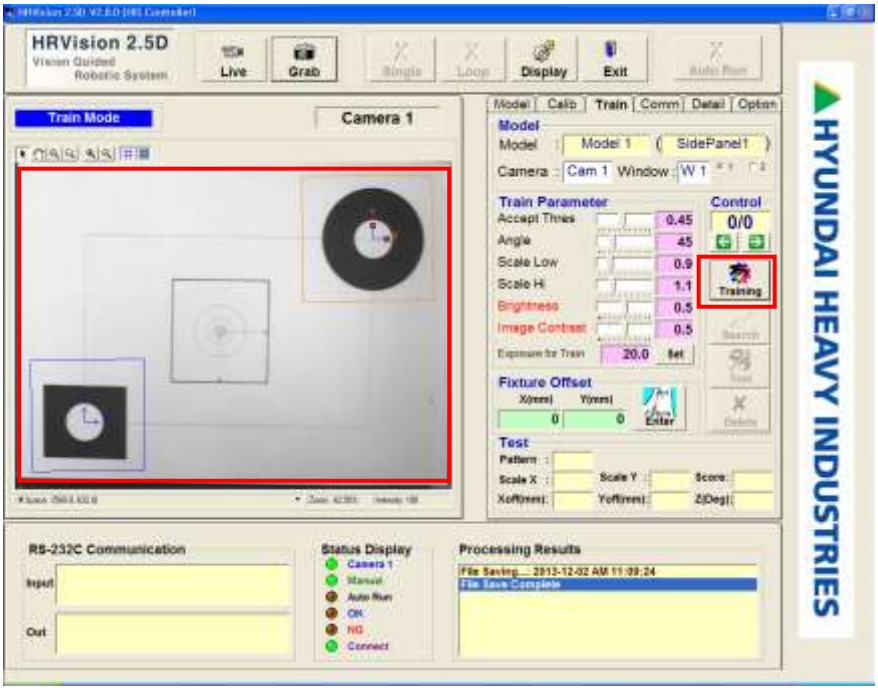
Move the Hyundai robot to a position which cannot be seen in the image. At this time, the workpiece should not be moved.
Click on the “Train” tab from the Setup mode, and click on the “Grab” button of the operation buttons.



4.6.2. Pattern Addition

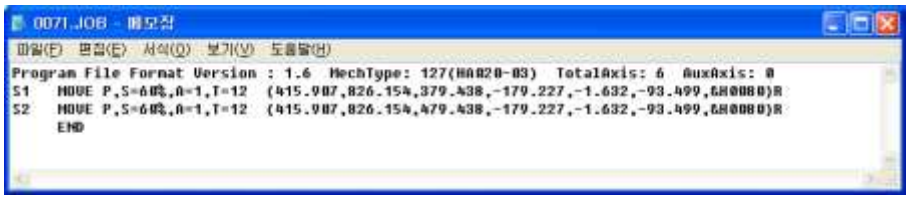
Select the characteristic to easily distinguish each model as a pattern.
Considering the visual area of the camera (FOV), accuracy required for the work etc., select eh characteristic pattern. Click on the “Add/Mod” button of the “Train” tab. At this time, pattern setup window and coordinate axis are displayed in light blue in the Image window, and the “Add/Mod” button switches to “Training” button.

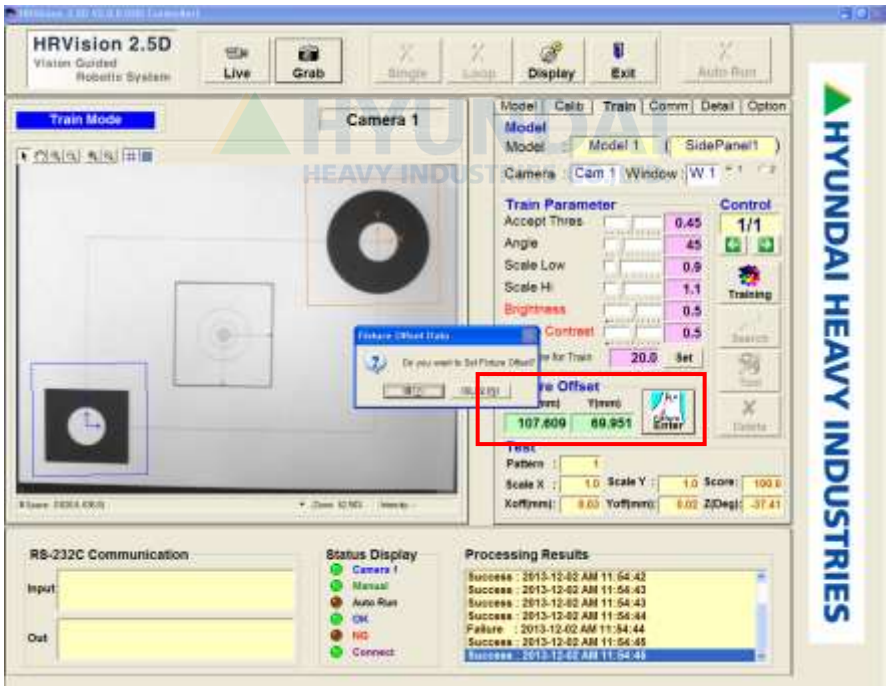




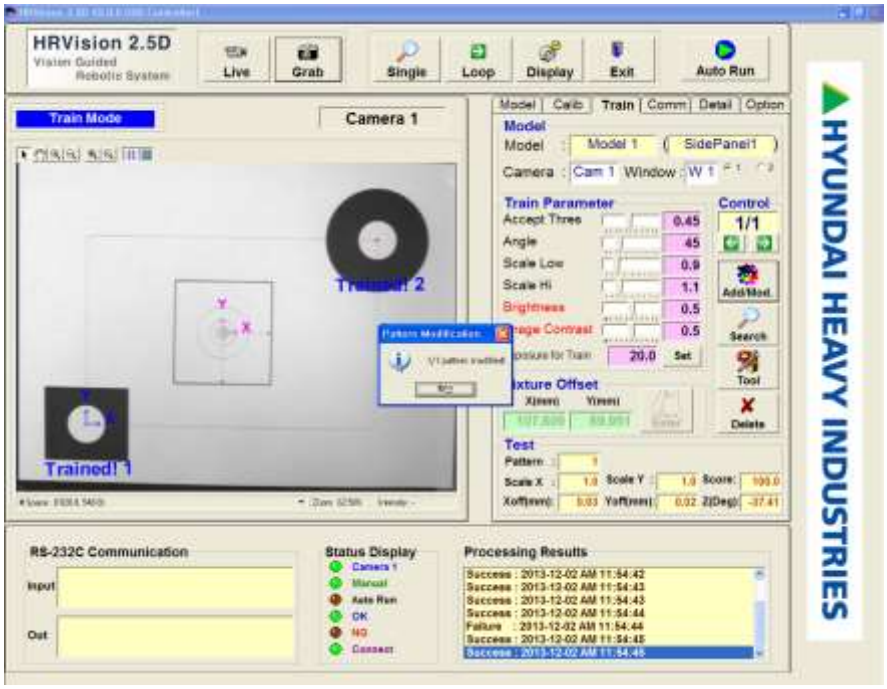
4.6.3. Fixture Offset Setting

Set the relative distance between the origin point of the pattern to be registered and the grip point at which actual work will be performed. Input the difference in the actual distance between the "calibration point of the position to grip the target" under 4.5. and the "origin point of Pattern 1", and click the "Enter" button.
There are two methods of finding out the position of the "origin point of Pattern 1". The first method is to calibrate the origin point of "Pattern 1" through robot calibration, and input the position based on the robot coordinates system.
If camera calibration has been completed, the second method can be utilized. This method is to use the "Test" function of the "Calib" tab under 3.7.2 to find out the position that corresponds to the mouse cursor based on the robot coordinates system.

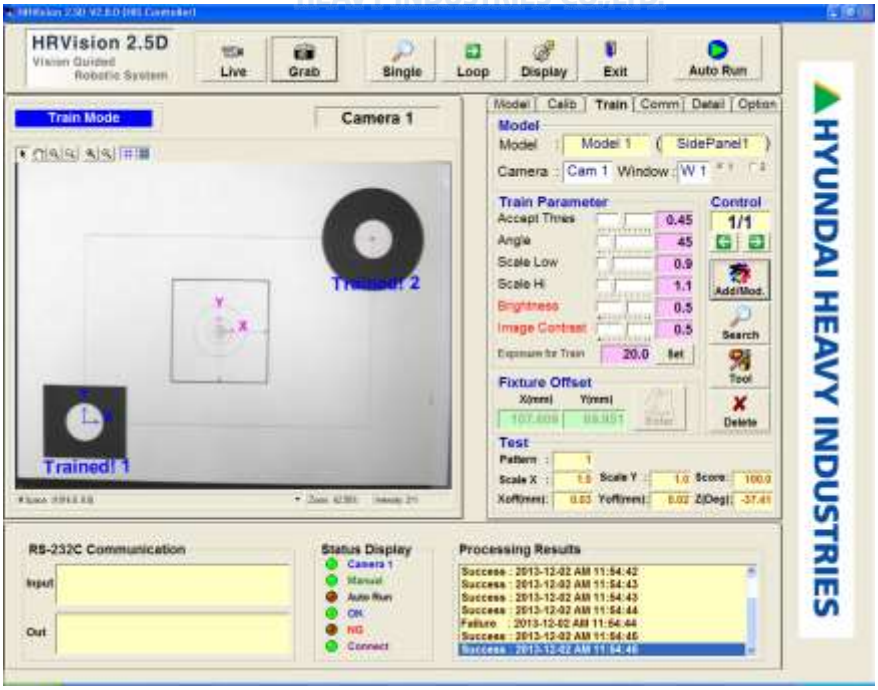




After setup up the pattern setup window and coordinate axis, click on the “Training” button. When the pattern recognition is successful, the following Pattern addition window appears. If there is an error in the pattern recognition, reset the pattern and parameter. Refer to 3.7.3 “Train” tab for parameter setup.

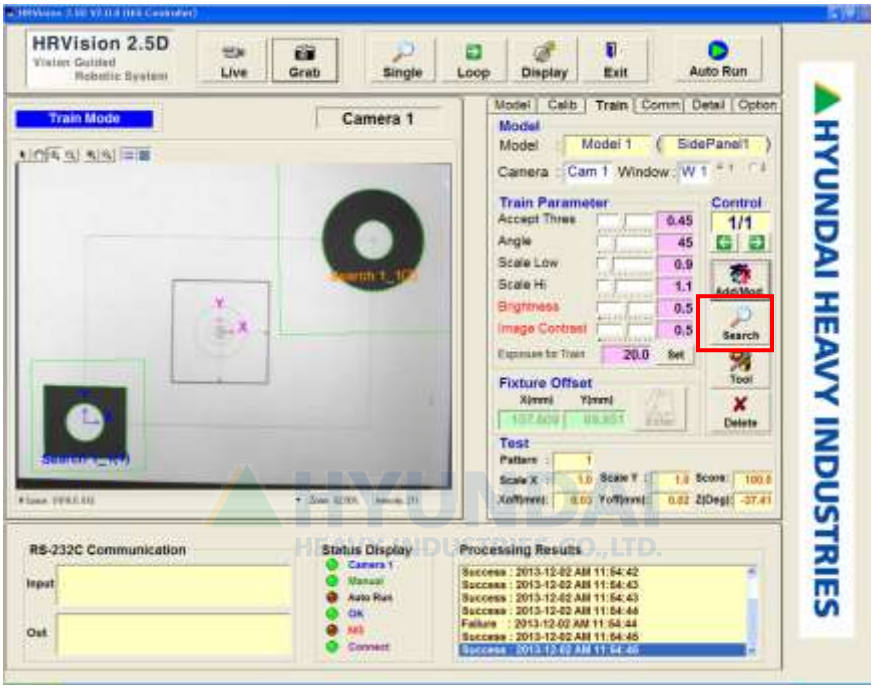


At this time, the origin point of the pattern set under 4.6.2 will be displayed in blue-colored coordinate axis, while the origin point set through Fixture Offset will be displayed in magenta color.



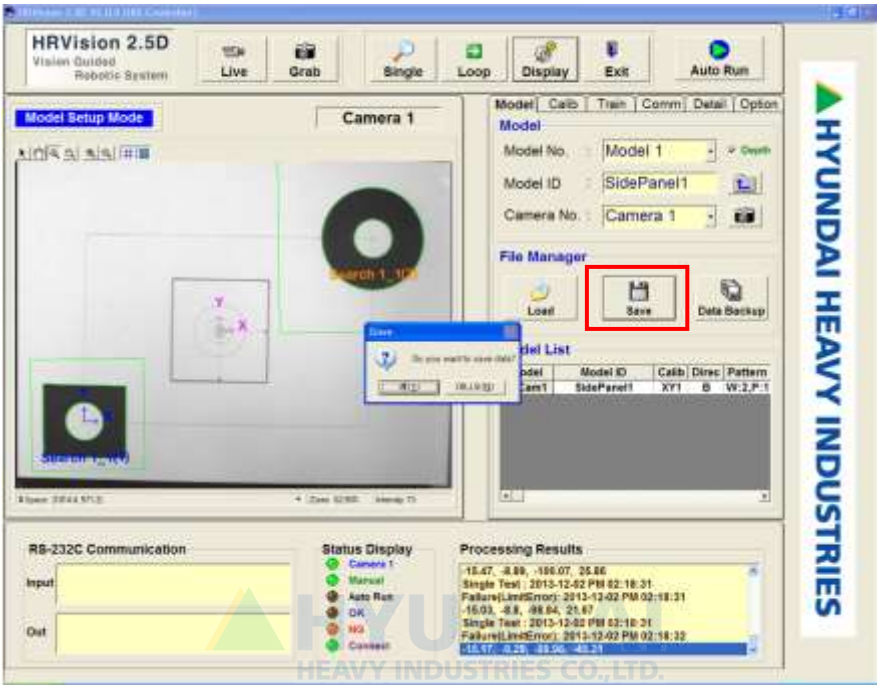
4.6.4. Pattern Recognition Test

Execute the pattern recognition work for the specific added patterns by grabbing the image.
Click on the “Search” button of the “Calib” tab. The pattern recognized area will be displayed in the image window, and the pattern recognition result is displayed for the Test item. View the pattern recognition result and decide whether to Add/Mod./Delete to setup the optimal pattern model. Refer to 3.7.3. “Train” tab for detail setup method.



4.6.5. Data File Saving

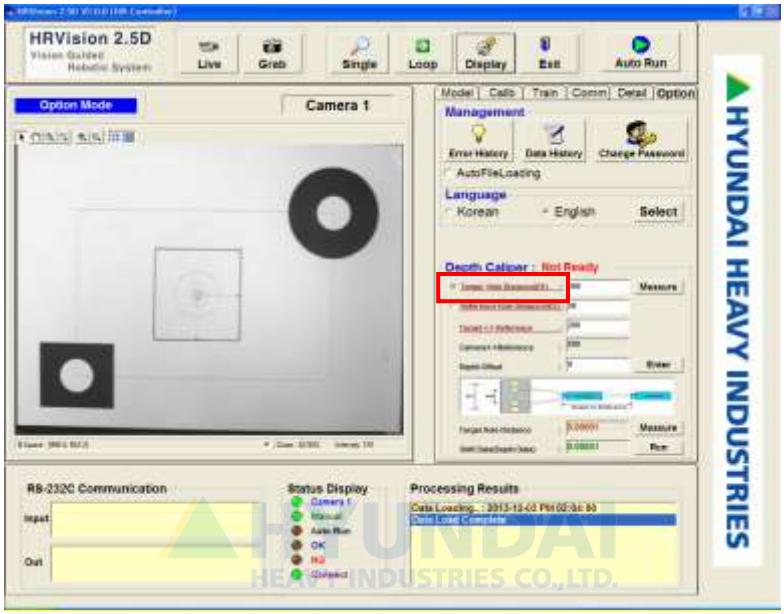
Click the "Save" button of the "Model" tab, save the registered pattern and configuration data into file.



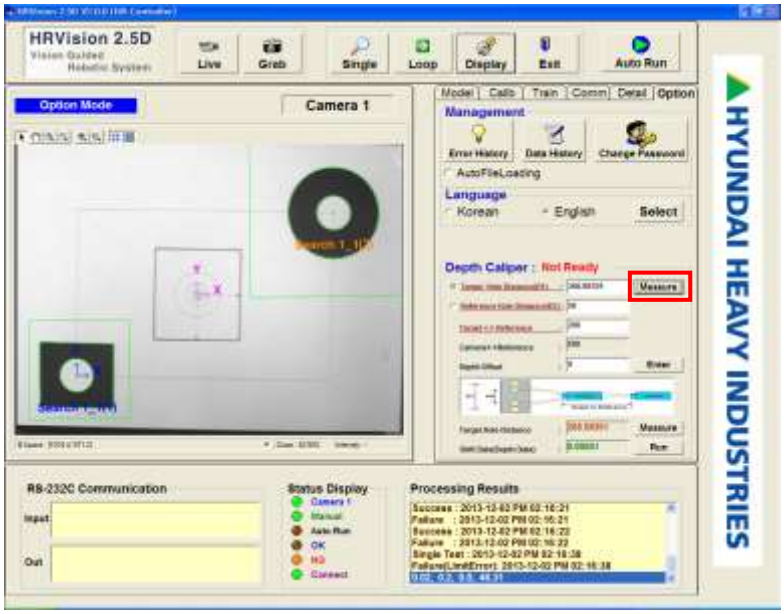
4.6.6. Depth Caliper Function Setting

Click the "Option" tab. Place the robot at the position for image acquisition, and click the "Grab" button of the manipulation buttons to acquire images.

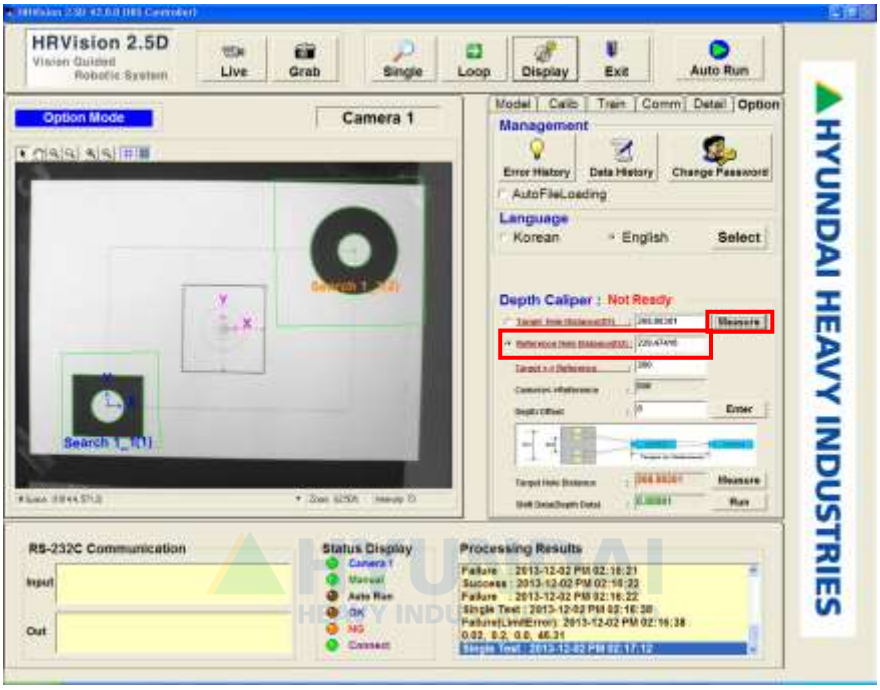
Click the "Target Hole Distance (D1)" radio button of the "Depth Caliper".



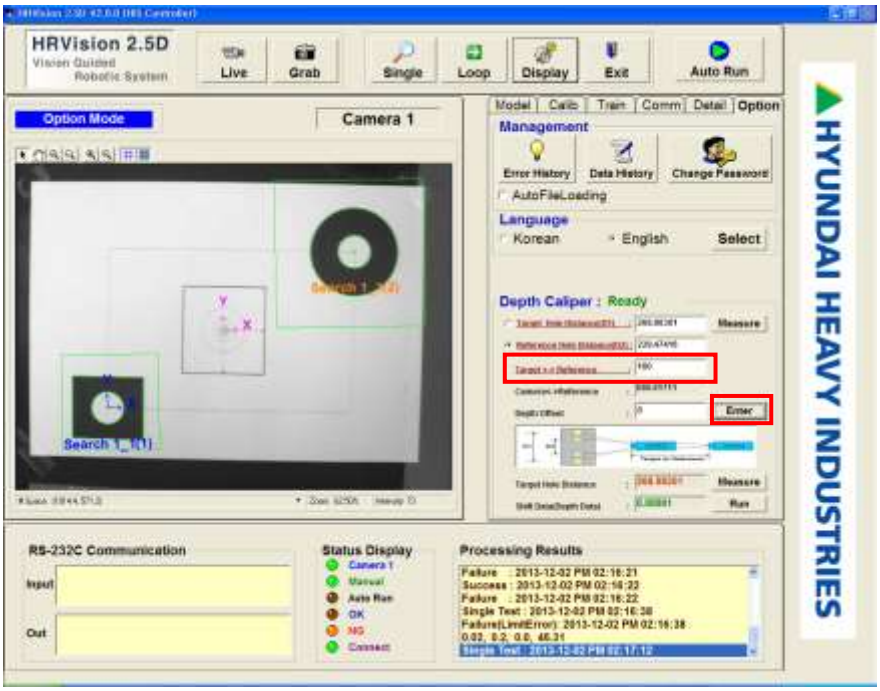
If you click the "Measure" button, pattern recognition process will be performed as shown in the following figure, and the pixel distance between the two origin points of the recognized patterns will be calculated.



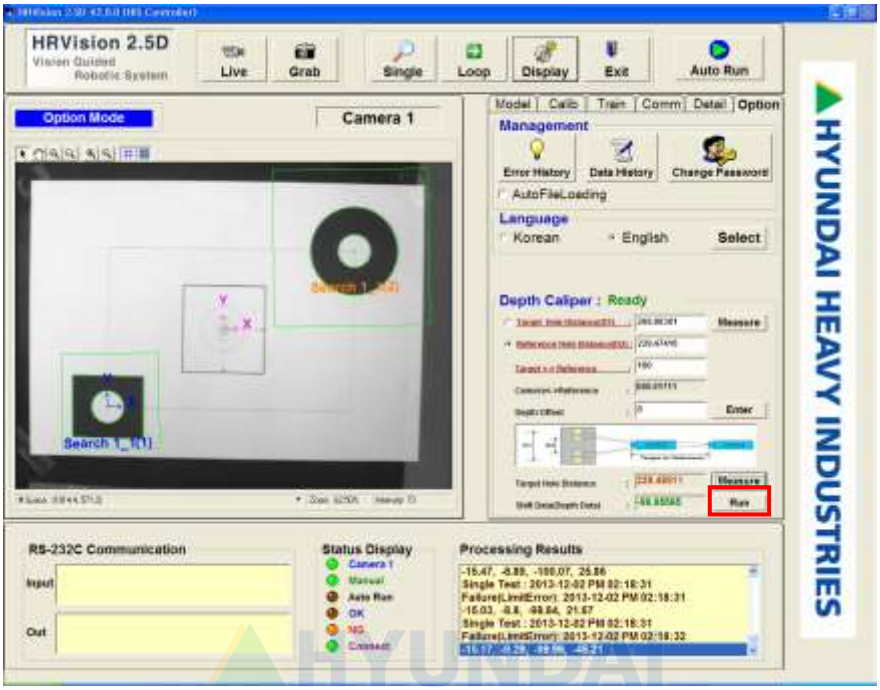
Next, shift the robot so that the distance between the robot and the target can increase by a certain amount. In this example, it was shifted +100mm in the direction of the distance.
Click the "Reference Hole Distance (D2)" radio button of the "Depth Caliper".
If you click the "Measure" button, pattern recognition process will be performed, and the pixel distance between the two origin points of the recognized patterns will be calculated.



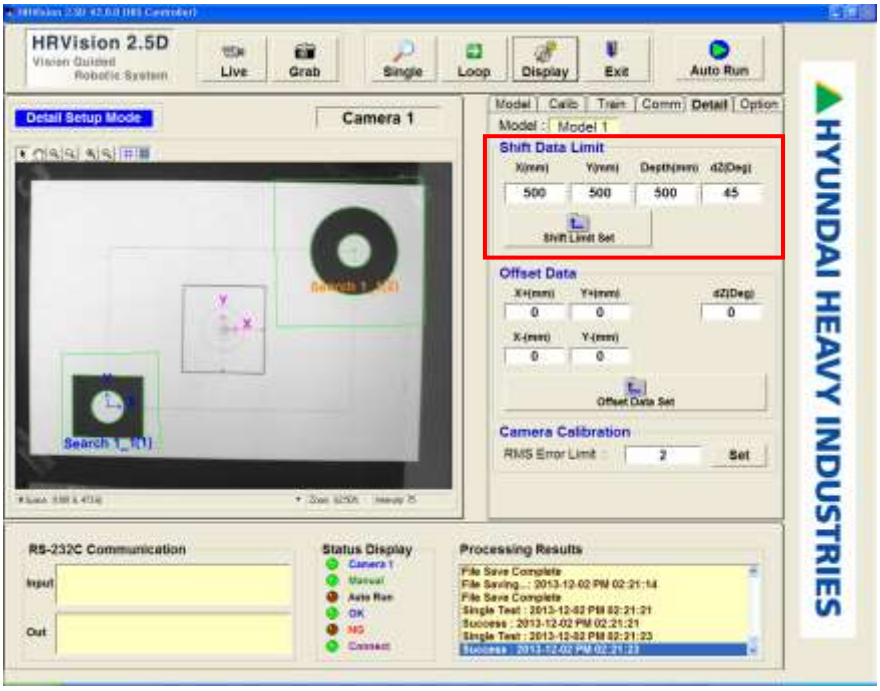
Input the actual shift distance of the robot (100mm) in the "Target<->Reference" item, and click the "Enter" button.



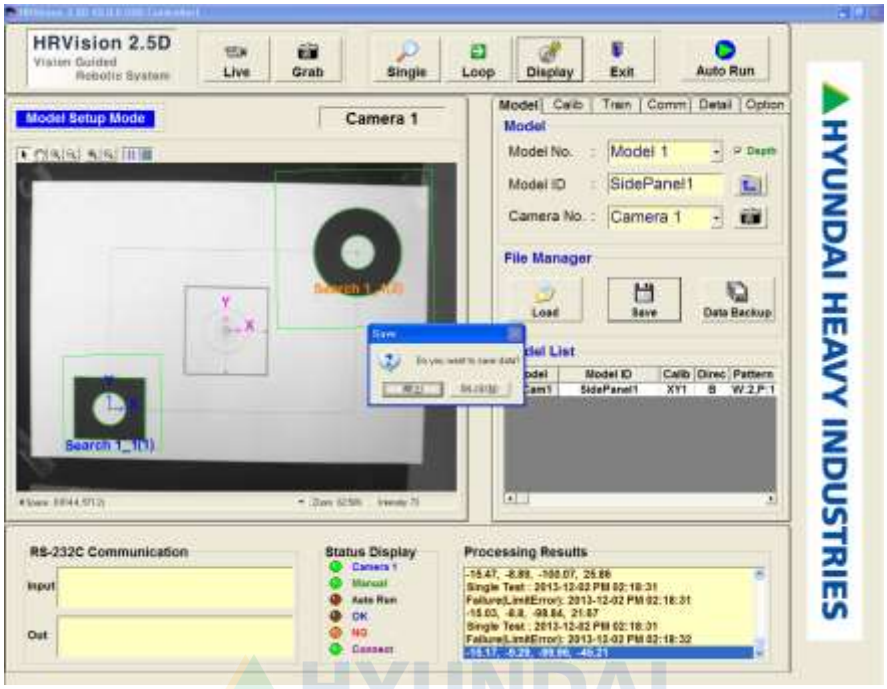
Click the "Run" button, and check whether the "Shift Data (Depth Data)" is measured in the negative sign distance (100mm) in which the robot has been actually shifted.



Input the "Shift Data Limit" of the "Detail" tab to fit the process, and click the "Shift Limit Set" button.



Click the "Save" button of the "Model" tab, and save the setting.



4.6.7. Setup mode Completion

Click the "Display" button in the manipulation button window to complete the setup mode.
If you click the "Display" button, the following dialog box will be displayed.

The buttons on the dialog box have the following functions:
- Save and Exit Setup Mode:
  This re-executes file saving, and changes the system to the display mode.
- Exit Setup Mode:
  This changes the system to the display mode without re-executing file saving.
- Cancel: This cancels change to the display mode.

4.6.8. Recognition performance test

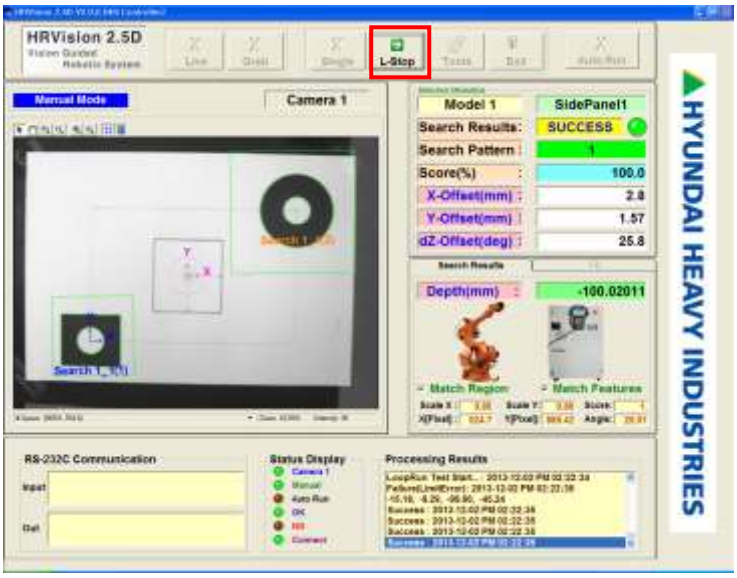
Execute the pattern recognition work by using all added pattern and display the pattern recognition result.

4.6.8.1. Single (Inspection) Execution

Click on the “Single” button from the operating button and execute the pattern recognition work once.

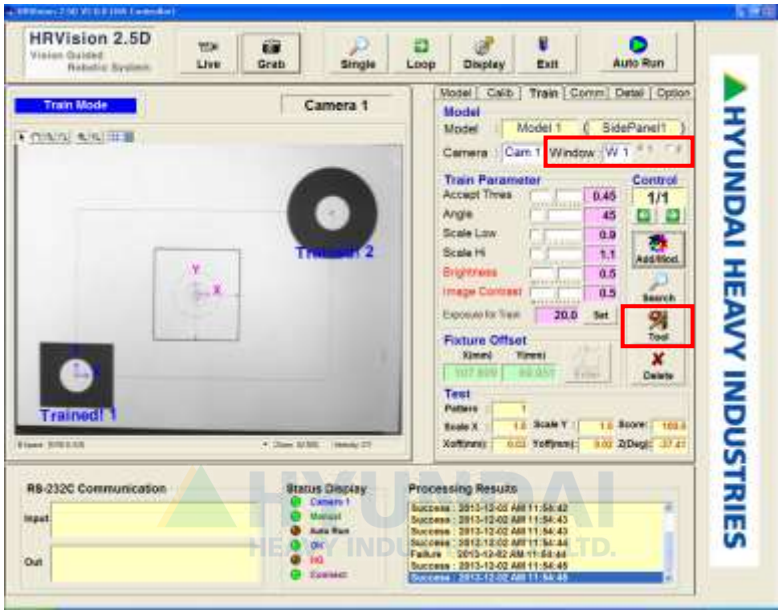
4.6.8.2. Continuous inspection Execution

Click on “Loop” from the operating button, and execute the pattern recognition work continuously for the inputted image until the “L-Stop” is clicked.

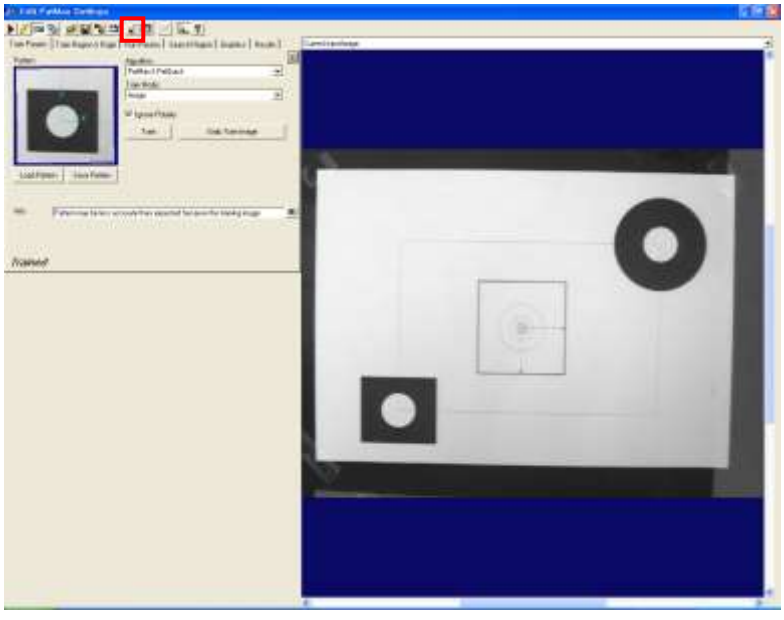


4.6.9. Model Pattern Supplement

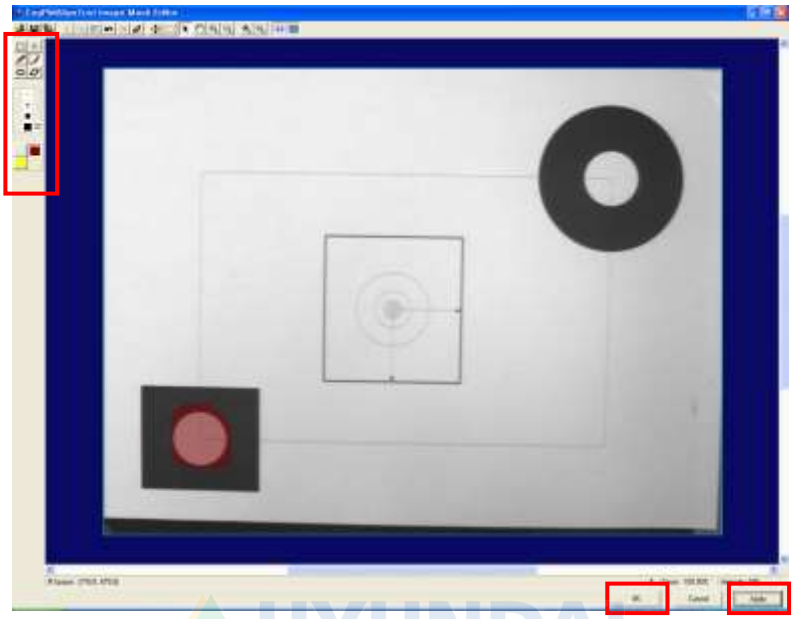
Do not “Add/Mod./Delete” the pattern depending in the inspection result. Also you can mask the added pattern in detail by using the “Tool” of “Train” tab of Setup mode. In measuring depth, since 2 patterns have been registered, select the pattern to supplement by selecting one by the "Window Radio Button 1/2" in the first place.
First of all, click the "Window" radio button 1.



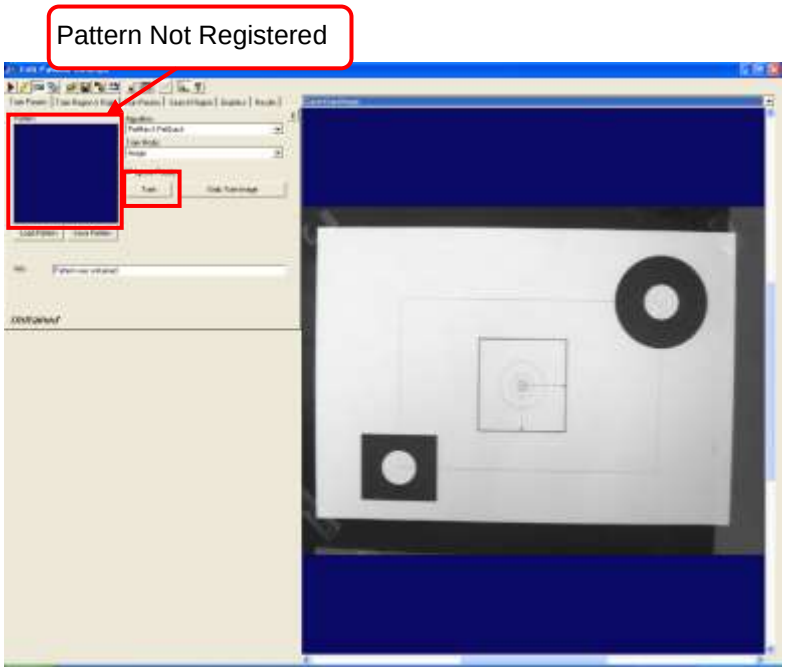
The next figure shows the "Masking Editor" which has been called by clicking the "Masking" icon () in the "Edit PatMax Setting" dialog box created with the clicking of the "Tool" button of the "Train" tab for the "Window 1" pattern .

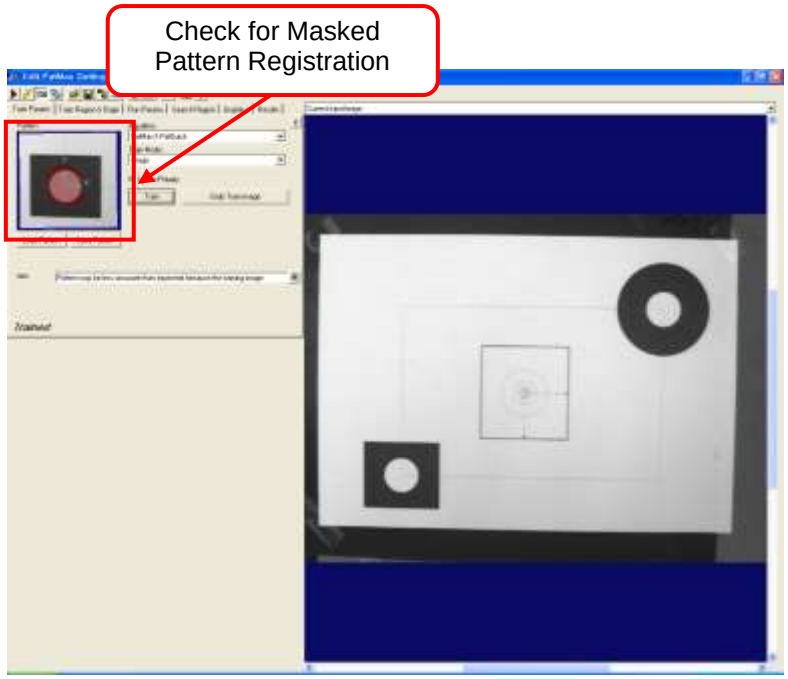


Select brush color, size, etc., to select the area to be masked. The brown-colored area in the following figure shows the masked area. After the completion of masking, click the "Apply" button, then the "OK" button.



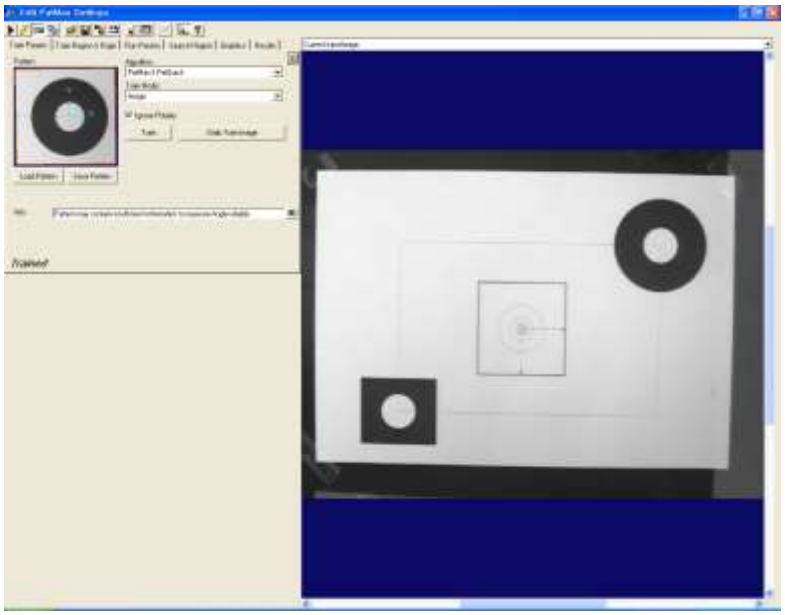
Since a masked pattern will not be learned automatically, click the "Train" button in the "Edit PatMax Setting" dialog box to make the system learn the masked pattern.



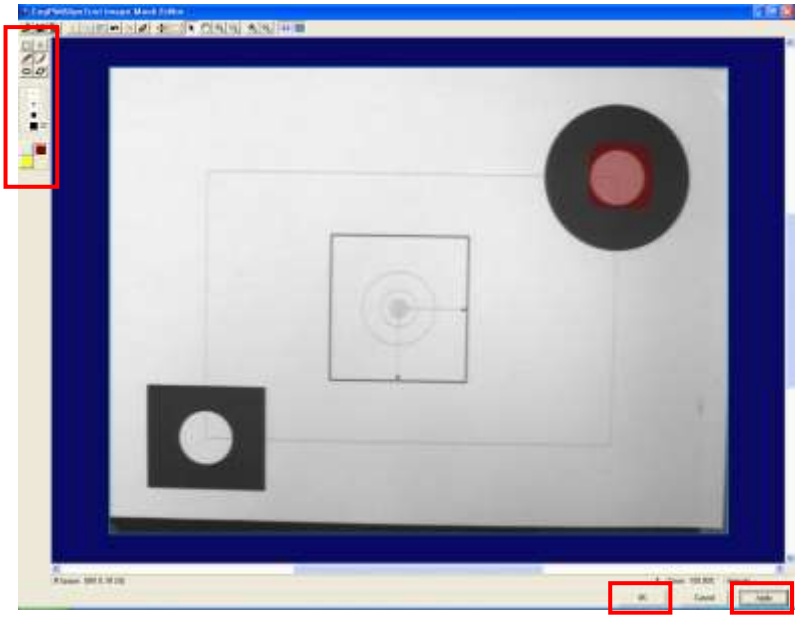


Close the "Edit PatMax Setting" dialog box, and click the "Save" button of the "Model" tab to save the setting data.

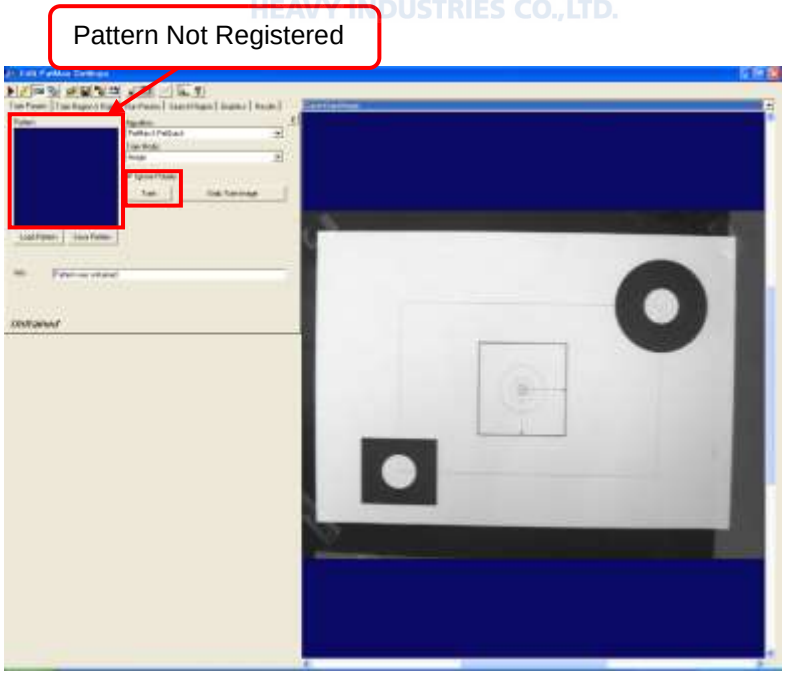
For the "Window 2" pattern, apply the masking function in the same way as that for the "Window 1" pattern. Click the "Window Radio Button 2" of the "Train" tab. In the "Edit PatMax Setting" dialog box created with the clicking of the "Tool" button, click the "Masking" icon ( ) to call the "Masking Editor".

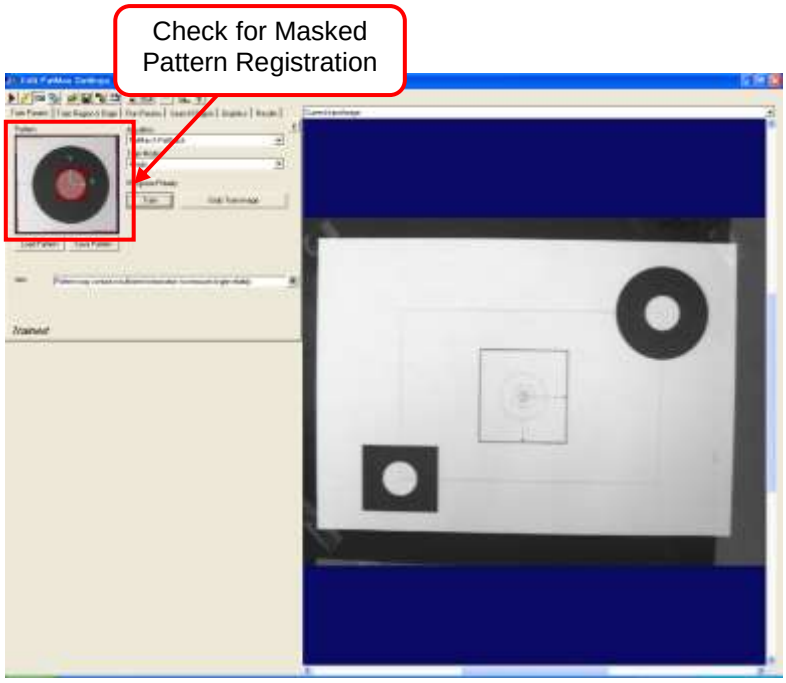


Perform masking on the registered pattern, click the "Apply" button, then the "OK" button.

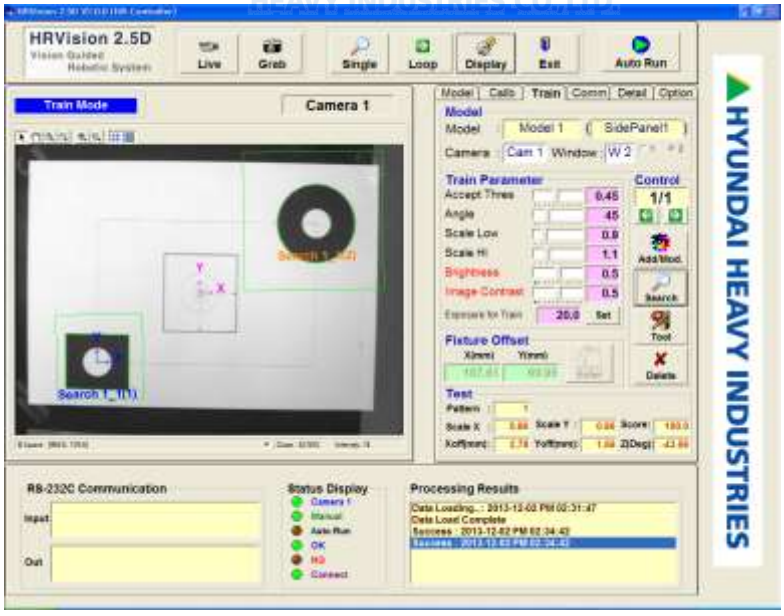


Since a masked pattern will not be learned automatically, click the "Train" button in the "Edit PatMax Setting" dialog box to make the system learn the masked pattern.





For the modified masking pattern, click the "Search" button of the "Train" tab to check recognition performance.



Click the "Save" button of the "Model" tab, and save the current vision setting.

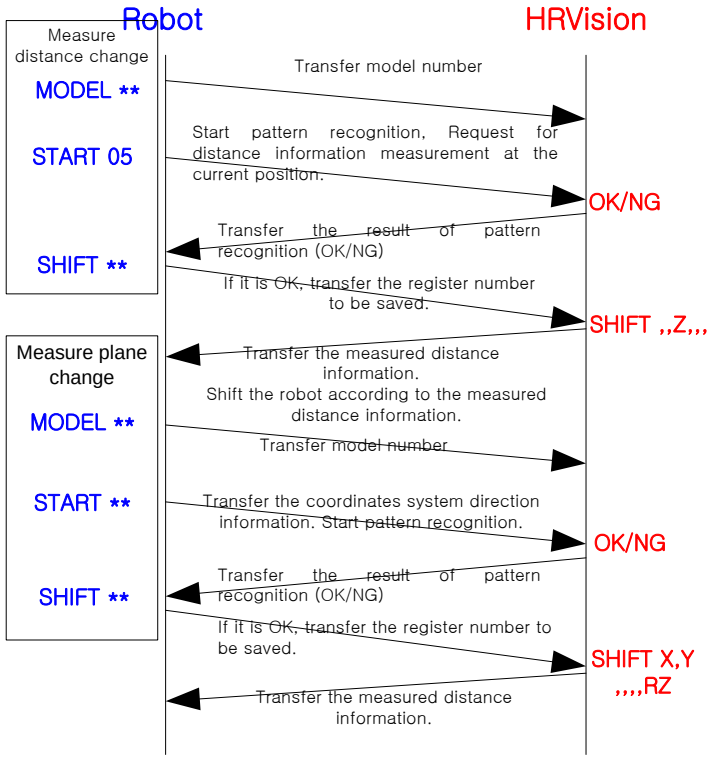
4.7. Robot Work Program Preparation

4.7.1. Communication protocol

HRVision 2.5D and Hyundai Robot controller transmits/receives data in accordance with the communications protocol as follows. The user prepares the robot work program in accordance with the communication protocol.
The communication is done by the request of Hyundai Robot. There are 3 types of commands that the robot requests to HRVision 2.5D. The following table is a summarized table of the HRVision 2.5D correspondence for the 3 types of commands of Hyundai Robot.

Command	Number	Function	HRVision 2.5D correspondence
MODEL	**01~99**	Transmit model information.	Saves model information to parameter and stands by.
START	**01~05**	Transmit camera direction to grab image.	Execute pattern recognition work and transmit the result to Hyundai Robot in OK/NG.
SHIFT (SREQ)	**01~08**	Designate the registry number of Hyundai Robot controller to save the SHIFT data.	Prepare the location shift in the format of format of "SHIFT X,Y,Z,θX, θY, θZ"and transmit to Hyundai Robot. In sending START command, if No. 5 is inputted, only the distance information will be sent.

The following figure depicts the communication sequence between Hyundai Robot and HRVision 2.5D.



4.7.2. Robot Work Program

The following code is an example of a robot work program that is interlocked with the vision system by utilizing RS 232 communication of an Hi5 controller. Add the following code to the communication part with HRVision 2.5D.

```
        ' P1, P2 : Robot grip point
        P1=(X1,Y1,Z1,RX1,RY1,RZ1,CFG) ‘Upper side of the grip point
        P2=(X2,Y2,Z2,RX2,RY2,RZ2,CFG) ‘Grip point
        R1=(0,0,0,0,0,0)R
        R8=(0,0,0,0,0,0)R
        CLR232C 2          ‘COM2 Port Buffer Clear
        _TEINPUT=13        ‘Carriage Return
        _TEINPUT=10        ‘Line Feed
        V1$=""
        V2$=""
S1      MOVE P,S=100%,A=0,T=1‘Robot standby position
        V3$="MODEL 01"
        PRINT #2,V3$
        DELAY 1
        V4$="START 05"   ‘Depth Calculation
        PRINT #2,V4$
        INPUT #2,V1$,4
        V2$=LEFT$(V1$,2)
        IF V2$="OK" THEN
        GOTO *DepthCal
        ELSE
        GOTO *VisionNG
        ENDIF
        *DepthCal
        R1.CFG.REQ=2
        PRINT #2,"SHIFT 1"
        WAIT R1.CFG.ASSIGN,3,*ERROR
        PRINT #0,"X :";R1.X,"Y :";R1.Y,"Z :";R1.Z
        LP1=P*             ‘Current Robot Position
S2      MOVE P,LP1+R1,S=20%,A=0,T=12‘Move Image Acquisition Position
        DELAY 0.5
        CLR232C 2
        V1$=""
        V2$=""
        V3$="MODEL 01"
        PRINT #2,V3$
        DELAY 1
        V4$="START 02"             ‘2D Vision Calculation
        PRINT #2,V4$
        INPUT #2,V1$,4
        V2$=LEFT$(V1$,2)
        IF V2$="OK" THEN
        GOTO *VisionOK
        ELSE
        GOTO *VisionNG
        ENDIF
        *VisionOK
        DELAY 0.5
        R8.CFG.REQ=2
```

```
        PRINT #2,"SHIFT 8"
        WAIT R8.CFG.ASSIGN,3,*ERROR
        PRINT #0,"X :";R8.X,"Y :";R8.Y,"RZ :";R8.RZ
        R8.Z=R1.Z
        'Work to be performed
S3      MOVE P,P1+R8,S=80%,A=0,T=1
S4      MOVE L,P2+R8,S=80%,A=0,T=1
        END
        *VisionNG
        PRINT #0,"Vision NG"
        END
        *ERROR
        PRINT #0,"Comm. NG"
        END
```

If you utilize an Hi4a controller, the work will be executed only when you change the "ShiftData" reception part as shown in the following:

```
R1.CFG=4
        PRINT #2,"SHIFT 1"
        WAIT R1.CFG AND &B10000,3,*VisionNG
```

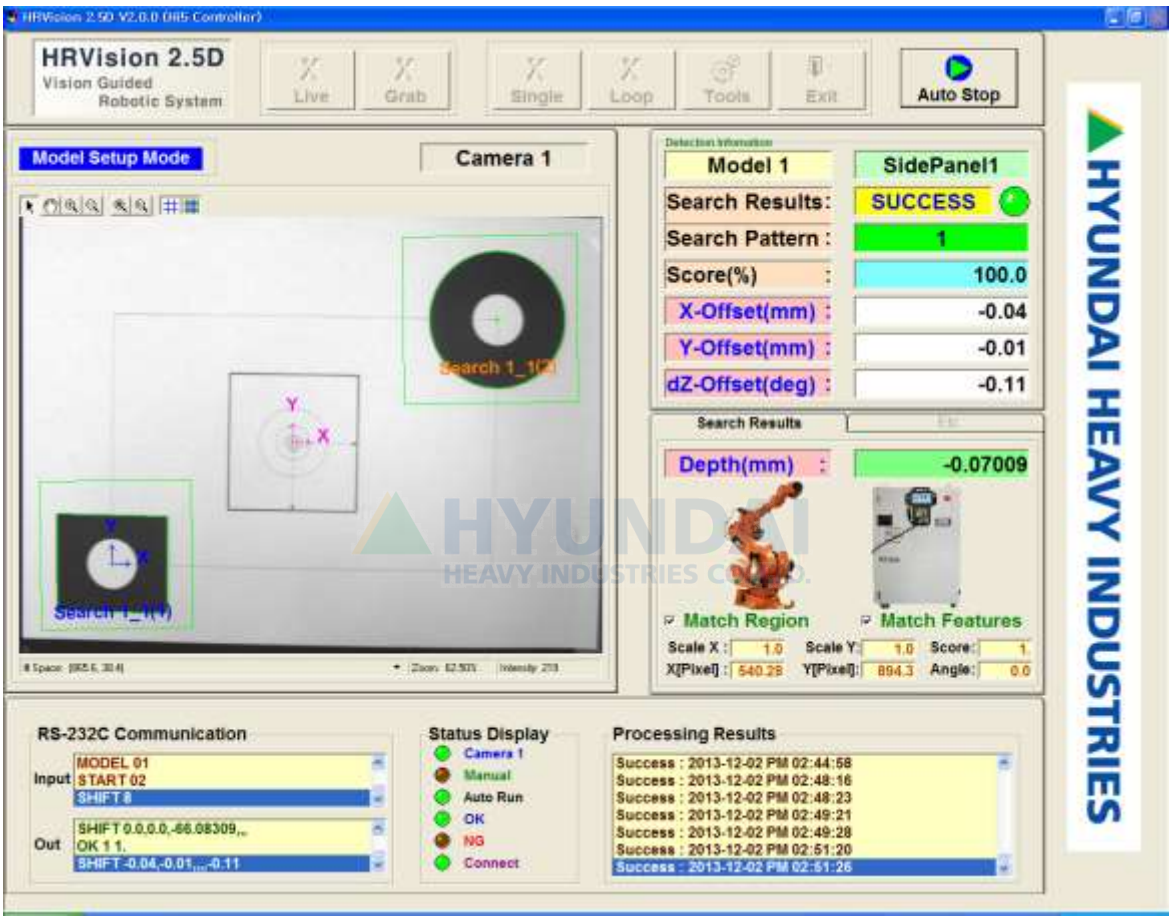
The following code is an example of a robot work program which performs Ethernet communication. Add the following code to the communication part with HRVision 2.5D.

```
' P1, P2 : Robot grip point
        P1=(X1,Y1,Z1,RX1,RY1,RZ1,CFG) ‘Upper side of the grip point
        P2=(X2,Y2,Z2,RX2,RY2,RZ2,CFG) ‘Grip point
        R1=(0,0,0,0,0,0)R
        R8=(0,0,0,0,0,0)R
        'ENET Comm. Setup
        'Vision PC
        ENET1.IP="10.8.1.179"
        ENET1.RPORT=2000
        ENET1.LPORT=5000
        ENET1.OPEN 1
        _TEINPUT=13     ‘Carriage Return
        _TEINPUT=10     ‘Line Feed
        'Buffer Clear
        CLR_RBUF ENET1          ‘ENET Buffer Clear
        V1$=""
        V2$=""
S1      MOVE P,S=100%,A=0,T=1‘Robot standby position
        V3$="MODEL 01"
        PRINT ENET1,V3$
        DELAY 1
        V4$="START 05"   ‘Depth Calculation
        PRINT ENET1,V4$
        INPUT ENET1,V1$,4
        V2$=LEFT$(V1$,2)
        IF V2$="OK" THEN
        GOTO *DepthCal
        ELSE
        GOTO *VisionNG
        ENDIF
        *DepthCal
        R1.CFG=17
        PRINT ENET1," SHIFT 1" ‘Depth Data Request
        INPUT ENET1,R1,3,*ERROR ‘Shift Data Receive
        R1.CFG=32
        PRINT #0,"X :";R1.X,"Y :";R1.Y,"Z :";R1.Z
        LP1=P*              ‘Current Robot Position
S2      MOVE P,LP1+R1,S=20%,A=0,T=12‘Move Image Acquisition Position
        DELAY 0.5
        CLR_RBUF ENET1          ‘ENET Buffer Clear
        V1$=""
        V2$=""
        V3$="MODEL 01"
        PRINT ENET1,V3$
        DELAY 1
        V4$="START 02"          ‘2D Vision Calculation
        PRINT ENET1,V4$
        INPUT ENET1,V1$,4
        V2$=LEFT$(V1$,2)
        IF V2$="OK" THEN
        GOTO *VisionOK
```

```
        ELSE
        GOTO *VisionNG
        ENDIF
        *VisionOK
        R1.CFG=17
        PRINT ENET1," SHIFT 8" ‘Depth Data Request
        INPUT ENET1,R8,3,*ERROR ‘Shift Data Receive
        R1.CFG=32
        PRINT #0,"X :";R8.X,"Y :";R8.Y,"RZ :";R8.RZ
        R8.Z=R1.Z
        ‘수행할 작업
S3      MOVE P,P1+R8,S=80%,A=0,T=1
S4      MOVE L,P2+R8,S=80%,A=0,T=1
        END
        *VisionNG
        PRINT #0,"Vision NG“
        END
        *ERROR
        PRINT #0,"Comm. NG“
        END
```

4.8. Auto Operation

When all the setup is completed, HRVision 2.5D will run automatically.
Click on the “Auto Run” button of operating button. At this time, the “Auto Run” button switches to “Auto Stop” button so that other buttons cannot be operated. HRVision 2.5D can only be operated through the communication with the Hyundai Robot.



HYUNDAI
HEAVY INDUSTRIES CO.,LTD.

- **Head Office**
  Tel. 82-52-202-7901 / Fax. 82-52-202-7900
  1, Jeonha-dong, Dong-gu, Ulsan, Korea

- **A/S Center**
  Tel. 82-52-202-5041 / Fax. 82-52-202-7960

- **Seoul Office**
  Tel.82-2-746-4711 / Fax. 82-2-746-4720
  140-2, Gye-dong, Jongno-gu, Seoul, Korea

- **Ansan Office**
  Tel.82-31-409-4945 / Fax.82-31-409-4946
  1431-2, Sa-dong, Sangn[OK]-gu, Ansan-si, Gyeonggi-do, Korea

- **Cheonan Office**
  Tel.82-41-576-4294 / Fax.82-41-576-4296
  355-15, Daga-dong, Cheonan-si, Chungcheongnam-do, Korea

- **Daegu Office**
  Tel.82-53-746-6232 / Fax.82-53-746-6231
  223-5, Beomeo 2-dong, Suseong-gu, Daegu, Korea

- **Gwangju Office**
  Tel. 82-62-363-5272 / Fax. 82-62-363-5273
  415-2, Nongseong-dong, Seo-gu, Gwangju, Korea

- **본사**
  Tel. 052-202-7901 / Fax. 052-202-7900
  울산광역시 동구 전하동 1 번지

- **A/S 센터**
  Tel. 82-52-202-5041 / Fax. 82-52-202-7960

- **서울 사무소**
  Tel. 02-746-4711 / Fax. 02-746-4720
  서울특별시 종로구 계동 140-2 번지

- **안산 사무소**
  Tel. 031-409-4945 / Fax. 031-409-4946
  경기도 안산시 상록구 사동 1431-2 번지

- **천안 사무소**
  Tel. 041-576-4294 / Fax. 041-576-4296
  충남 천안시 다가동 355-15 번지

- **대구 사무소**
  Tel. 053-746-6232 / Fax. 053-746-6231
  대구광역시 수성구 범어 2 동 223-5 번지

- **광주 사무소**
  Tel. 062-363-5272 / Fax. 062-363-5273
  광주광역시 서구 농성동 415-2 번지