WARNING

THE INSTALLATION SHALL BE MADE BY QUALIFIED INSTALLATION PERSONNEL AND SHOULD CONFORM TO ALL NATIONAL AND LOCAL CODES

Hyundai Robot

Hi4aVS071001FMEN3

Hi4a Controller Function Manual

HRVision (2D)

HYUNDAI
HEAVY INDUSTRIES CO.,LTD.

HYUNDAI
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Introduction

1.1. About HRVision (2D)

HRVision (2D) is vision software for robot guidance based on the PC for Hyundai robot and Hyundai Hi4a controller.

HRVision (2D) 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.

Also, by applying the pattern recognition method using multiple pattern addition and geometric shape information, the work piece can be located in 2-D and rotation information quickly and accurately measured even in an environment where the light condition is unstable.

HRVision (2D) is the optimal tool to execute the 2-D location recognition work easily and stably when apply the work piece handling using the Hyundai Robot.

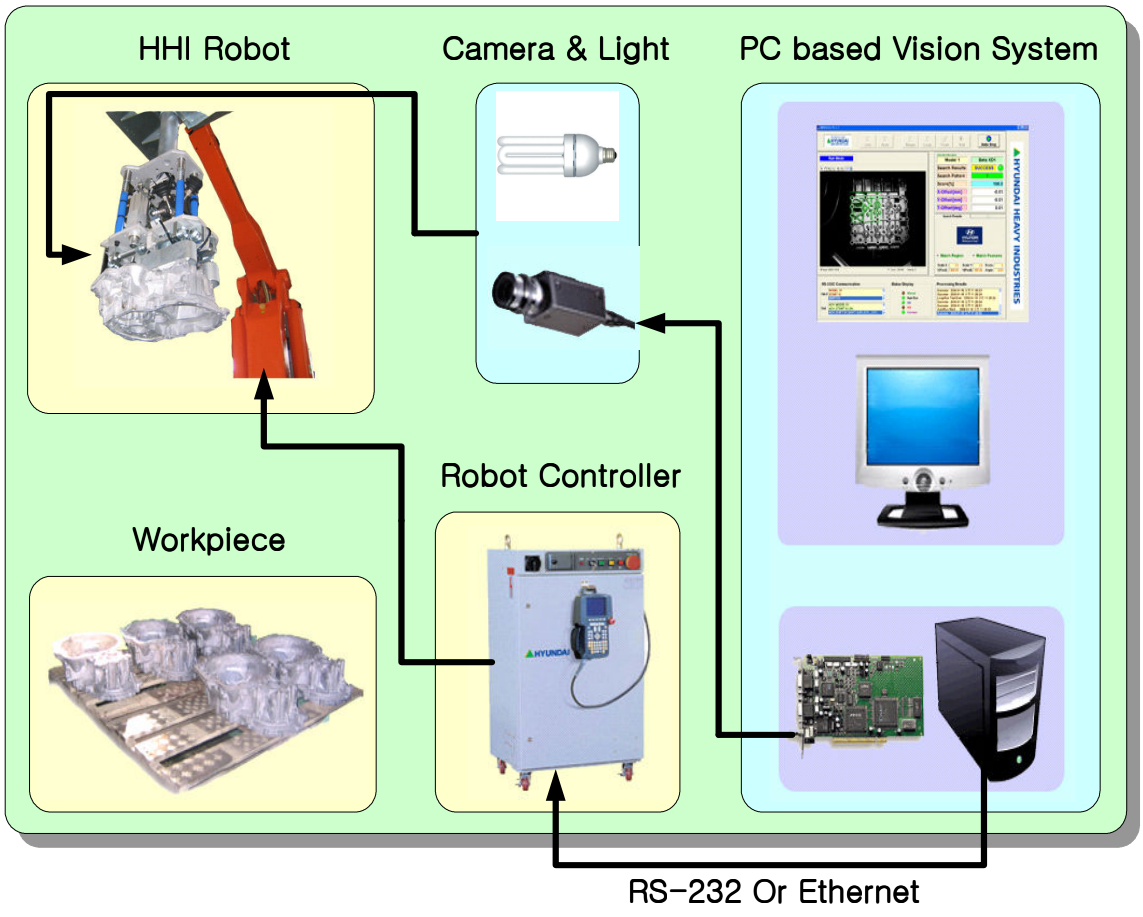
HRVision (2D) provides the following convenient functions.

Simple operation	You can set and operate the vision system easily by using the operating button.
Multiple pattern support	You can add multiple numbers of patterns for one model and enables various pattern addition depending on the light and surrounding environment.
Geometric pattern score	By executing the pattern score by using the geometric shape of the work piece, 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 (2D). 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 (2D).

The user can use the HRVision (2D) 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.



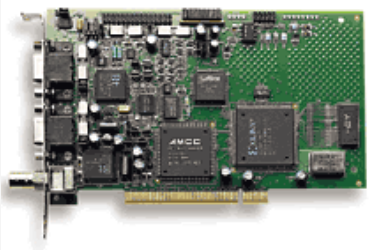
1.2.1. Hardware Configuration

The recommended H/W of HRVision (2D) is as follows.

H/W	Item	Recommended specifications
PC	CPU	Pentium 4 2.8 GHz or above
	OS	Windows XP
	RAM	1GB or above
	HDD	80GB or above
	CD-ROM	X48
Lighting	Light	3 way florescent light
Vision system	Frame Grabber	8100LVX (Cognex)
	Camera	XC-ST50 (Sony)
	Lens	ML-0614 (Moritex) : Can be modified depending on usage
	Cable	10 ~ 15 m

If you would like to use HRVision (2D) 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.

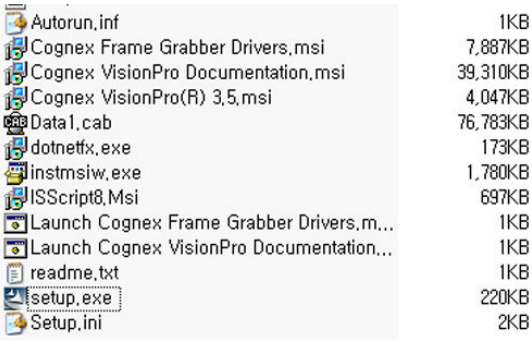
Model name	Exterior	Specifications
MVS-8100		High speed Frame Grabber Channel : 1 Number of camera that can be connected: Maximum of 4 units Connection method:RS170, CCIR 1/2 slot PCI Memory: Line Buffer
XC-ST50		1/3" IT CCD 768(H)×494(V) C - Mount DC 12V(+9~16V) 44(W)×29(H)×57.5(D) mm
ML-0614		Focal Distance : f6mm Focus : F1.4~close Field Of View (VxH) : 43.4°x56.7° Closest Distance : 0.2m Filter Screw Diameter (mm) :M27.5 P0.5 Weight : 57g CCTV Camera : 1/2", 1/3" Mount : C-mount

1.2.2. Software Configuration

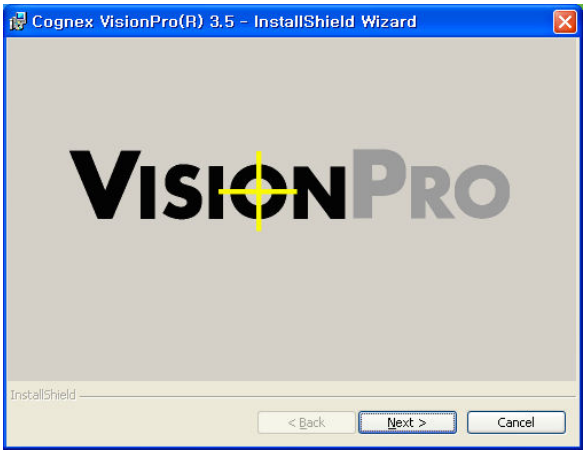
The software is composed of VisionPro 3.5 and HRVision (2D).
VisionPro 3.5 is a software that provides the driver for Cognex Frame Grabber and various application tools.
HRVision (2D) is a vision software for robot guidance based on PC of exclusively Hyundai Robot, and can only be used after installing the program and adding the license.

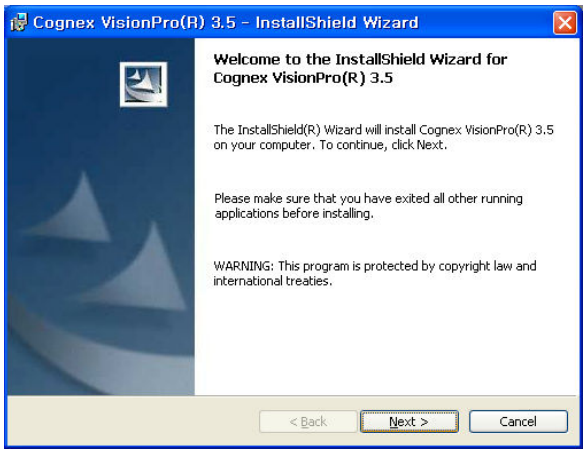
1.2.2.1. VisionPro Installation

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.

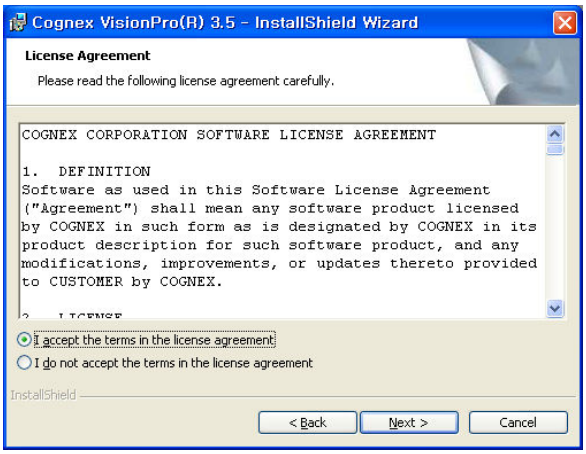


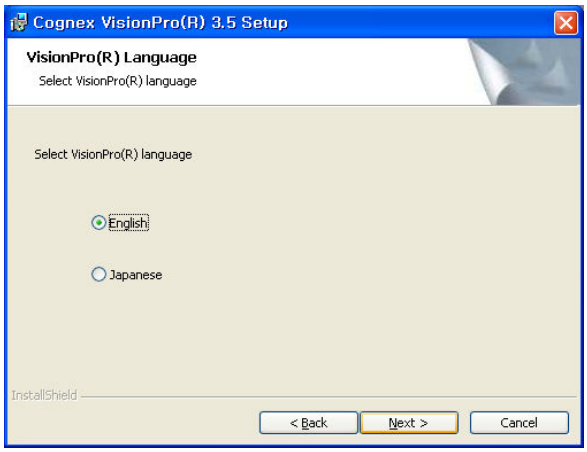
When the following installation appears, follow the installation procedure and direction as the general Windows program.



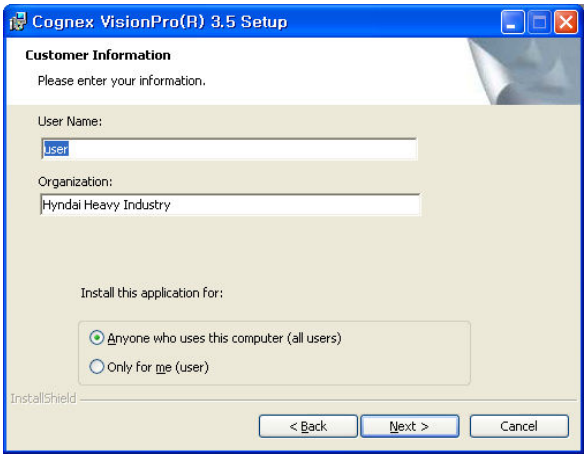


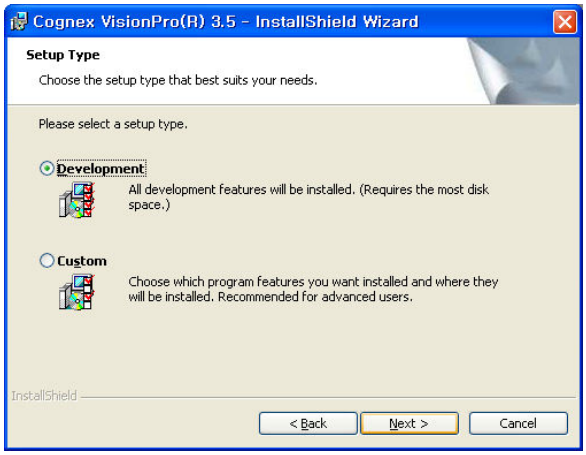
Agree to the license use as follows and select the language.



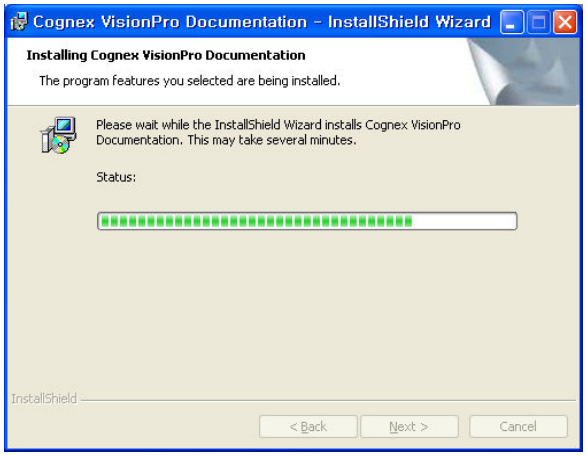


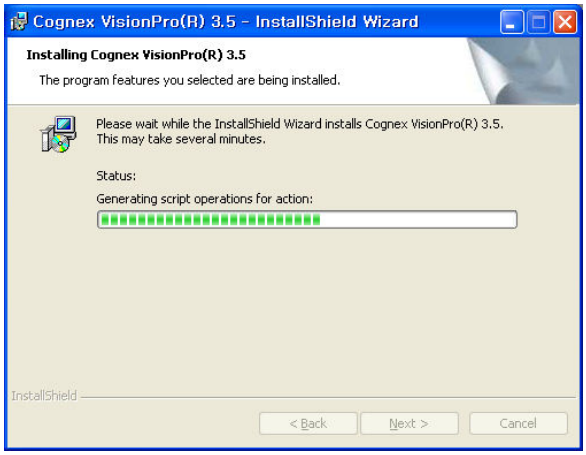
Enter the user information and select the installation type as shown below.



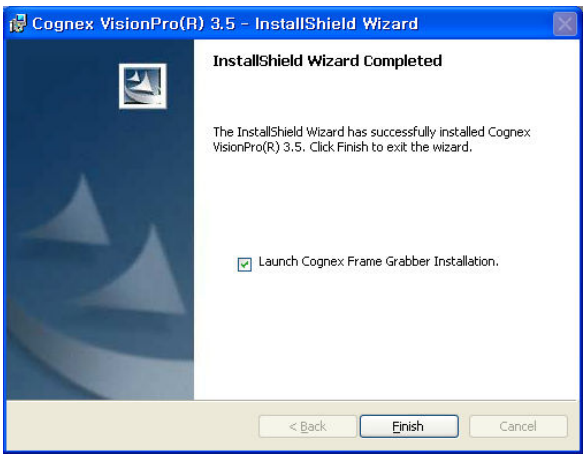


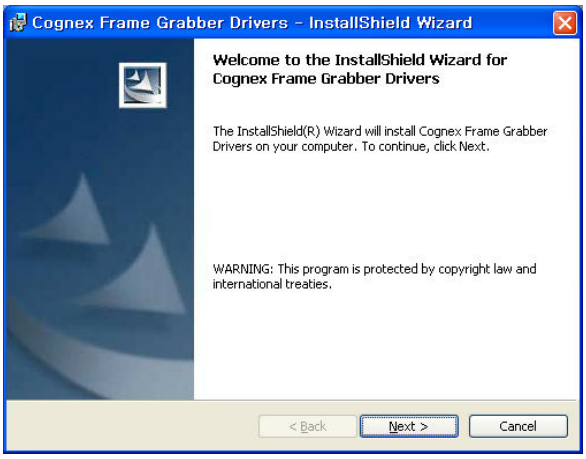
Follow the direction and the Cognex VisionPro Documentation and Cognex VisionPro(R) will be automatically installed.



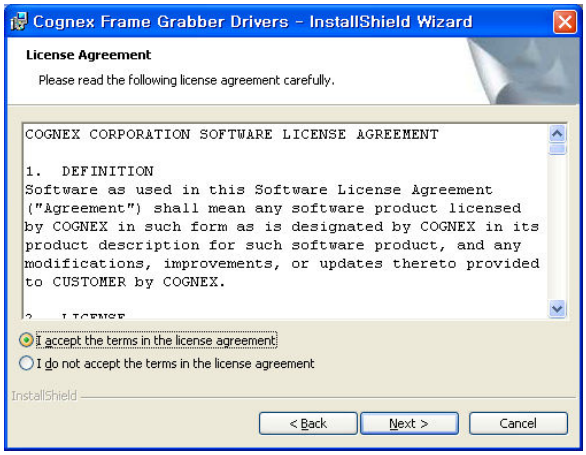


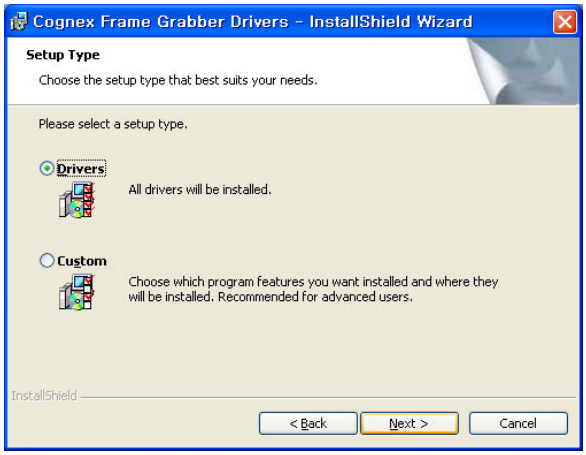
When the VisionPro3.5 is installed, it installs the Cognex Frame Grabber driver.



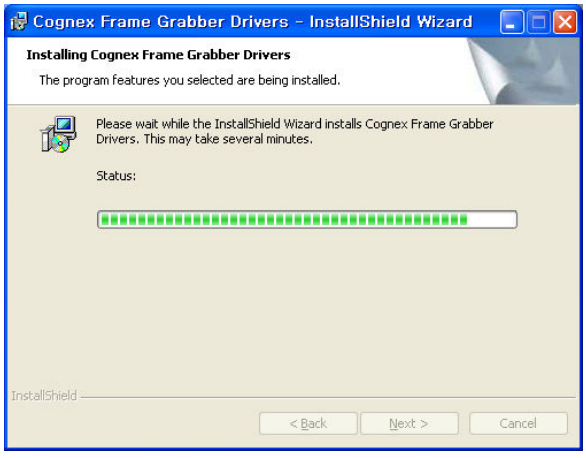


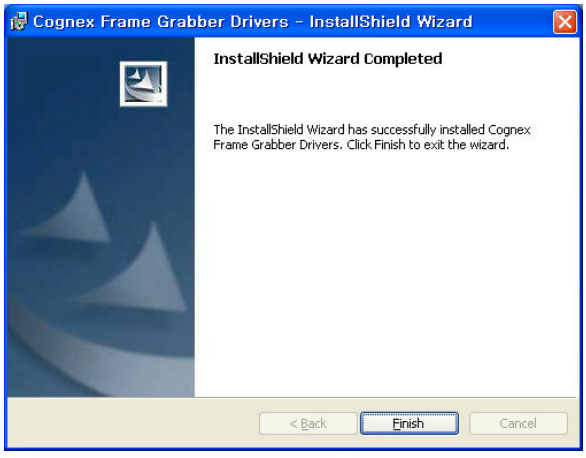
Agree to the license use as follows and select the installation type as shown below.



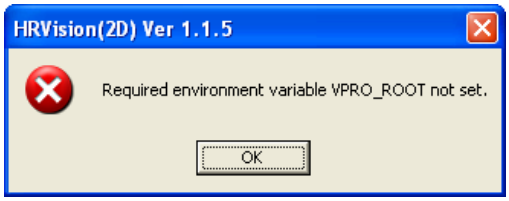


When the driver installation is complete, restart the computer.





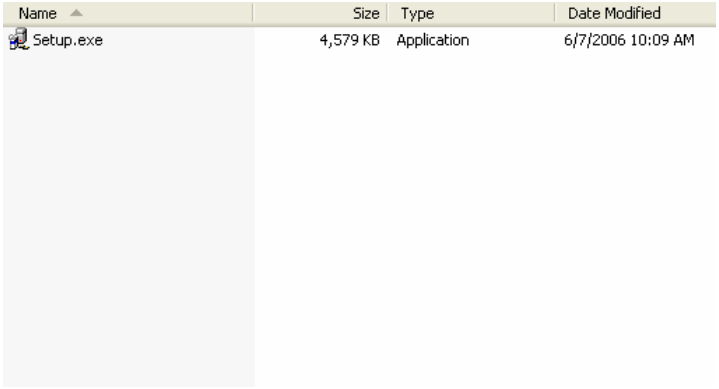
When you follow the direction, the software installation related to Cognex Frame Grabber will be completed. If VisionPro 3.5 is not installed, and you try to execute the HRVision (2D) program, the following warning window will appear. The user checks whether “C:\Program Files\Cognex\VisionPro” is installed and reinstalls the program.



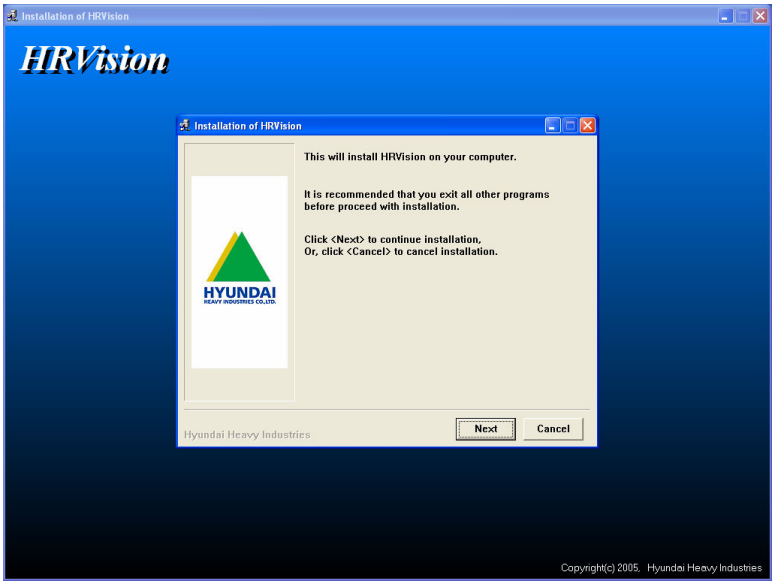
1.2.2.2. HRVision (2D) Installation

HRVision (OCV) installation procedure is as follows.

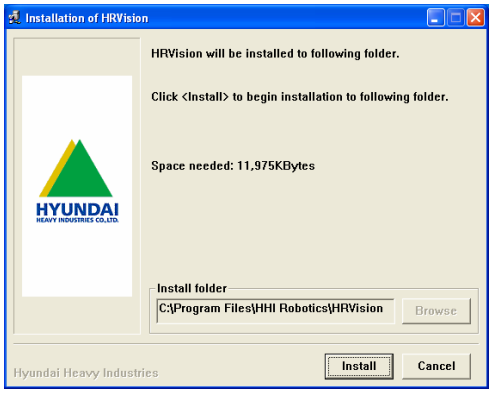
Close all application softwares on the system.
Insert the installation CD of HRVision (2D) in the CD-ROM drive and execute the “Setup.exe” file among the installation files.

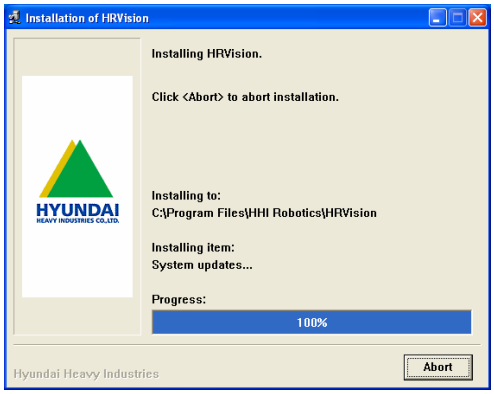


When the following screen appears, follow the directions as the installation procedure of general Windows program.

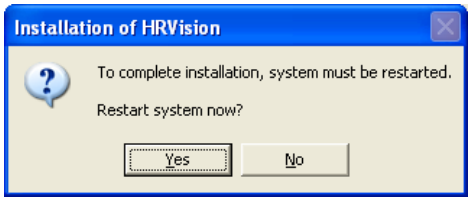


The HRVision (2D) execution files are copied to the “C:\Program Files\HHI Robotics\HRVision” folder and the user cannot change directory arbitrarily.

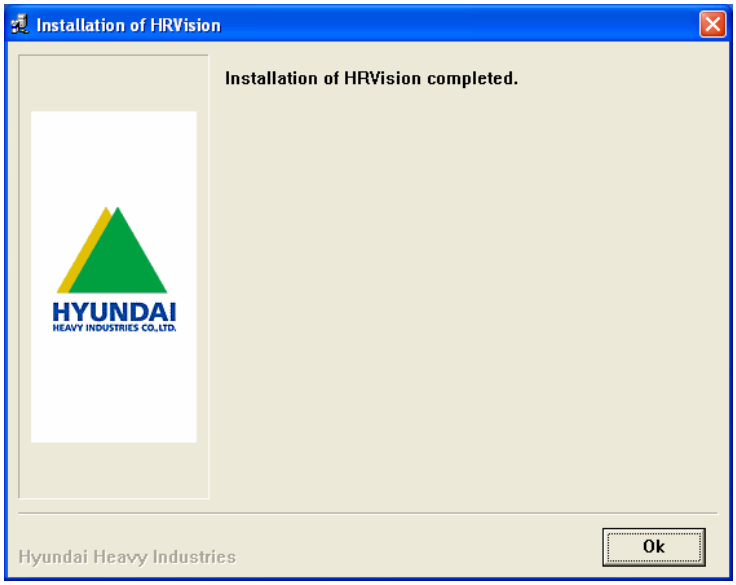




The program is restarted after copying the files.



When the restart process is completed, the following window appears. The installation of HRVision (2D) program is completed.



1.3. HRVision (2D) Execution

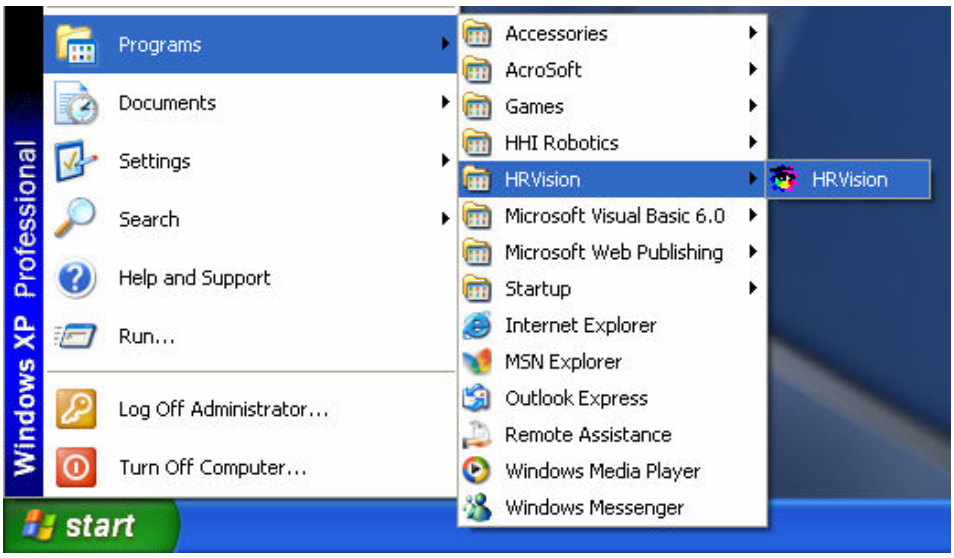
To execute HRVision (2D), use one of the following methods.

- Method 1

  1) Click on the Start.

  2) Select HRVision as follows.

- Method 2

  Double click on the HRVision icon on the desktop.

2
License Entry

To use HRVision (2D), you must enter the license key.
You cannot execute any work in the condition without the license key entered.

2.1. HRVision (2D) License

To use HRVision (2D), 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 (2D) from the supplier, you must notify the “System Serial No” for the Frame Grabber of Cognex to use.

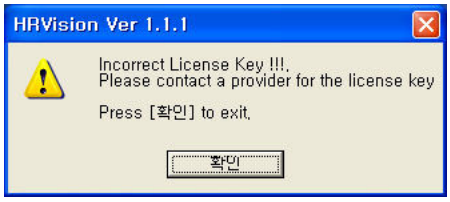
The key code that fits the number provided by the customer will be notified to the user.

After the HRVision (2D) installation, execute the HRVision (2D) 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 (2D) 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 (2D) supports Korean and English, and the language can be changed in the Option tab of setup mode when the program is running.

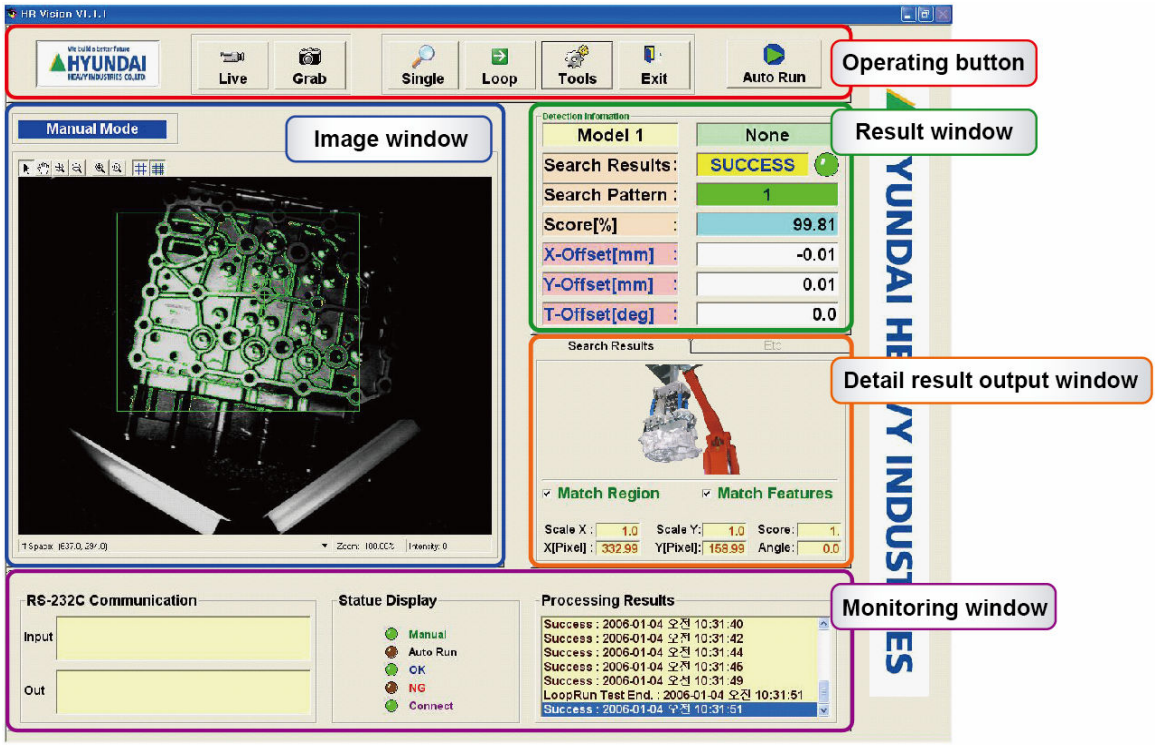
3.1.1. Splash Screen

When the serial key is entered accurately after executing the program, the following splash screen will be displayed to execute the HRVision program.

If the language of HRVision is set to English, the version information will be displayed in English like *Ver 1.1.1*.

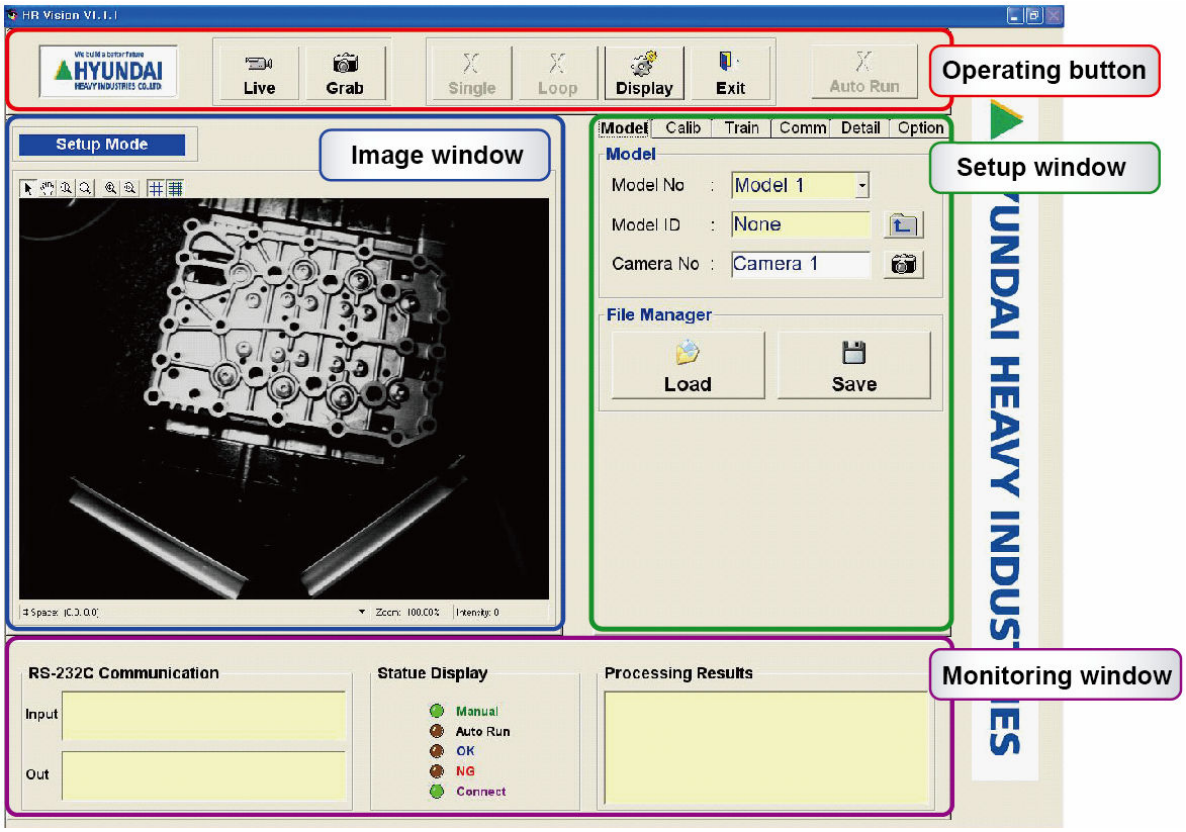
3.1.2. Main Screen Configuration

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



The following picture shows the screen configuration of HRVision (2D) changed to setup mode by clicking on the Tools (Setup) 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 (2D). The user logs in and changes the password in the option (Option) tab of setup window. Refer to [3.7.5. Option (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.



The key function of each window is as follows.

Operating button	This provides the operating buttons to operate HRVision (2D) including grab image, inspection, various setups, auto operation etc.
Image window	This displays the current live or grabbed image.
Monitoring window	This displays the communication details with the Hyundai Robot, various status display, progress details etc.
Result output window	This displays the detected results of inspection/continuous inspection and auto operation.
Detail result output 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.

3.2. Operating Button

As the button operating the key function of HRVision (2D), each function is as follows.

- Live (Continuous image)
  This displays continuous image from the installed camera.

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

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

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

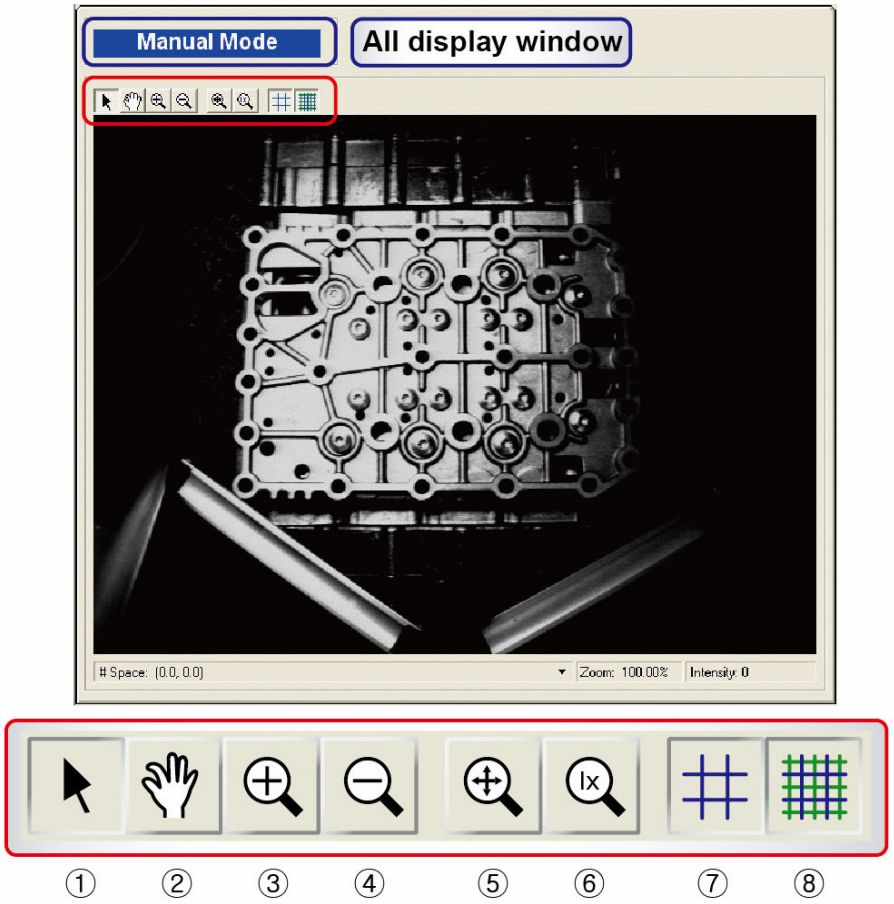
- Tools (Setup) / Display (Display)
  This is a toggle button that when you click on it once, it becomes Display (Display) and when you click again, it becomes Tools (Setup).
  - Tools (Setup): You can set the model to execute image processing, camera calibration, communication, other data files etc.
    The setup mode is set so that only the administrator can access the functions. Refer to 3.7.5. Option (Option) tab on how to change the password.
  - Display (Display): This displays the pattern recognition result and location movement.

- Exit (End)
  This ends the program.

- Auto Run(Auto operation)/Auto Stop (Auto cancel)
  This is a toggle button that when you click on this button, it becomes Auto Stop (Auto Cancel) and when you click on this button again, it becomes Auto Run (Auto operation).
  In accordance with the communications standard with the robot, until Auto Stop is clicked Auto Run (Auto operation) 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 Window

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



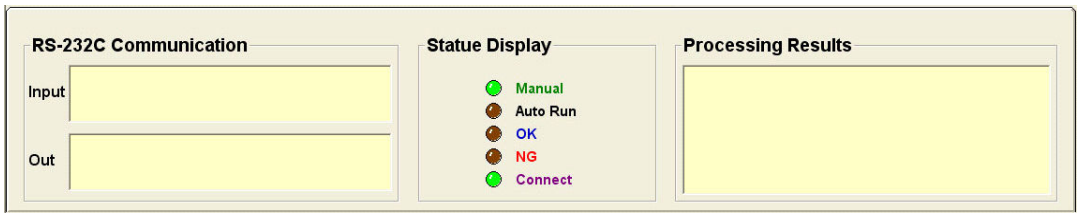
Within the image window, there is the mode display window that shows you all the currently executed modes, and the operating tool mode that will help you efficiently view the grabbed image.
HRVision (2D) has largely 3 modes, the manual mode, the run mode and the setup mode, and the setup mode has 6 modes, model setup, calibration, train, communication setup, DIO and option.

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

① Mouse point
② Move
③ Zoom in
④ Zoom out
⑤ Fit to window
⑥ Expand 100%
⑦ Display grid (Can be seen when expanded)
⑧ Display sub pixel grid (Can be seen when expanded)

3.4. Monitoring Window

Monitoring window can be divided into 3 parts, communication details with robot and HRVision (2D), status display and work progress status.



- Communication monitoring
  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

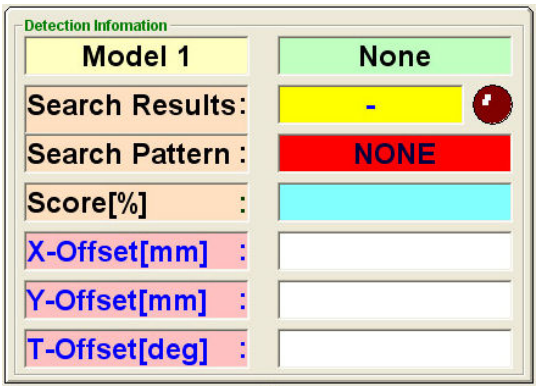
- Condition display
  It displays auto/manual run condition, OK/NG recognition status, communication connection etc. with LED.

  - 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.

- Progress status
  It displays the work in progress by HRVision (2D) in order.

3.5. Result Display Window

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

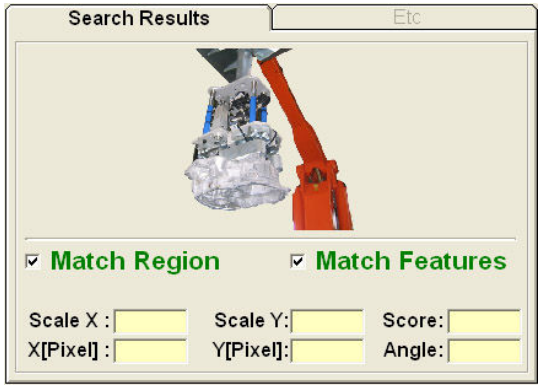


The details of each item are as follows.

- MODEL information: It displays the model name and ID of the pattern recognition process.
- Search Result:
  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 : As the result of search pattern, it displays the offset in X axis direction of the robot.
- Y-Offset : As the result of search pattern, it displays the offset in Y axis direction of the robot.
- T-Offset : As the result of search pattern, it displays the offset in Z axis direction of the robot.

3.6. Detail Result Display Window

It displays the detail results of image processing.



The detail description of each item is as follows.

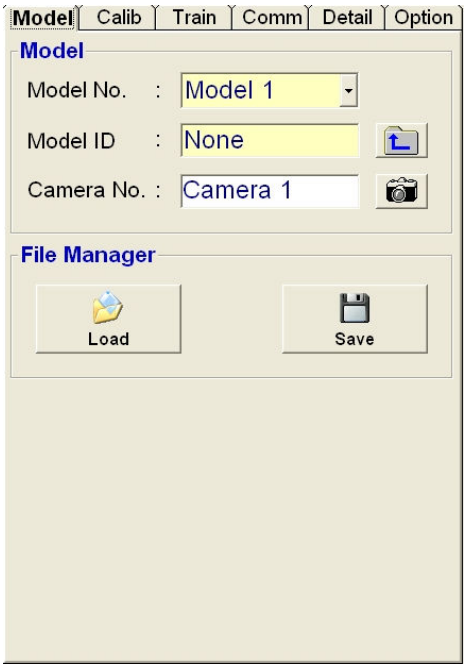
- Match Region :
  When this checkbox is checked, it displays the search window area when executing pattern recognition.
- Match Features :
  When this is checkbox is checked, it displays the matched features when executing pattern recognition.
- Scale X : As the result of search pattern, it displays 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

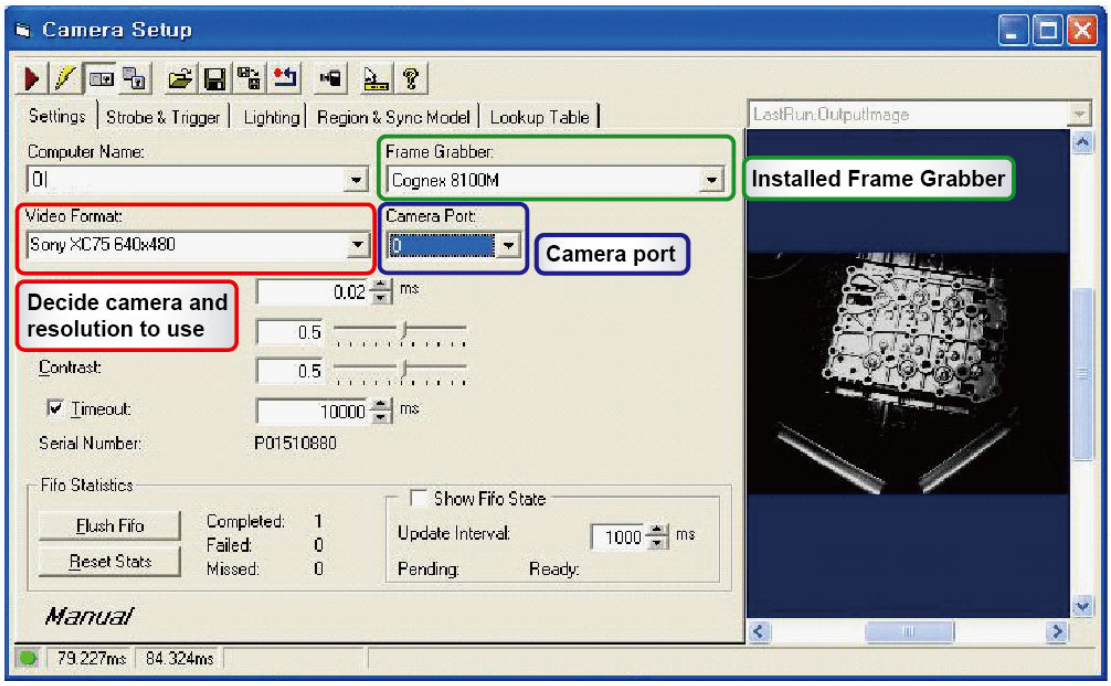
You can use the setup window after clicking the tools of operating button and logging in successfully. When the setup window appears, the result display window and detail result display window disappear.
The setup window is composed of total of 6 tabs, and each component is as follows.

3.7.1. Model (Model) Tab

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



- Model No.: It sets the model to add the pattern.
- Model ID: It sets the model name.
-  button: It saves the entered model name.
- Camera No.: It sets the camera to execute image process.
- 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.



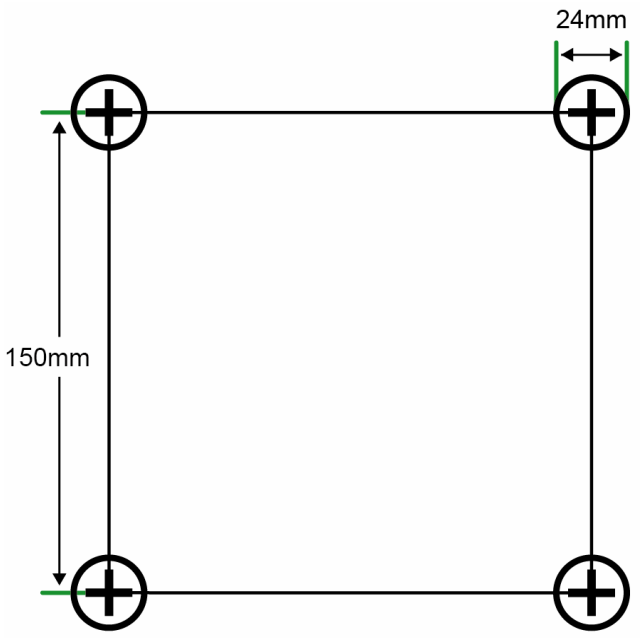
- Load: Load the data file.
  Load the HRVisionQ_init.vpp data file (Change the file name depending on the version)in the "C:\Program Files\HHI Robotics\HRVision" folder.

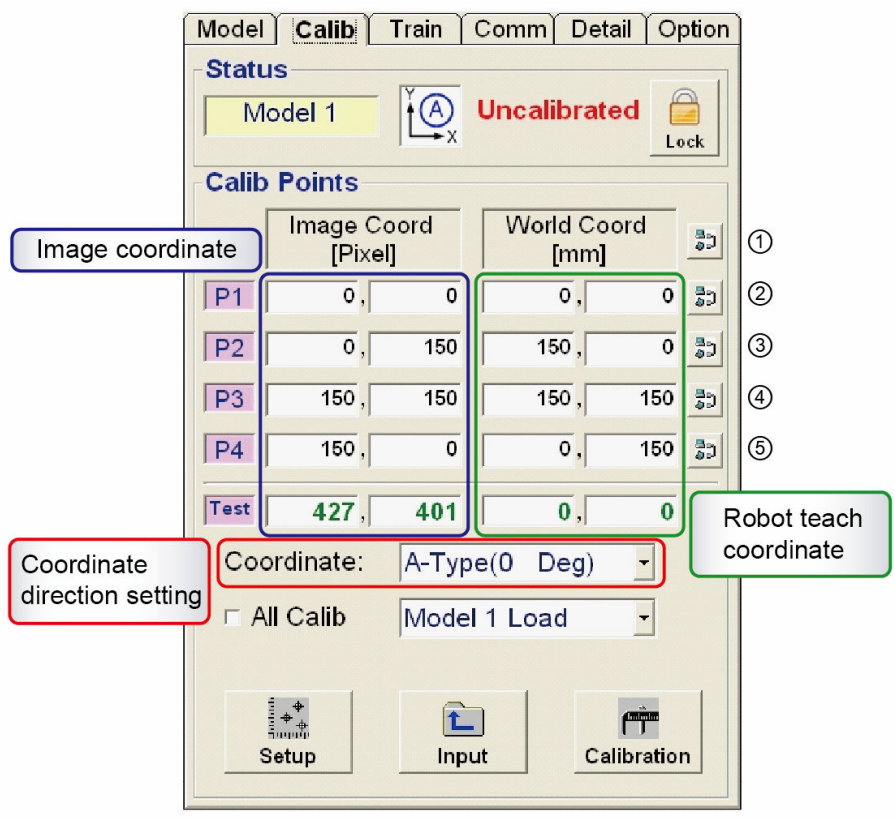
- Save: Save the data file.
  Save the HRVisionQ_init.vpp data file (Change the file name depending on the version)in the "C:\Program Files\HHI Robotics\HRVision" folder.

3.7.2. Calib (Calibration) Tab

This mode executes the camera calibration to align the image coordinate and camera coordinate. HRVision (2D) executes the calibration using the following calibration board.

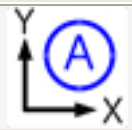
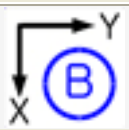
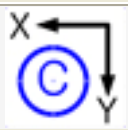
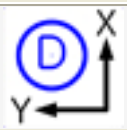
The calibration board is the form of setting the circle with a diameter of 24mm at the corners of a square with a length of 150mm. Refer to the “2D calibration board.dwg” file in the installation CD. Here the 4 circles are called the calibration points, and the calibration work is executed by teaching 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, calibration form, whether there is calibration etc.
  - Model: It displays the model executing the calibration.
  - Calibration form: It displays the coordinate direction executing the calibration according to the coordinate (coordinate direction). There are 4 types of coordinates (Coordinate direction), and the shapes are as follows.

Direction	A-Type (0 Deg)	B-Type (90 Deg)	C-Type (180 Deg)	D-Type (270 Deg)
Screen				

  - Calibration condition: It display whether the calibration is executed or not as shown below.

Condition	Screen	Description
Before calibration	Uncalibrated	Calibration is not executed.
After calibration	Calibrated	Calibration is executed.

- Lock button: This locks all buttons related to calibration.

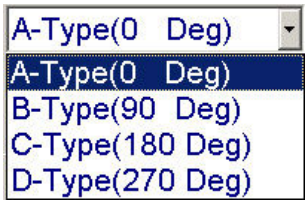
■ Calib Points (Calibration point setup)
Enter the image coordinate and robot teach data for the Calibration Points.
Click on the setup (image setup) button to setup the location of calibration points in the image coordinate by executing pattern recognition.
Directly enter or setup the X and Y location of each calibration point for the location of the calibration points in the robot coordinate, or click on the  button to automatically receive the input of the pose data of the robot.

 button: It automatically reads and displays the pose data saved in the robot.
①: It receives the Pose 901, Pose 902, Pose 903 and Pose 904 data of Hyundai Robot controller in order with an interval of 1 second, and displays the P1, P2, P3 and P4 robot teach coordinate.
②: It receives the Pose 901 data of Hyundai Robot controller and displays the P1 robot teach coordinate.
③: It receives the Pose 902 data of Hyundai Robot controller and displays the P2 robot teach coordinate.
④: It receives the Pose 903 data of Hyundai Robot controller and displays the P3 robot teach coordinate.
⑤: It receives the Pose 904 data of Hyundai Robot controller and displays the P4 robot teach coordinate.

But, the coordinates on which each calibration point is taught must be saved in the pose parameter of the controller, P901, P902, P903 and P904, and the robot work program must be prepared to automatically transmit this pose data. Refer to 4.3.1.2. POSE data communication setup for detail setup.

■ Test
When the calibration is executed, the image coordinate location of the current mouse position and robot coordinate reference location are provided as output.

■ Coordinate (Coordinate 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.



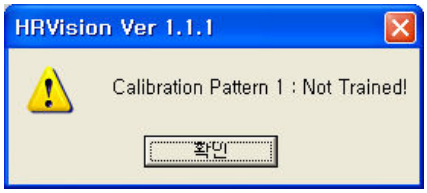
■ All Caib (Applies to all calibration data)
When you select check the checkbox, the same calibration data is applied to all the models.

When you uncheck the checkbox, you can copy specific calibration data or calibrate applicable models separately.

- Setup (Image setup)
  When you click on this button, it toggles between Search and Setup. When you c lick on Setup, the search window and the coordinate axis of each search window are displayed.

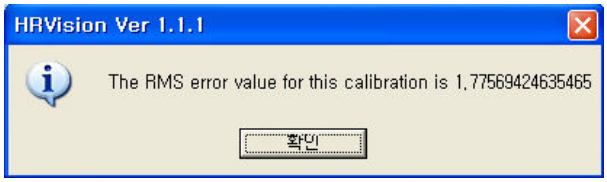
  Appropriately arrange 4 rectangles to recognize the 4 calibration points and arrange the coordinate axis at the center of each calibration point. For details, refer to 4.4.2.4.1. Image coordinate setup.
  When the arrangement of each search window and coordinate axis is completed, click on the Search 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.



- 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.

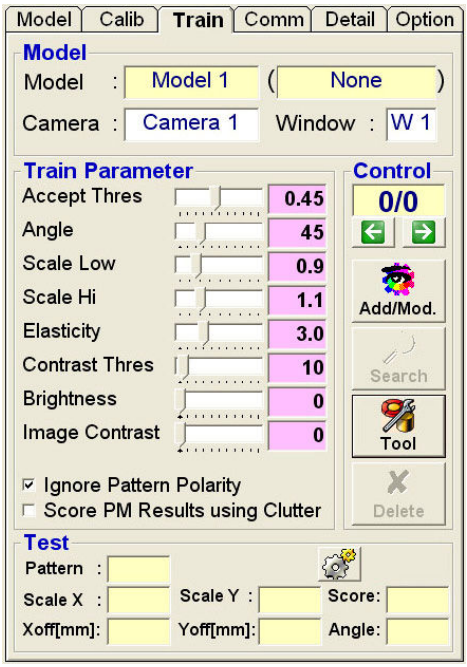
- Calibration
  When the image coordinate and robot coordinate of calibration points are entered, click on this button to execute the camera calibration. If the RMS value of executed calibration is lower than the RMS Error Limit, the following window is provided and the camera calibration is completed. 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 (Train) Tab

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

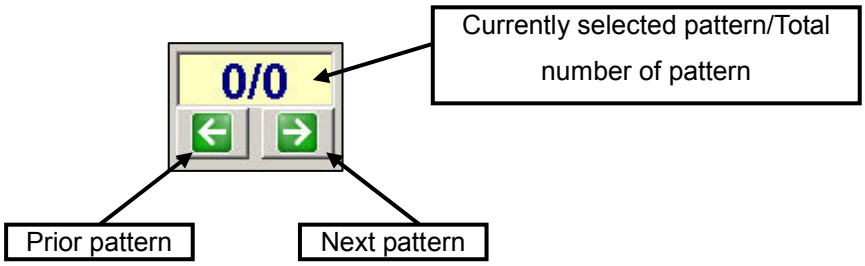


- Model
  The model name, model ID and camera information set in the model tab are displayed.
  - Window: When adding the pattern, it displays the ID of used window.

- Train Parameter
  Use this parameter to train the pattern.

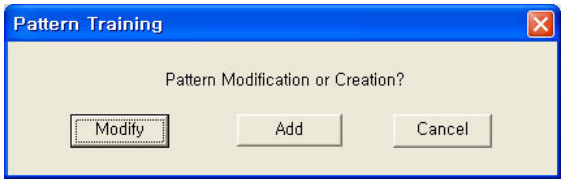
  - Accept Thres : This sets the score threshold for pattern recognition.
  - Angle : This sets the angle range that can be recognized.
  - Scale Low : This sets the minimum change that can be recognized.
  - Scale Hi : This sets the maximum change that can be recognized.
  - Elasticity : This sets the specifically permitted change in pixel.
  - Contrast Thres : This sets the minimum contrast threshold value for pattern recognition.
  - Brightness : This sets the brightness of the image.
  - Image Contrast : This sets the image contrast.
  - Ignore Pattern Polarity: This ignores the pattern polarity.
    Pattern Polarity : Brightness change trend of pattern characteristics.
  - Score PM Results using Cluster :
    This executes the pattern score by using irrelevant or scattered characteristics.

■ 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.

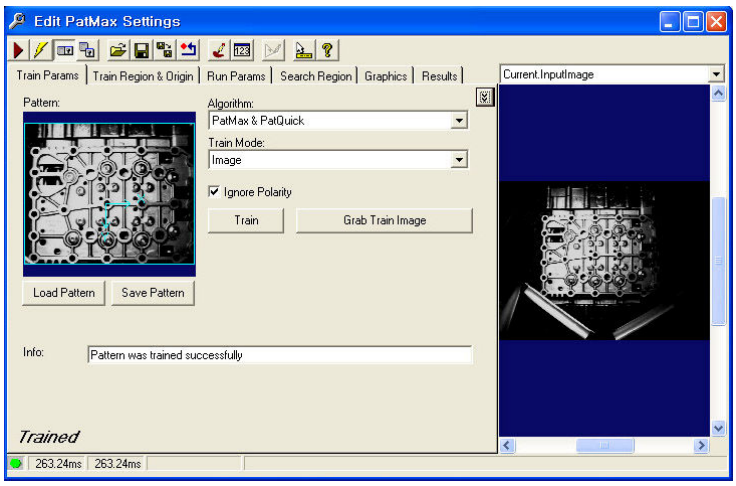
■ Add/Mod
When you click on this button, it toggles between Training and Add/Mod.
You can add the pattern, modify the added pattern or train the pattern.
When you click on the Add/Mod button, the following window appears. Click on Modify, Add or Cancel depending on the purpose.



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.
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
This calls the PATMAX tool provided from Cognex.



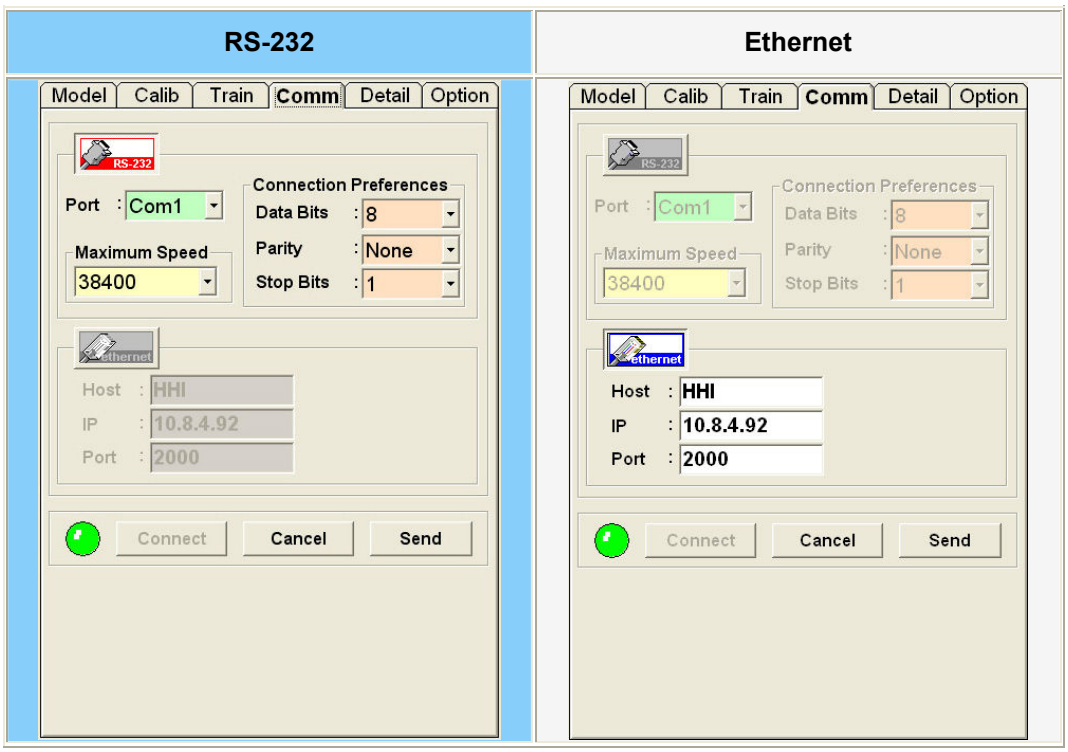
■ Delete
When you click on this button, the following window appears. When you click on the Y button, the added pattern will be deleted.

■ Test (Detection results)
Detail detection information is displayed for Training and Search process.

-  button: This resets the pattern count.
- 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.
- X-Offset : This displays the location offset in X direction.
- Y-Offset : This displays the location offset in Y direction.
- Angle : 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.



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	Activated	Deactivated
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
  - HOST : Enter the host name to connect.
  - IP : This sets the IP address of the server to connect.
  - Port : This sets the port of the server to connect.

- 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.

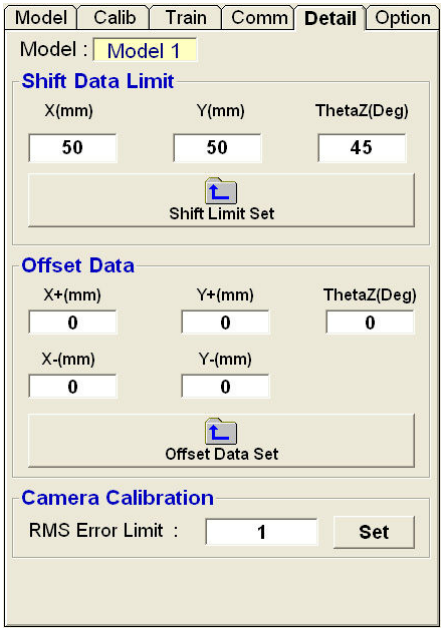
3.7.5. Detail (Detail) Tab

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: 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.

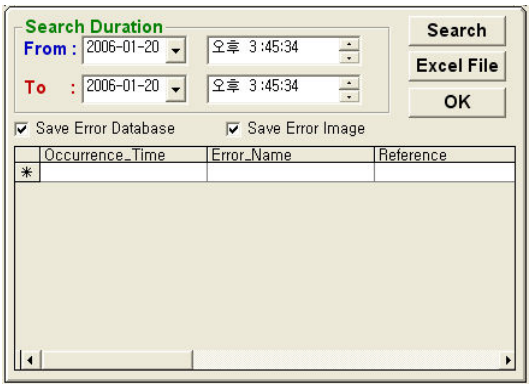


3.7.6. Option (Option) Tab

This mode manages the error and searched data, password and language change etc.

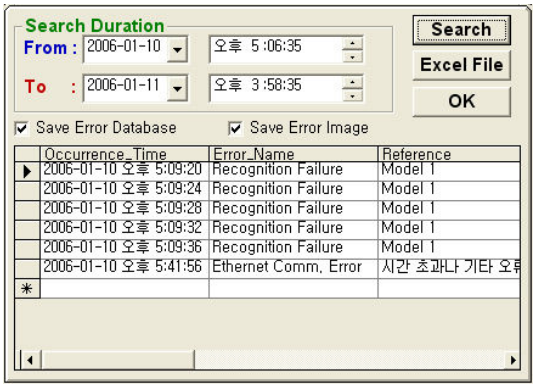
- Management (Data/Password management)
  This manages the error, data record, user password change, reset file auto loading setup.

- 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”

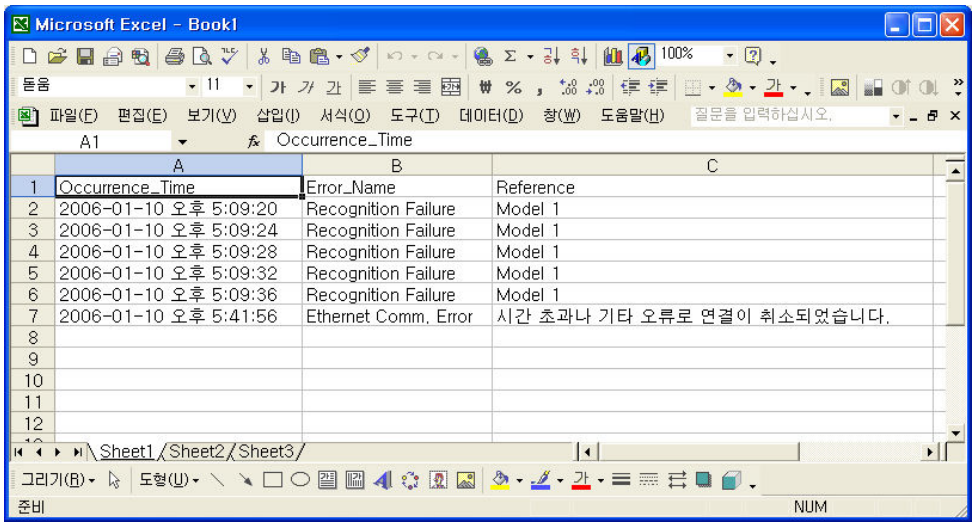


- Search Duration: This sets the search duration.
  Initially this sets the time to execute HRVision (2D).
- Search: This searches the error history that satisfies the search duration set.
  The search result is displayed in the data grid.

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



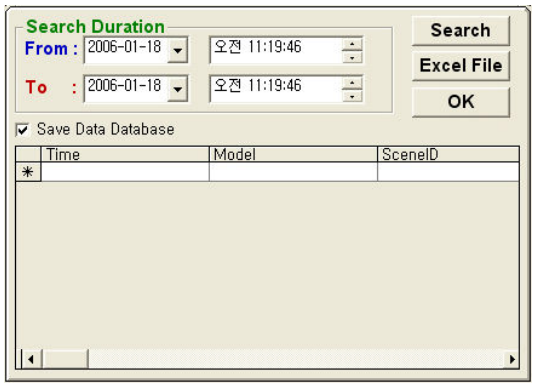
- Excel File: Call the searched result in Excel file.



- 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
  The image with the pattern recognition error is saved in the “C:\Program Files\HHI Robotics\HRVision\Images” folder.
- When the checkbox is unchecked, the error image is not saved.

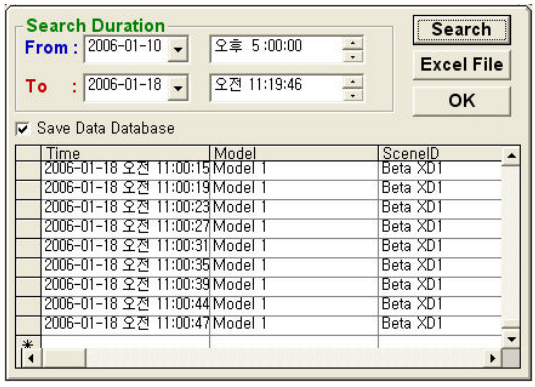
■ Data History

The pattern recognition result and location offset history are managed during Auto Run. The database is composed of Time (Pattern recognition time), Model (Model name), Scene ID (Model ID), Score (Score), Pattern (Pattern number), ImageX (Searched pattern image X coordinate), ImageY (Searched pattern image Y coordinate), ScaleX (Size change in X axis direction), ScaleY (Size change in Y axis direction) and ShiftData (Location shift), and it is managed in the DataDB.mdb file in the “C:\Program Files\HHI Robotics\HRVision” folder.

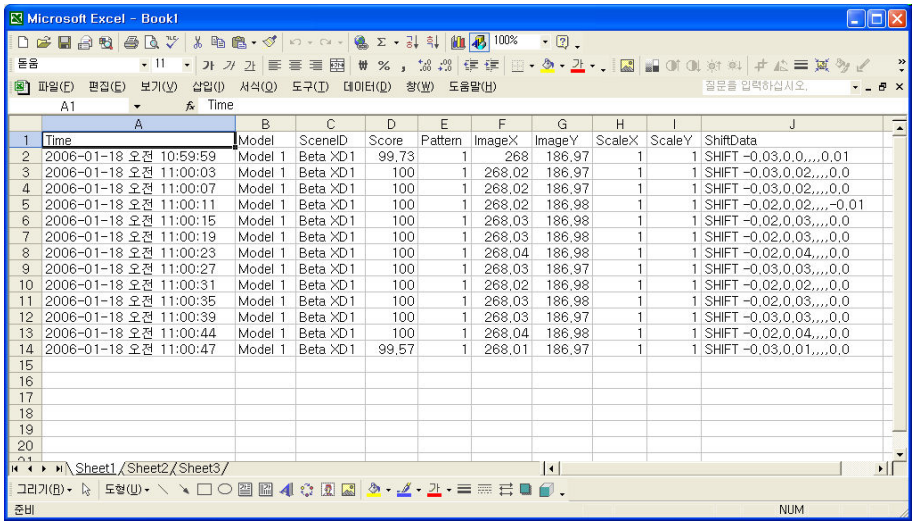


- Search Duration: This sets the search duration.
  Initially this sets the time to execute HRVision (2D).
- Search:
  This searches the error history that satisfies the search duration set.
  The search result is displayed in the data grid.

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



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

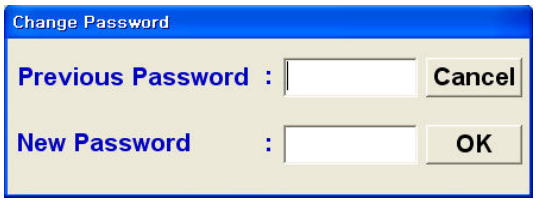


	A	B	C	D	E	F	G	H	I	J
1	Time	Model	SceneID	Score	Pattern	ImageX	ImageY	ScaleX	ScaleY	ShiftData
2	2006-01-18 오전 10:59:59	Model 1	Beta XD1	99,73	1	268	186,97	1	1	SHIFT -0,03,0.0,,,,0.01
3	2006-01-18 오전 11:00:03	Model 1	Beta XD1	100	1	268,02	186,97	1	1	SHIFT -0,03,0.02,,,,0.0
4	2006-01-18 오전 11:00:07	Model 1	Beta XD1	100	1	268,02	186,97	1	1	SHIFT -0,03,0.02,,,,0.0
5	2006-01-18 오전 11:00:11	Model 1	Beta XD1	100	1	268,02	186,98	1	1	SHIFT -0,02,0.02,,,,-0,01
6	2006-01-18 오전 11:00:15	Model 1	Beta XD1	100	1	268,03	186,98	1	1	SHIFT -0,02,0.03,,,,0.0
7	2006-01-18 오전 11:00:19	Model 1	Beta XD1	100	1	268,03	186,98	1	1	SHIFT -0,02,0.03,,,,0.0
8	2006-01-18 오전 11:00:23	Model 1	Beta XD1	100	1	268,04	186,98	1	1	SHIFT -0,02,0.04,,,,0.0
9	2006-01-18 오전 11:00:27	Model 1	Beta XD1	100	1	268,03	186,97	1	1	SHIFT -0,03,0.03,,,,0.0
10	2006-01-18 오전 11:00:31	Model 1	Beta XD1	100	1	268,02	186,98	1	1	SHIFT -0,02,0.02,,,,0.0
11	2006-01-18 오전 11:00:35	Model 1	Beta XD1	100	1	268,03	186,98	1	1	SHIFT -0,02,0.03,,,,0.0
12	2006-01-18 오전 11:00:39	Model 1	Beta XD1	100	1	268,03	186,97	1	1	SHIFT -0,03,0.03,,,,0.0
13	2006-01-18 오전 11:00:44	Model 1	Beta XD1	100	1	268,04	186,98	1	1	SHIFT -0,02,0.04,,,,0.0
14	2006-01-18 오전 11:00:47	Model 1	Beta XD1	99,57	1	268,01	186,97	1	1	SHIFT -0,03,0.01,,,,0.0

- 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

This changes the user password to vision setup.
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.

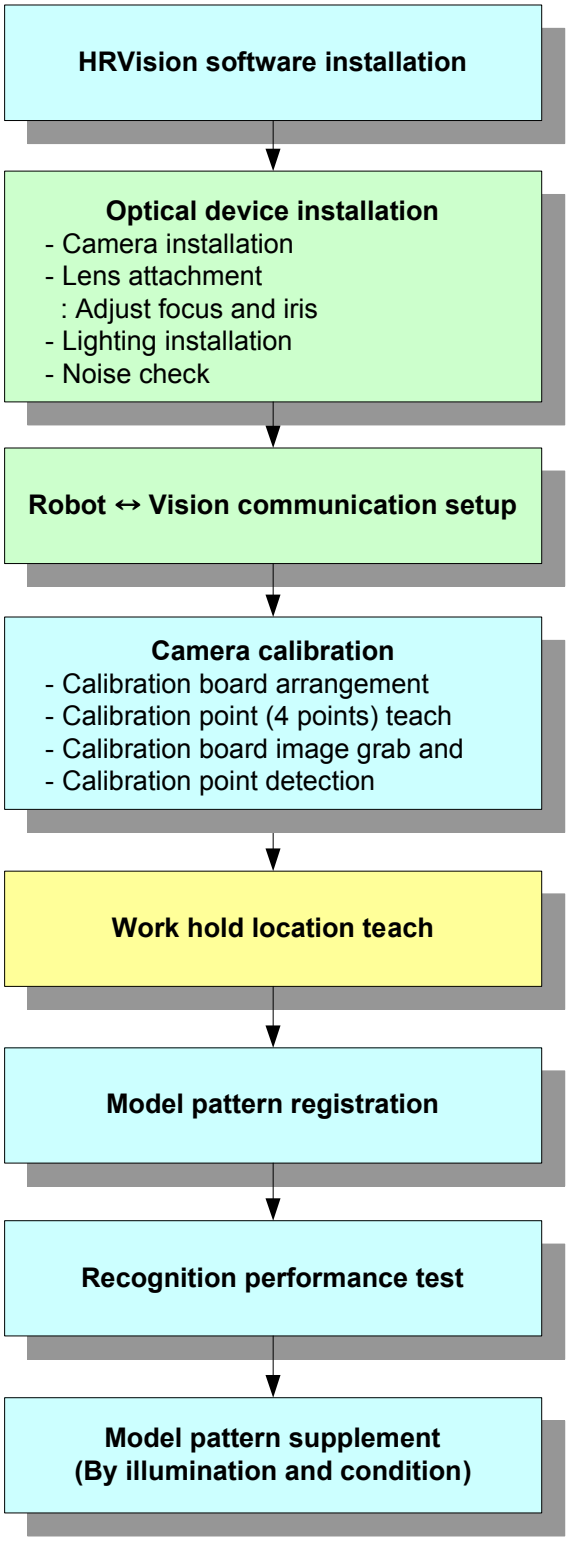
- AutoFileLoading
  When executing HRVision (2D), the initialization file (HRVisionQ_init.vpp) is automatically loaded.
  When the checkbox is unchecked, the initialization file is not automatically loaded. You must load the initialization file by clicking the Load button from the Model tab in the Setup window.

- Language
  Select the language to be displayed on the main menu, pop up menu, window, message etc. HRVision (2D) 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.

4

Work Procedure

The work procedure of the HRVision (2D) is as follows.
The detail description of each procedure is provided in the following sections.

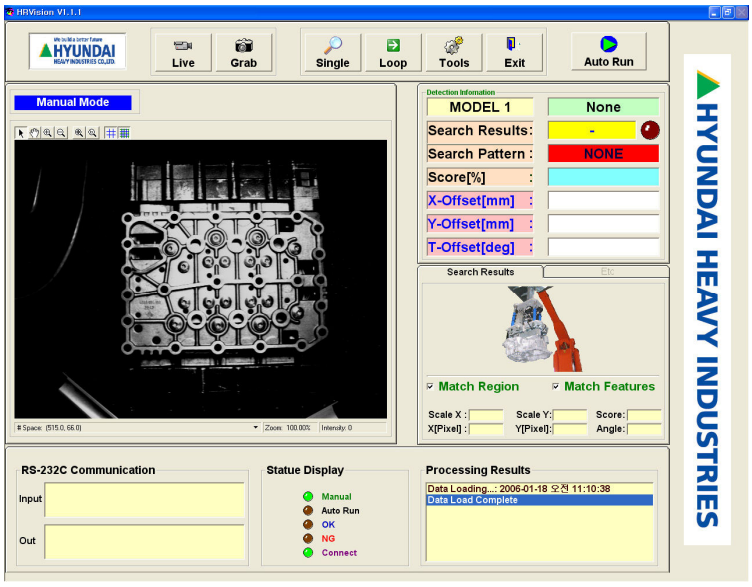


4.1. HRVision (2D) Software Installation

Install VisionPro 3.5 and HRVision software in accordance with 1.2.2, and register the license key in accordance with 2.1.

4.2. Optical Device Installation

Install the camera and lighting according to the using purpose.
Set the distance between the work piece and camera, focus & iris of the lens to fit the surrounding environment.
When the camera is attached on the robot, fixate the camera so that it does not move when the robot is moving, and check the focus ring and iris ring of the lens.
After completing the vision installation, check whether the image is properly grabbed when the robot is moving. If there is noise in the image, check the insulation condition of the camera and cable etc.
The following picture is the initial screen when executing the HRVision (2D) after installing the optical device and HRVision (2D) program.



4.3. Communication Setup of Robot and Vision

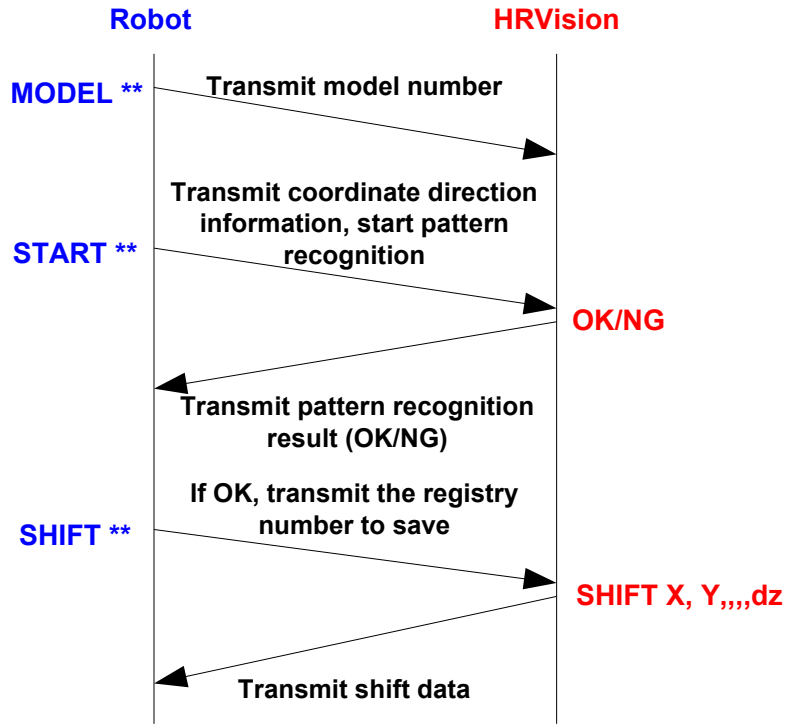
4.3.1. Robot Work Program Preparation

4.3.1.1. SHIFT Data Communication Setup

HRVision (2D) 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 (2D). The following table is a summarized table of the HRVision (2D) correspondence for the 3 types of commands of Hyundai Robot.

Command	Number	Function	HRVision (2D) correspondence
MODEL	01~32	Transmit model information.	Saves model information to parameter and stands by.
START	01~04	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.

The following figure depicts the communication sequence between Hyundai Robot and HRVision (2D).



The following code is the code related to the RS-232 communications protocol to be added from the robot work program. Add the following code to the communication part with HRVision (2D).

```
==========================================================================
      V2%=0
      R9=(0,0,0,0,0,0)R
      *MEASURE
S3    MOVE L,P1+LR[V1%+1]+R[V3%+50]+R9,S=300mm/sec,A=0,T=0    ' Move to measuring location
      DO23=1    ' Lighting ON
      '==================
      'Vision measuring location
      CLR232C 2
      R8=(0,0,0,0,0,0)R
      *NG
      PRINT #2,"MODEL 1"
      DELAY 0.3
      PRINT #2,"START 02"
      DELAY 0.3
      _TEINPUT=13
      _TEINPUT=10
      INPUT #2,V1$
      V2$=LEFT$(V1$,2)
      IF V2$="OK" THEN
      R8.CFG=8
      GOTO *GOOD
      ELSE
      GOTO *NG
      *GOOD
      PRINT #2,"SHIFT 8"
      DELAY 0.2
      WAIT R8.CFG AND 16,3,20    ' Jump to S20 when the data is not received for 3 seconds
      PRINT #0,"Vision data receipt "
      PRINT #0,"Vision vision value:";R8.X;"mm","Y value:";R8.Y;"mm","RZ value:";R8.RZ;"mm"
      CLR232C 2
      DO23=0
      R9=R9+R8
      V2%=V2%+1
      IF V2% < 2 THEN *MEASURE
      CLR232C
```

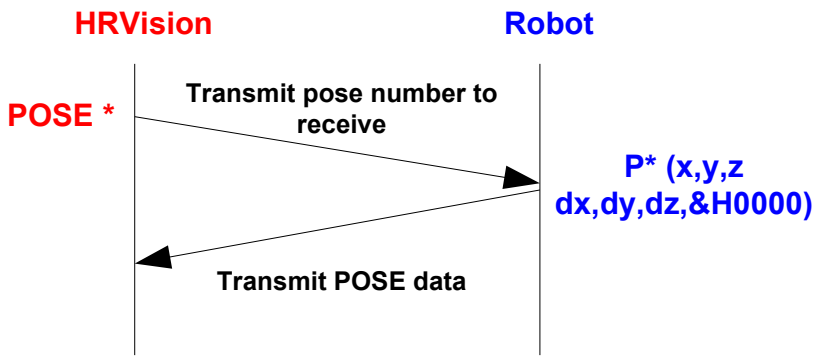
4.3.1.2. POSE Data Communication Setup

The communication method to grab the pose data of the robot is requested by HRVision (2D). There is only one command “POSE” for HRVision (2D) to request to Hyundai Robot.

POSE command receives the all pose data saved in the controller when the number after the command is 900. The following table is a summarized table of the correspondence of Hyundai Robot for the POSE command of HRVision (2D).

Command	Number	Function	Correspondence of Hyundai Robot controller
POSE	900	Request for all POSE data.	Transmit POSE parameter from Pose 901 ~ Pose 904 of Hyundai controller in 1 second intervals continuously.
POSE	901~904	Request for specific POSE data of the set number.	Transmit specific pose data of Hyundai controller.

The following figure depicts the POSE command sequence.

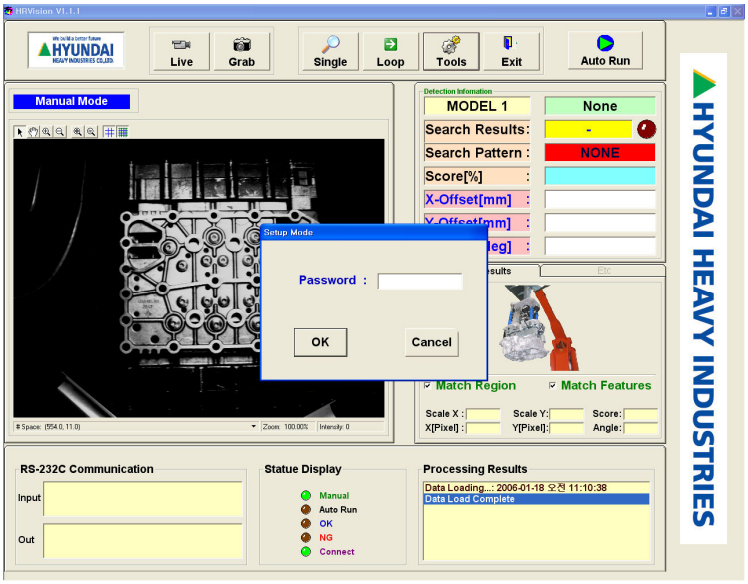


The following code is a robot work code to transmit the POSE data of the robot automatically in connection with HRVision (2D). The user generates the new robot work program and insert the following code as is. To receive the POSE data of the robot automatically, the robot work program must be in operation from the robot controller.

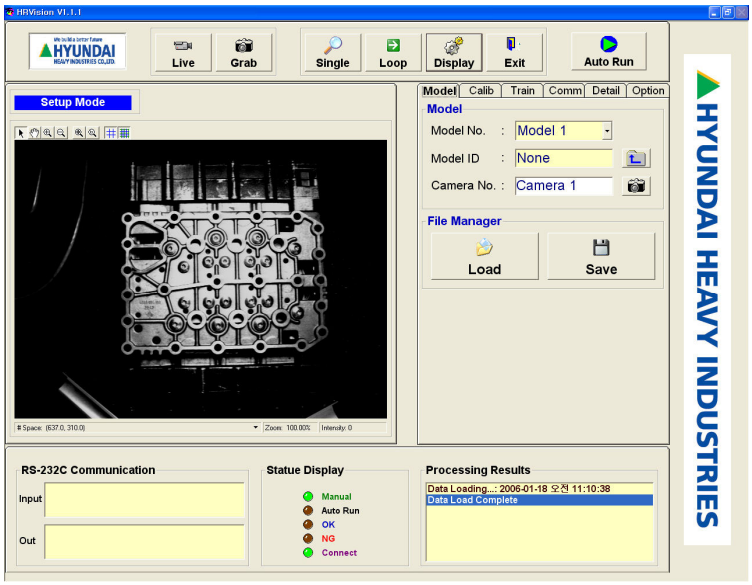
```
==========================================================================
    *START
     CLR232C 1
     _TEINPUT=13
     _TEINPUT=10
     V1$=""
     V2$=""
     INPUT #1,V1$
     V2$=LEFT$(V1$,6)
     IF V2$="POSE 900" THEN
     PRINT #1,P901
     DELAY 1
     PRINT #1,P902
     DELAY 1
     PRINT #1,P903
     DELAY 1
     PRINT #1,P904
     DELAY 1
     ELSEIF V2$="POSE 901" THEN
     PRINT #1,P901
     GOTO *START
     ELSEIF V2$="POSE 902" THEN
     PRINT #1,P902
     GOTO *START
     ELSEIF V2$="POSE 903" THEN
     PRINT #1,P903
     GOTO *START
     ELSEIF V2$="POSE 904" THEN
     PRINT #1,P904
     GOTO *START
     ELSE
     STOP
     ENDIF
     END
==========================================================================
```

4.3.2. HRVision (2D) Communication Setup

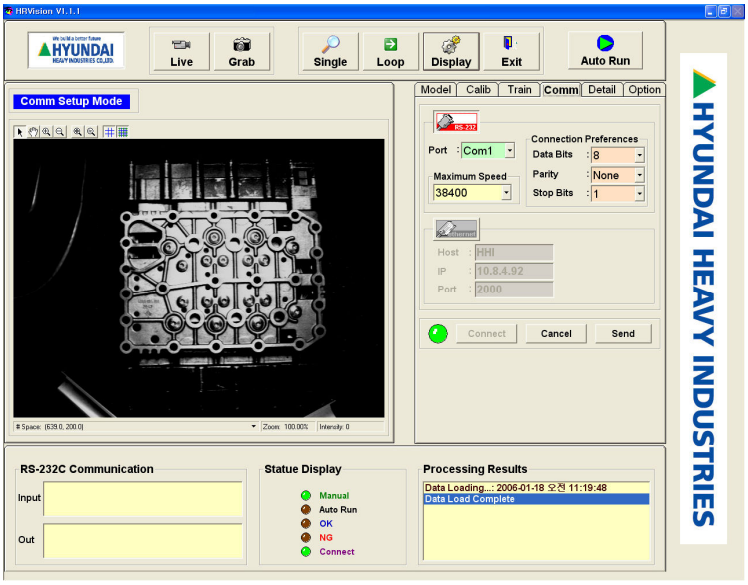
When the robot work program preparation is completed from the robot controller, the communication of HRVision (2D) must be set.
Click on the Tools button from the operating button and the following login window will appear. When purchasing HRVision (2D), enter the transmitted password.



When the login is successful, the screen changes to the setup mode as follows.



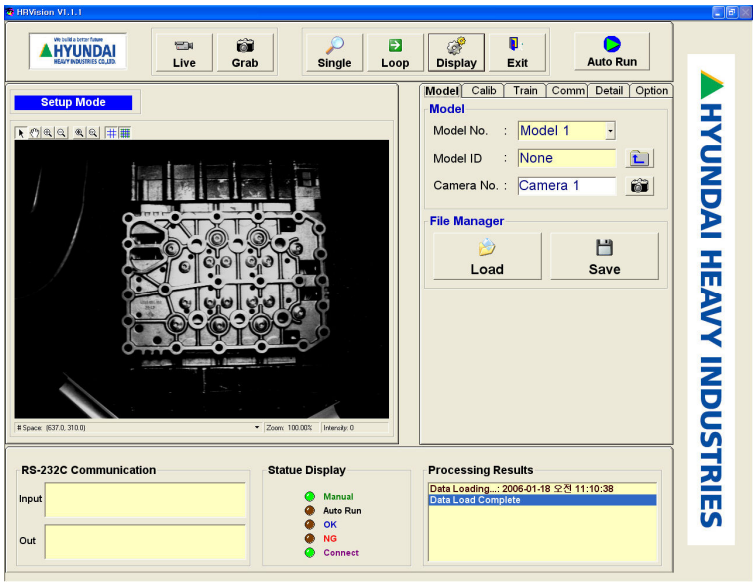
Click on the Comm from the setup mode. Click on the communication method you would like to connect to and setup various parameter. The following pictures shows the user of the connected screen connected to COM port 1 and speed of 38400 using RS-232 method



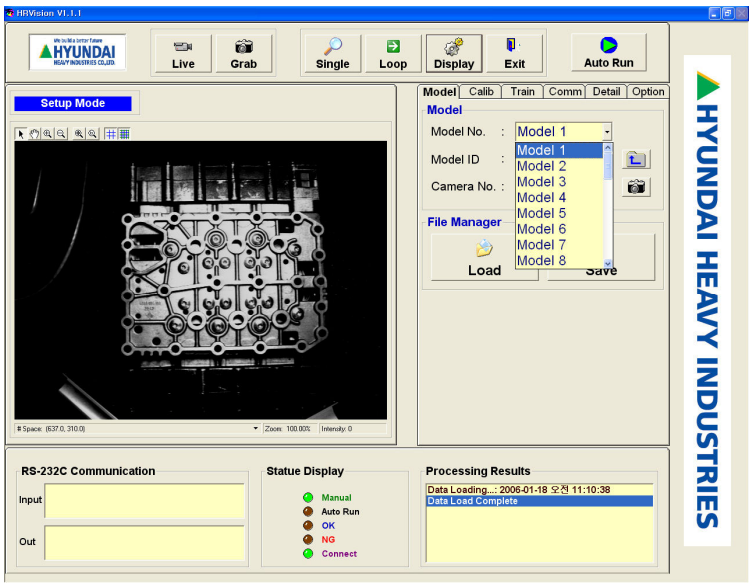
4.4. Camera Calibration

4.4.1. Model Setup

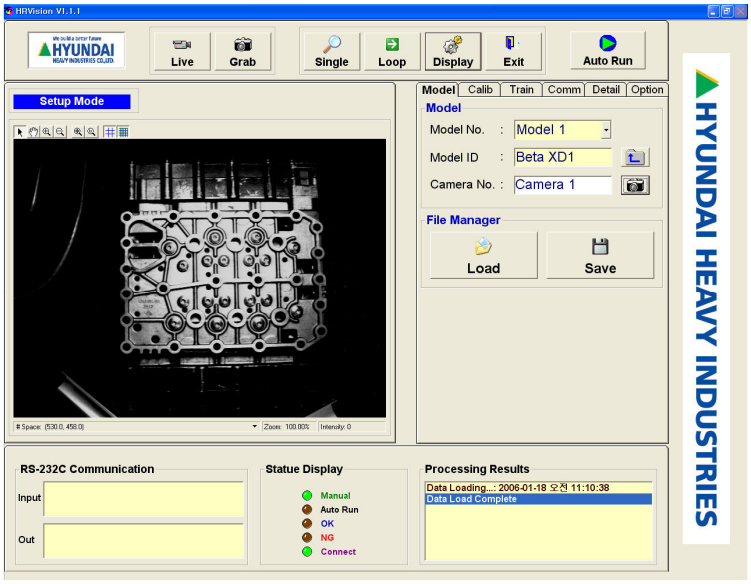
Pattern recognition result and calibration data is managed by model.
First, click on the Model tab in the setting mode.



Select the Model No. from the combo box.



Enter the model ID and click on the  button. In this example, I have entered “Beta XD1”.



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 (2D) 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, work piece arrangement, pattern recognition accuracy etc., set the distance between the camera and the work piece (Grab image location). The distance between the camera and the work piece 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 work piece has to be modified start resetting all the setup of HRVision (2D) including the camera calibration.

Set the calibration board on the pallet where the work piece 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.

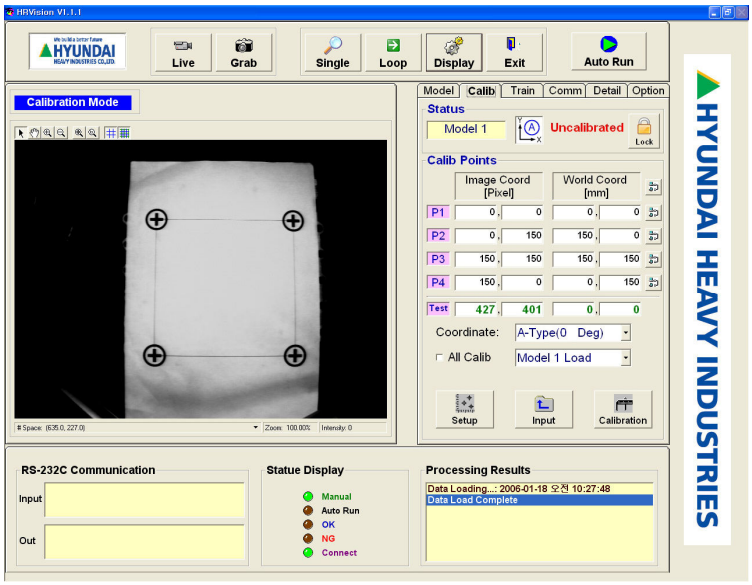
4.4.2.2. Teach Calibration Point

Attach a tip at the tool end of the robot and teach the 4 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.
Each calibration point is saved as Pose 901, Pose 902, Pose 903 and Pose 904 of Hyundai Robot controller in this order. When each calibration point is saved as POSE parameter, we can receive the transmitted robot location automatically by using the robot work program prepared in 4.3.1.2.

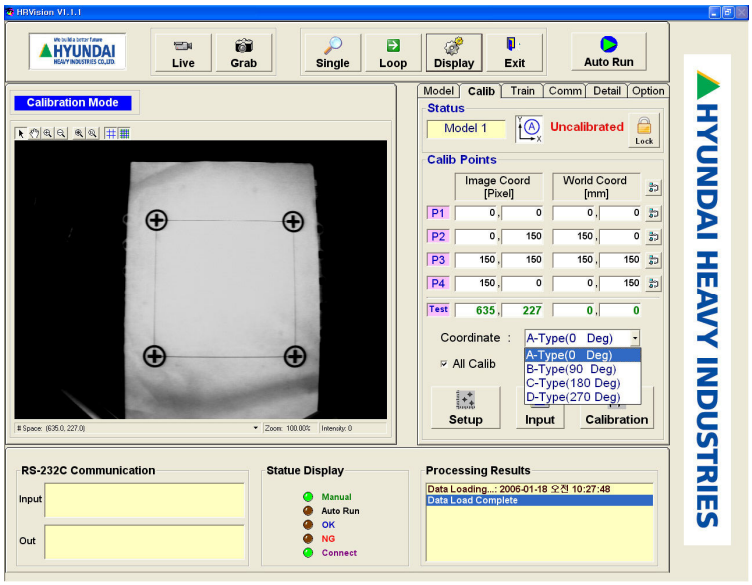
When the teach calibration point is completed, recover the tool parameter of the original tool parameter.

4.4.2.3. Grab Calibration Board Image

Grab the image including the calibration board from the Grab Image location.
At this time, set both “Distance between camera and calibration board” and “Distance between camera and the work target” in the same way.



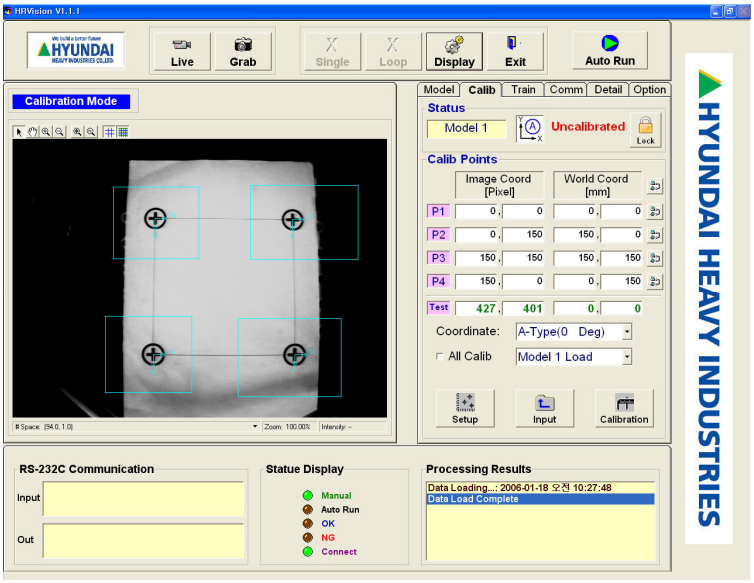
Enter the camera direction for the robot coordinate. Refer to 3.7.2 Calib for details.



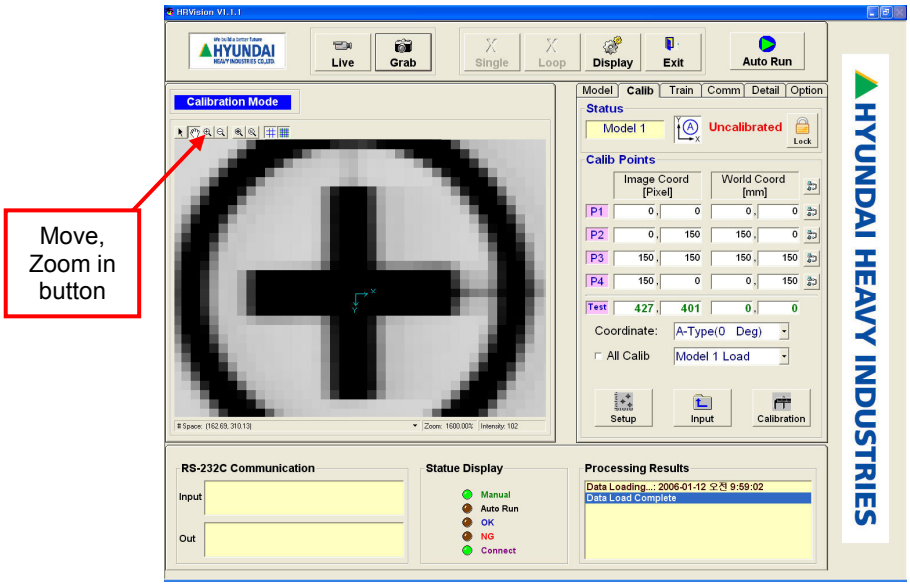
4.4.2.4. Detect Calibration Point and Enter Coordinate

4.4.2.4.1. Image Coordinate Setup

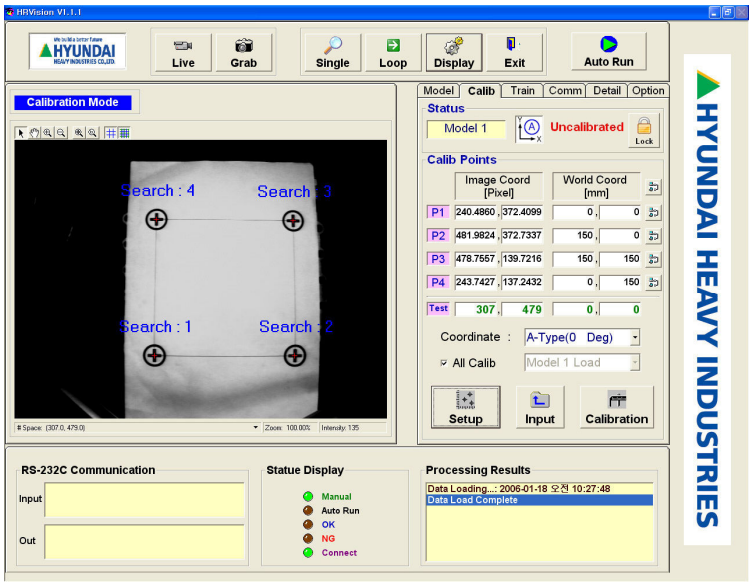
Click on the setup button of the Calib tab. 4 light blue search window and coordinate axes were created from the Image window, and the Setup button changes to the Search button. The user arranges each search window and coordinate axis on the 4 points of the calibration board.



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 4.5.2.4. Calibration point detection process.

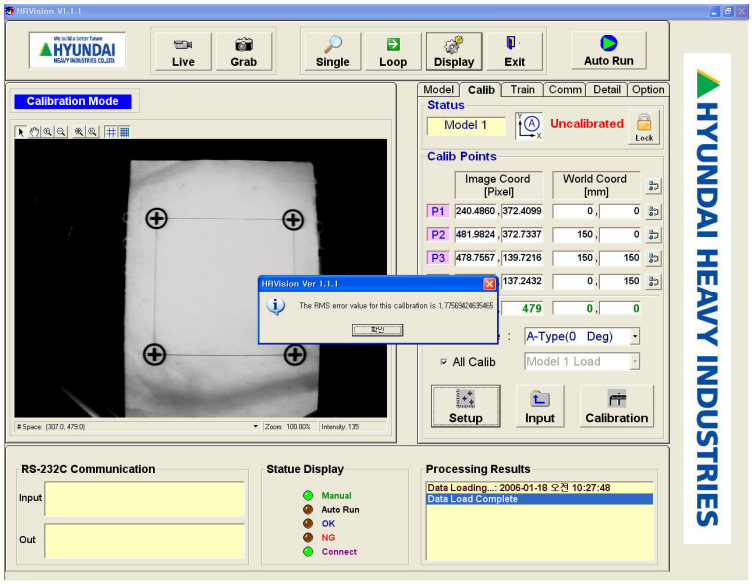


4.4.2.4.2. Robot Coordinate Setup

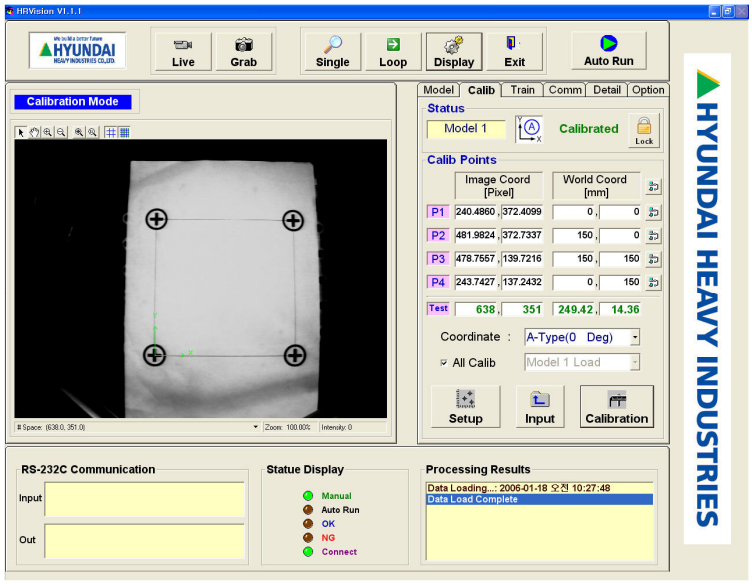
If you have saved the location of calibration points from 4.4.2.2 to the POSE parameter of the robot, execute the robot work program prepared in 4.3.1.2 by the robot controller and click on the Calib tab to receive the location of each calibration point automatically. If the location of the calibration point is not saved as the POSE parameter of the robot, enter the location of each calibration with the keyboard and then click on the Input button of the Calib tab.

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 the RMS error is lower than the RMS Error Limit of 3.7.5. Detail tab, is displays the coordinate axis set to green. If the RMS error is higher than the RMS Error Limit, you will see a warning window to guide you to re-execute the camera calibration. Generally the RMS Error Limit (Permitted RMS error value) is set to standard of 1.



4.5. Work Hold Location Teach

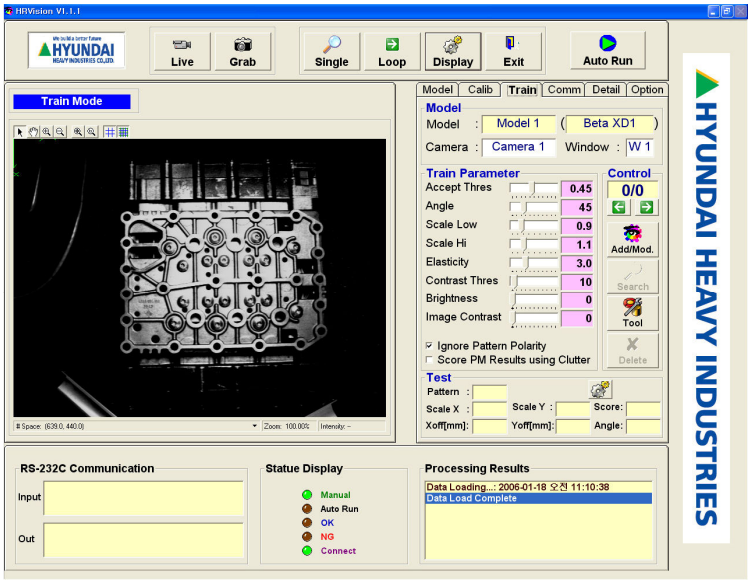
Arrange the work piece on the pallet and teach the Hyundai Robot to set the location to hold the work piece.

4.6. Model Pattern Addition and Pattern Recognition Test

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

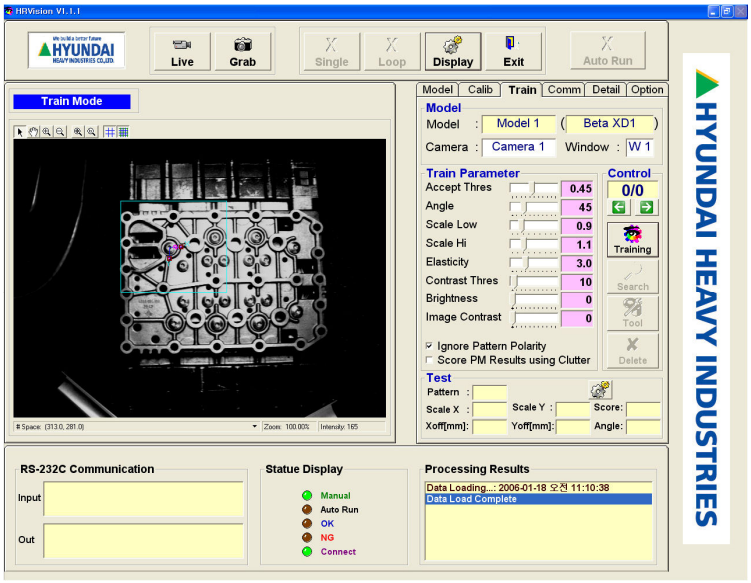
4.6.1. Grab Image

From the holding location of the work piece, move the Hyundai Robot to the Grab Image location. At this time, the work piece should not move. Click on the Train tab from the Setup mode, and click on the Grab button of the operation buttons.

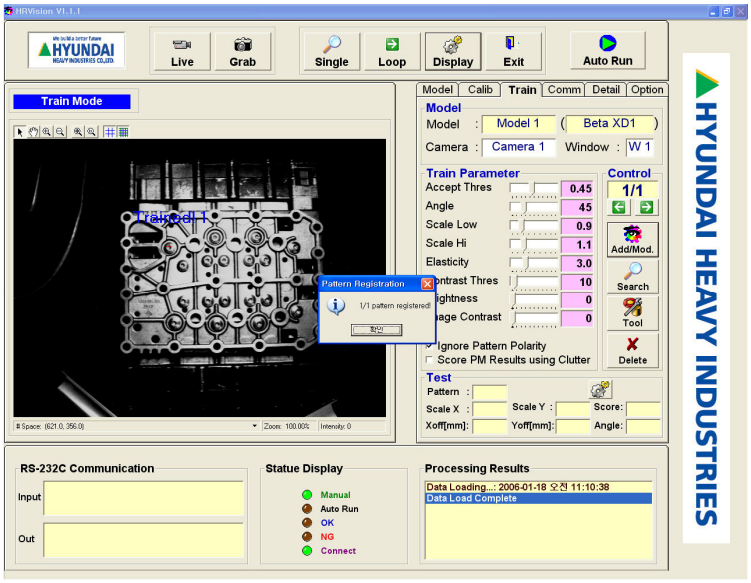


4.6.2. Pattern Addition

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.

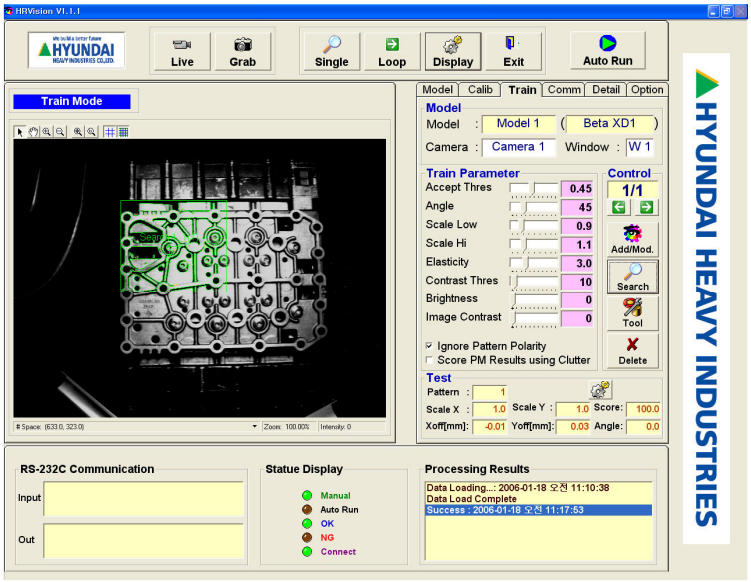


After setup up the pattern setup window and coordinate axis, click on the Train button. When the pattern recognition is successful, the following Pattern addition window appears. If there is an error in the pattern recognition, reset the pattern and parameter. Refer to 3.7.3 Train tab for parameter setup.



4.6.3. 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/modify/delete to setup the optimal pattern model. Refer to 3.7.3. Train tab for detail setup method.

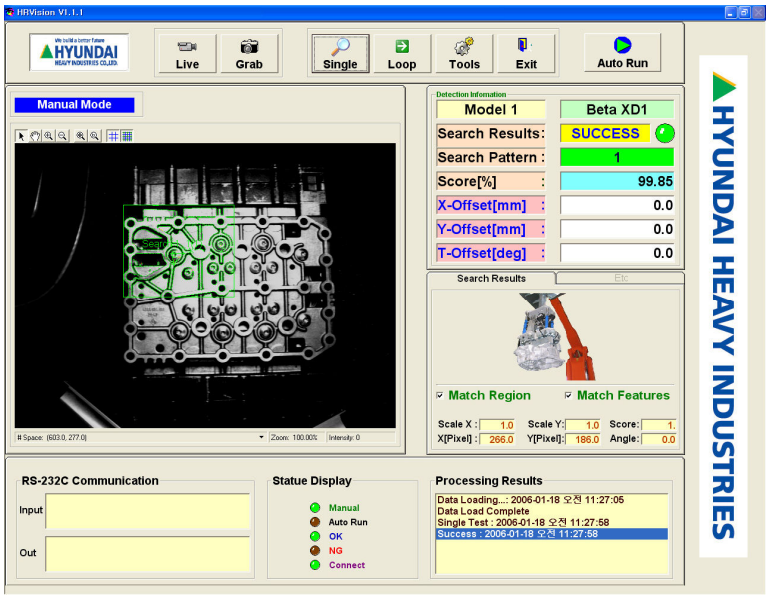


4.7. Recognition performance test

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

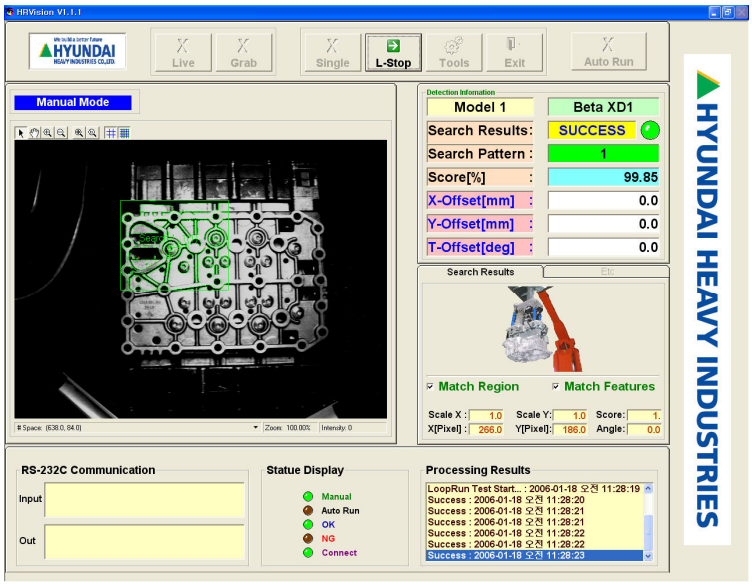
4.7.1. Single (Inspection) Execution

Click on the Single (Inspection) button from the operating button and execute the pattern recognition work once.



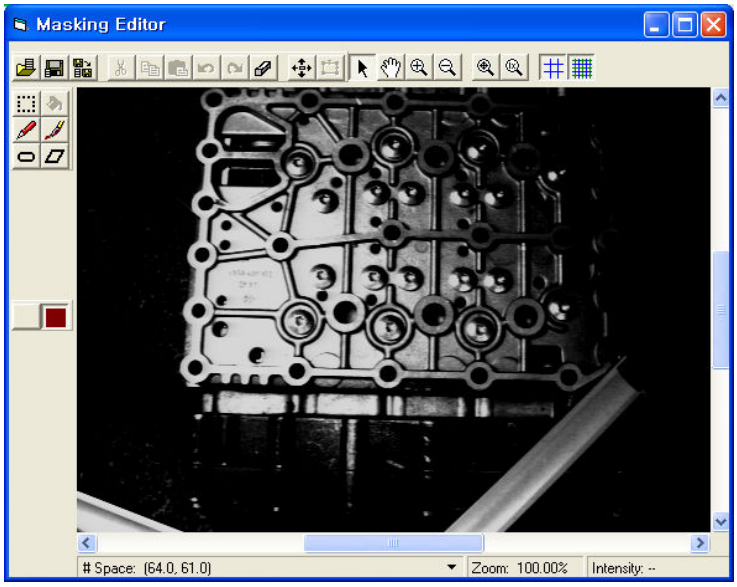
4.7.2. Loop (Continuous inspection) Execution

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



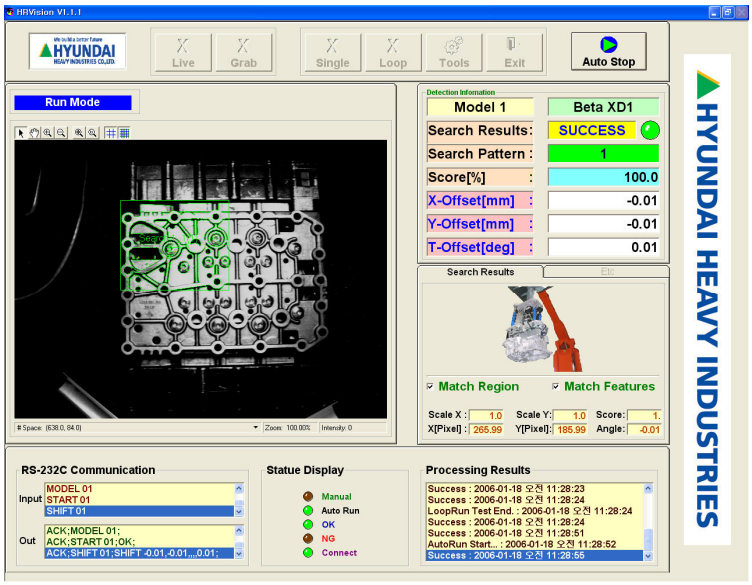
4.8. Model Pattern Supplement

Do not add/modify/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.
Click on the Tool button of the Train tab to open the screen to call Masking Editor.



4.9. Auto Operation

When all the setup is completed, HRVision (2D) 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 (2D) can only be operated through the communication with the Hyundai Robot.



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