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WARNING

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

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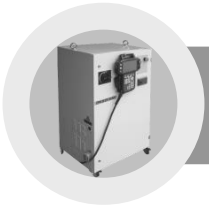

Hi5a Controller Function Manual

HRVision 3D-Stereo

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Printed in Korea – Apr. 2023 3nd Edition
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1 Introduction

1.1. About HRVision 3D-Stereo

HRVision 3D-Stereo is a PC-based vision software for the robots and Hi4a/Hi5/Hi5a controllers of Hyundai Robotics to measure the 3D position/posture of a car body.3

HRVision 3D-Stereo provides color graphic operating buttons and an intuitive user interface for easy user operation. Applying a pattern recognition method that uses autoexposure calibration, multiple pattern registration, and geometric shape information, this software makes it possible to perform pattern recognition rapidly and accurately even in an environment where the illumination condition unstable.

By measuring three or more feature points that exist on a workpiece, this software can measure the 3D position/posture of the workpiece. It prevents vision measurement errors that could occur due to the false recognition of a feature point.

In addition, with Hyundai Robotics robot controller data communication protocols embedded, any operator of an Hyundai Robotics robot can use the vision system and the robot system by linking them easily without problem.

HRVision 3D-Stereo is an optimal tool that can perform measurement of the 3D position/posture of the car body by using an Hyundai Robotics robot.

HRVision 3D-Stereo provides the following convenient functions.

Simple operation	You can set and operate the vision system easily by using the operating button.
Auto camera calibration	This function is provided to perform auto stereo camera calibration by using a calibration plate.
3D position/posture measurement	It is possible to acquire the 3D position/posture of a workpiece based on the common coordinate system by measuring the four positions acquired from one stereo camera.
Hand-eye structure application	It is possible to estimate the 3D position/posture through the acquisition of the images from multiple time points by changing the position of the robot if the 3D position/posture of a workpiece cannot be measured.
Exposure calibration	This function makes it possible to perform pattern recognition robustly despite the variation in illumination of the surrounding environment by providing some functions such as autoexposure calibration and user-designated exposure setting.
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.
Ellipse fitting	If there is a circular feature point with the workpiece, it is possible to enhance the measurement accuracy of the 3D position/posture by applying the ellipse fitting method.
Tool function	It is easy to set camera calibration, pattern registration, Reference car body registration, communication setting, various data managing by using each functional tool. 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.

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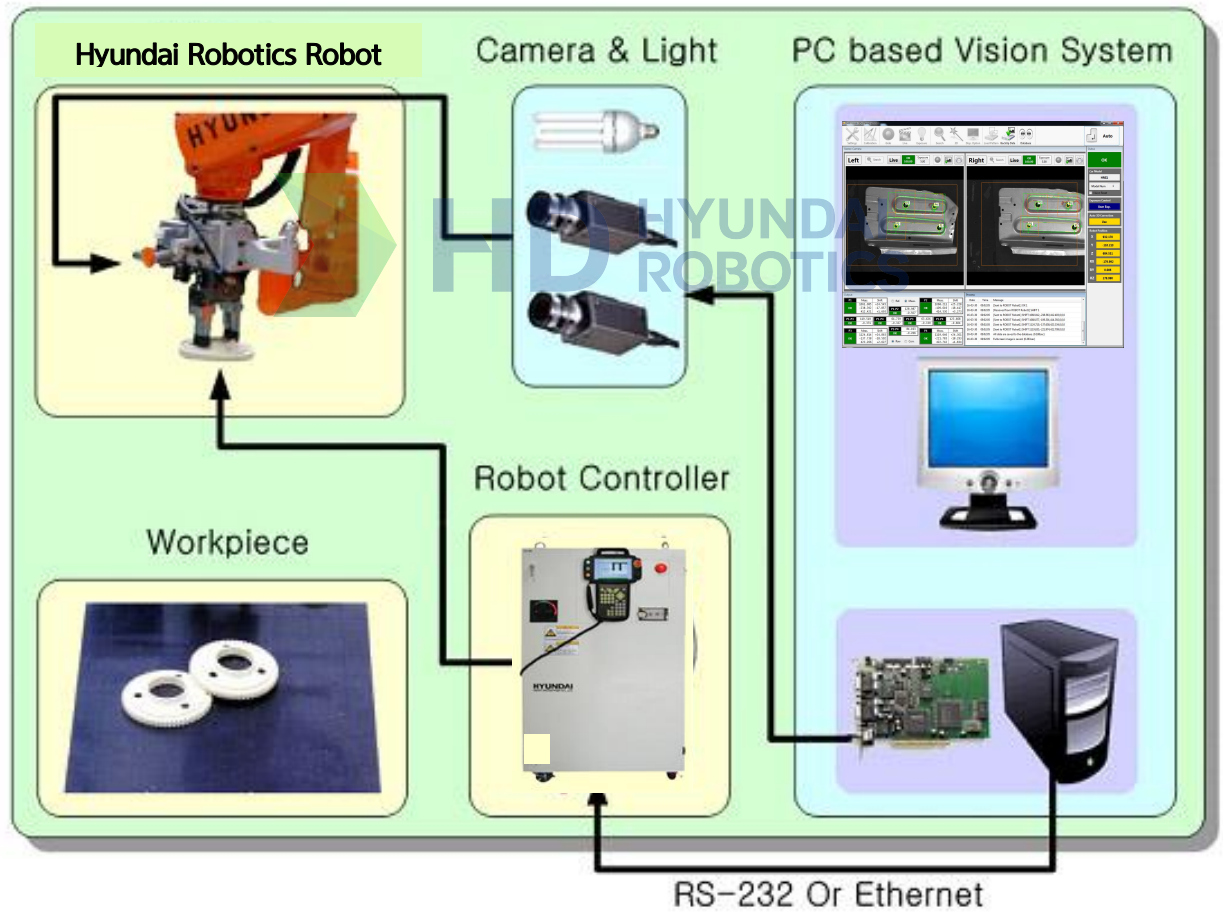
1.2. System Configuration

The following figure shows a schematic diagram of a handling robot vision system that uses the HRVision 3D-Stereo. The entire system consists of the robot system and the vision system. The vision system consists of hardware, including a PC, a frame grabber, a camera, an illumination unit, and a PLC, and the HRVision 3D-Stereo software.

The user can set and operate the vision system through the HRVision 3D-Stereo program, as well as communicate with the Hyundai Robotics robot through the Hyundai Robotics-specific communication protocol. The Hyundai Robotics robot handles the workpiece according to the position recognition result of its vision system.

A frame grabber will be unnecessary when using a digital camera.



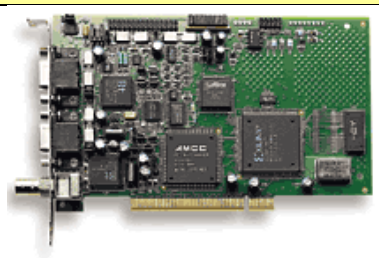
1.2.1. Hardware Configuration

The recommended H/W of HRVision 3D-Stereo is as follows.

H/W	Item	Recommended specifications
PC	CPU	At least 2GHZ Multi-core Processor 512KB or more L2 cache
	OS	Windows XP, Windows 7
	RAM	2GB or above
	Video	PCIe x16 Video Card
	HDD	80GB or above
	CD-ROM	X48
	PCI Slot	2 units * For mounting a frame grabber when using an analog camera
Lighting	Light	Will change depending on the LED, the fluorescent lamps, and the installation environment and usage.
Vision system	Frame Grabber	8511VX or 8514VX (COGNEX) 1 unit * Unnecessary when using a digital camera
	Camera	XC-HR70 (SONY) or MV-BX30A (CREVIS) 2 units
	Lens	H1214-M(PENTAX) Can be changed depending on installation environment and usage.
	Cable	20m

If you would like to use HRVision 3D-Stereo by adding multiple numbers of patterns, use a PC with high performance CPU and sufficient memory.

The following shows the details of the vision system required when using an analog camera.

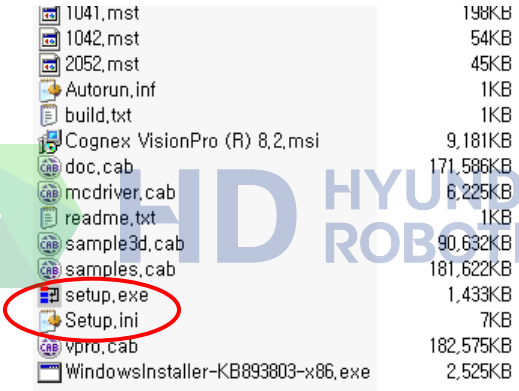
Model name	Exterior	Specifications
MVS-8111VX MVS-8514VX		High speed Frame Grabber Number of camera that can be connected: Maximum of 4 units Connection method: RS170, CCIR 1/2 slot PCI
XC-HR70, MV-BX30A		1/3" CCD 1024(H)×768(V) C Mount DC 12V 29(W)×29(H)×30(D) mm
H1214-M		Focal Length : f12mm Format 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

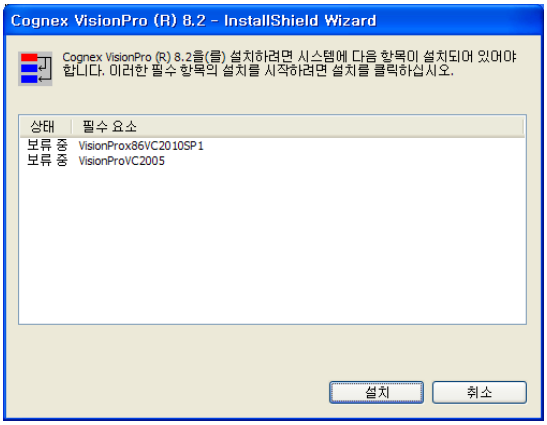
This consists of VisionPro 8.2 and the HRVision 3D-Stereo Setup software.
VisionPro 8.2 is a software that provides the driver for the Cognex frame grabber and other application tools.
The HRVision 3D-Stereo Setup software is an Hyundai Robotics-specific PC-based 3D robot vision software that can recognize a car body. It is required to install the program and to first register for a license before using it.

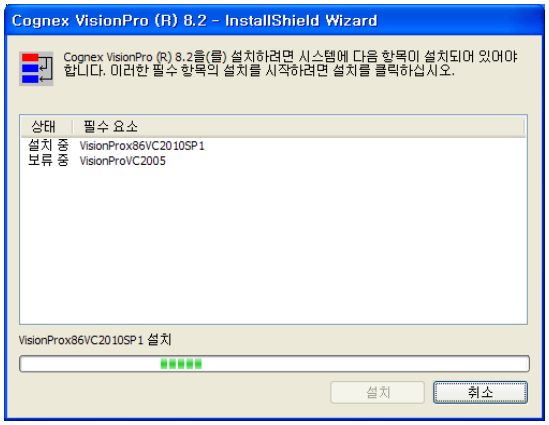
1.2.2.1. VisionPro Installation

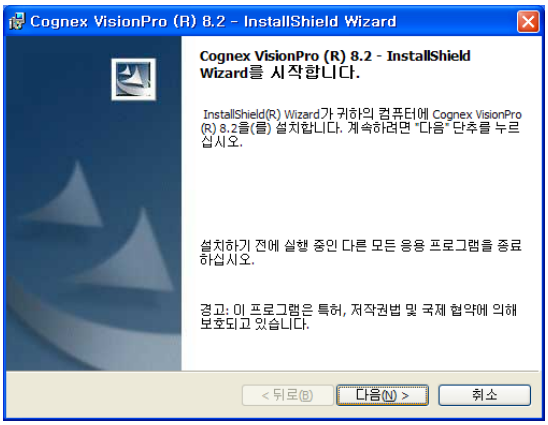
End all application softwares on the system.
Insert the installation CD of VisionPro into the CD-ROM drive. If it is not automatically executed, execute the setup.exe file among the installation files.



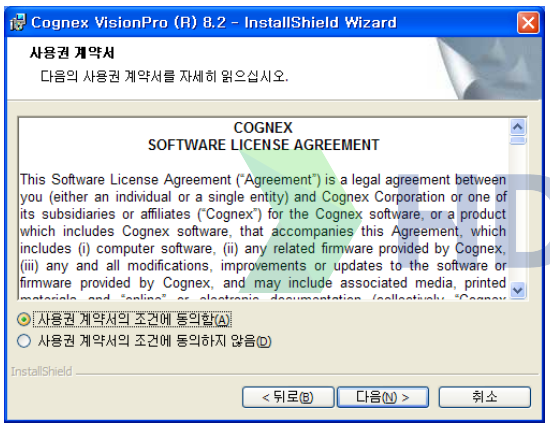
When the following installation appears, follow the installation procedure and direction as the general Windows program.



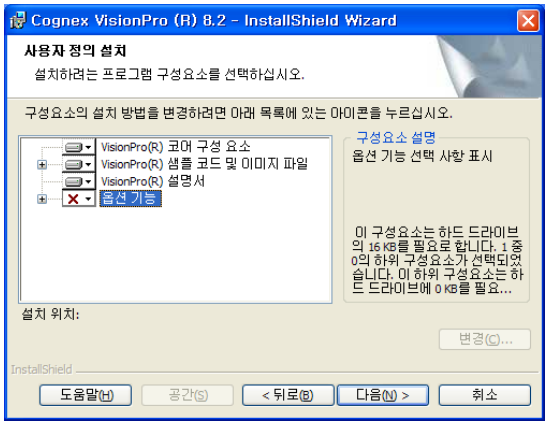


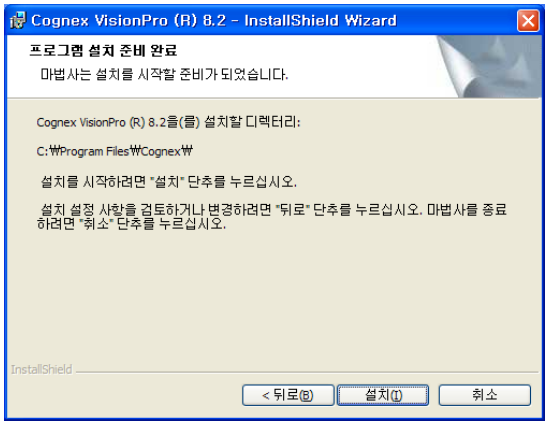


It is required to agree to using the license, as shown below, and to input the user information.



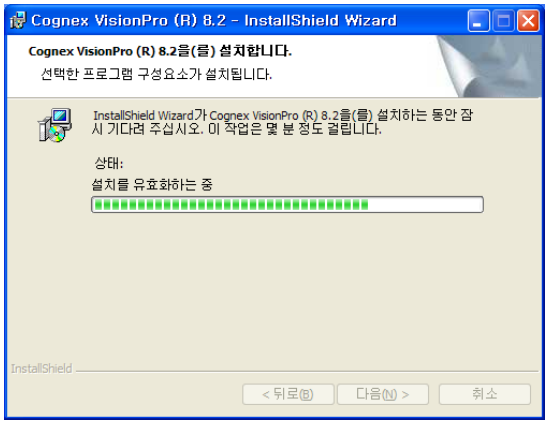
When you follow the instruction, the Cognex VisionPro(R) 8.2 will be installed, as shown below.

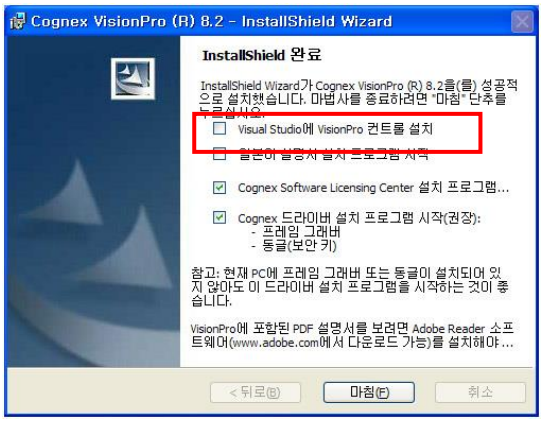




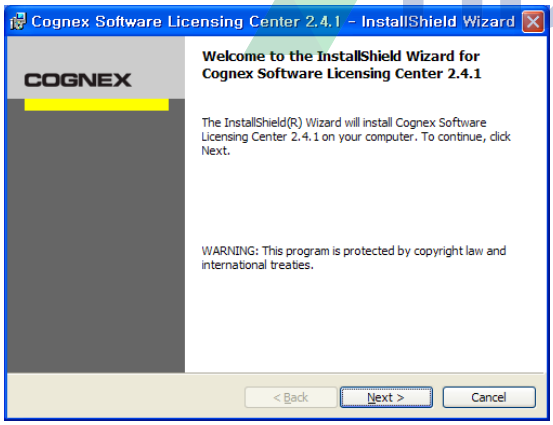
When the Cognex VisionPro(R) 8.2 is installed, it installs the Cognex Software Licensing Center, Cognex Frame Grabber driver..

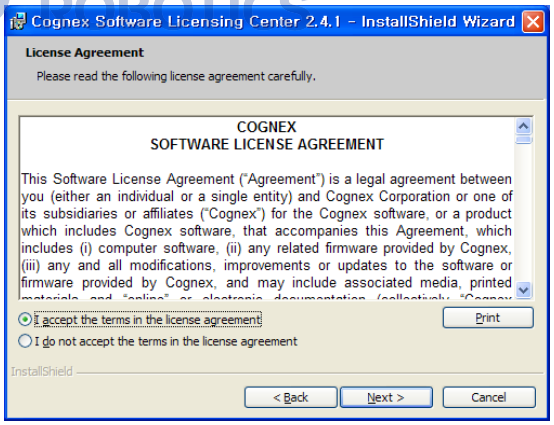
Depending on the system installed, the “Install the VisionPro Control in Visual Studio” button may have been clicked already. Uncheck, and then proceed with the installation.

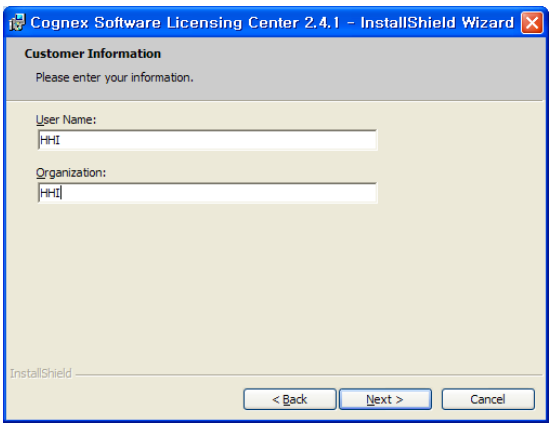


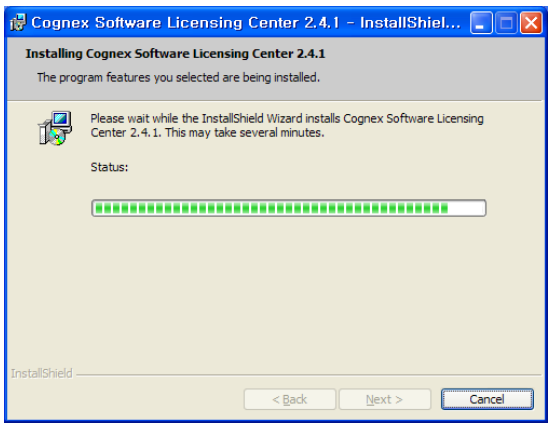


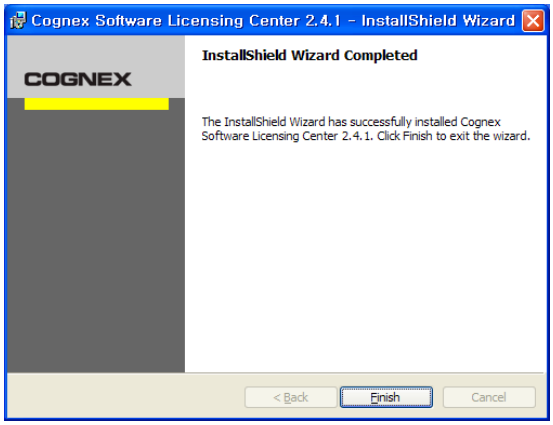
As shown below, you are required to agree to the use of a license and to first input the user information before installing the Cognex Software Licensing Center.



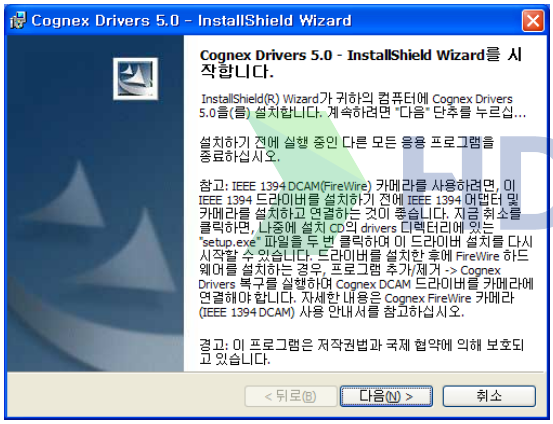


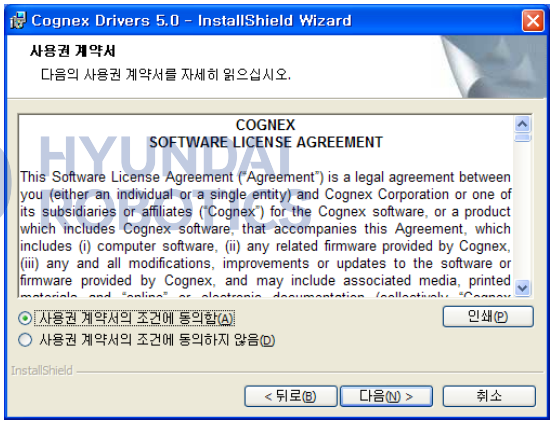


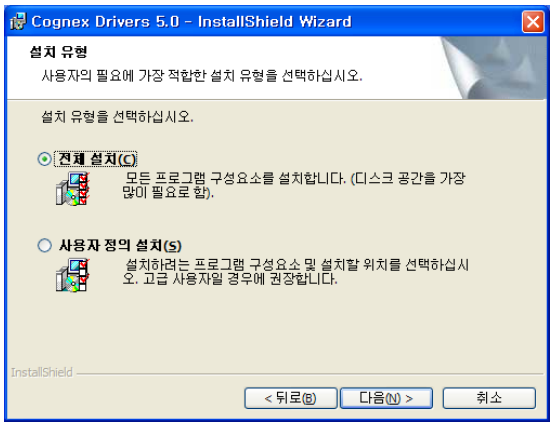


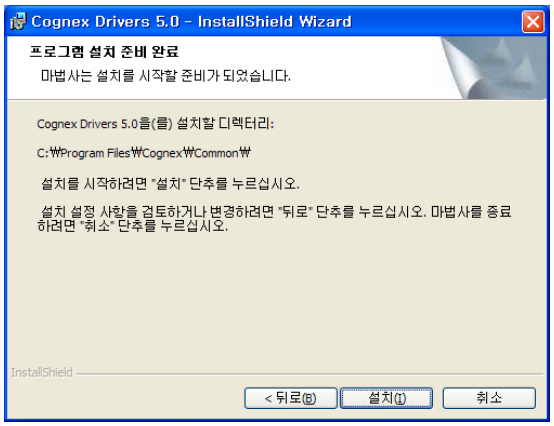


As shown below, you are required to agree to the installation and use of the Cognex driver. Then, select the installation type before proceeding with the installation.



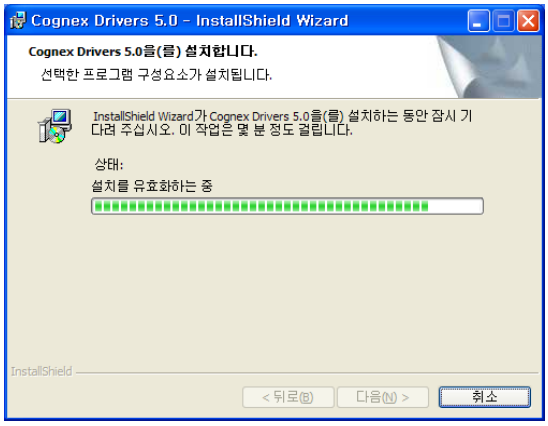


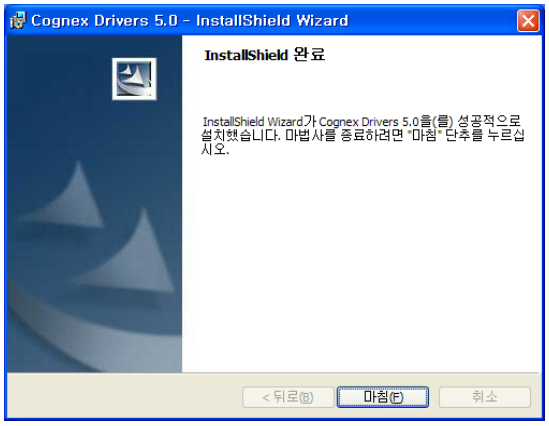


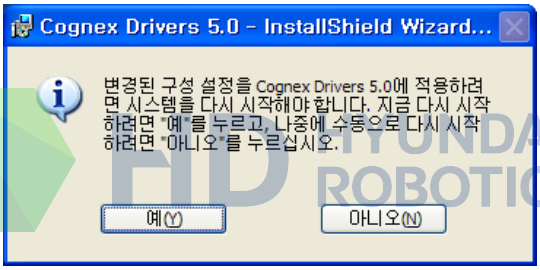


When you follow the instruction, the software related to the Cognex frame grabber will be installed completely, as shown below.

When the driver installation is complete, reboot.

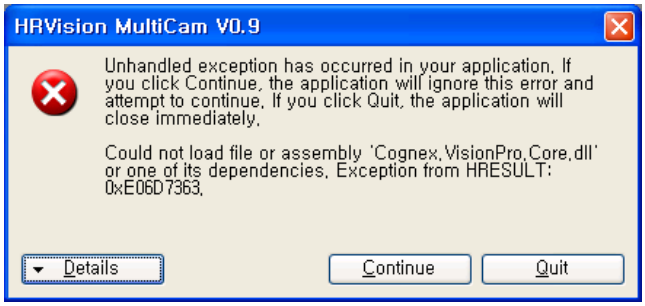






If the HRVision 3D-Stereo program is executed without installing VisionPro8.2, a warning window will be displayed, as shown below.

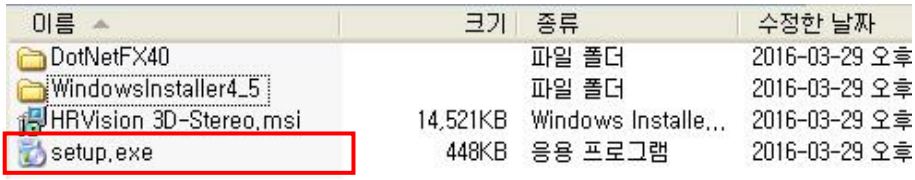
The user should check whether “C:₩Program Files₩Cognex₩VisionPro” is installed. If not, reinstallation should be carried out.



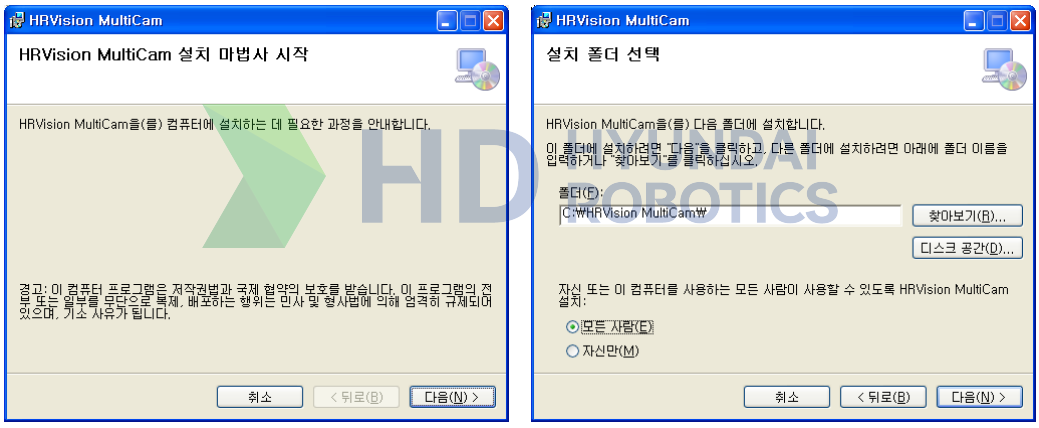
1.2.2.2. HRVision 3D-Stereo Installation

The procedure for installing the HRVision 3D-Stereo program is as shown below.

Execute “setup.exe” in the HRVision 3D-Stereo installation file.

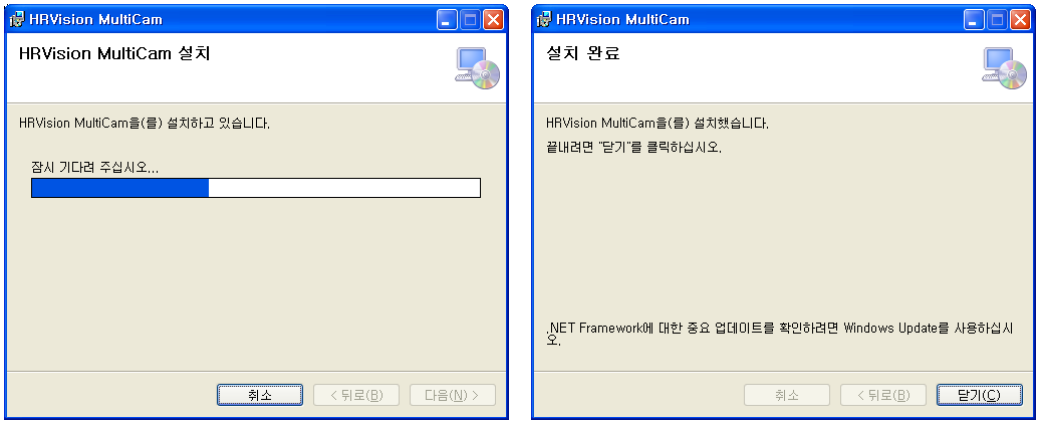


When the following screen appears, follow the directions as the installation procedure of general Windows program.



The HRVision 3D-Stereo execution files will be copied into the “C:₩ HRVision 3D-Stereo” folder. The user should not change the folder arbitrarily.

Clicking the “Next” button will progress and complete the installation of the HRVision 3D-Stereo program.



1.3. HRVision 3D-Stereo Execution

Execute the HRVision 3D-Stereo program by double-clicking on its icon on the desktop.

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2 License Entry

2. License Entry

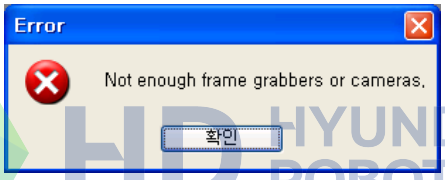
To use HRVision 3D-Stereo, you must enter the license key.
You cannot execute any work in the condition without the license key entered.

2.1. HRVision 3D-Stereo License

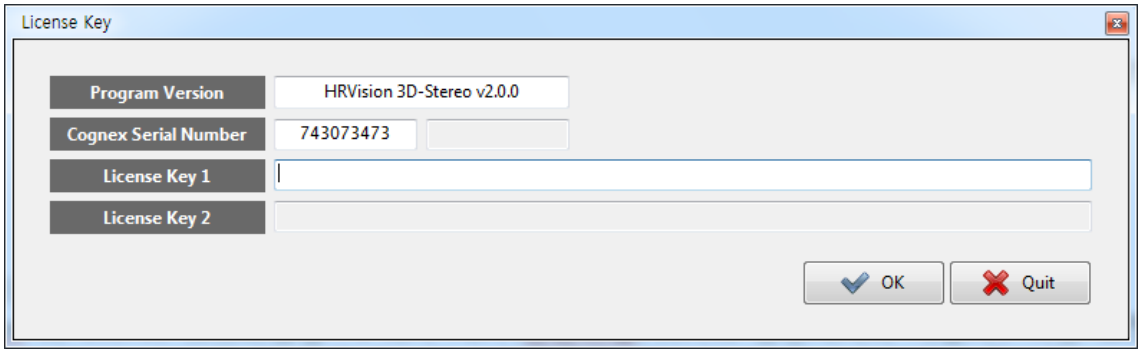
To use HRVision 3D-Stereo, you must enter the license key number that fits the Cognex Frame Grabber of the PC with the S/W installed.
To purchase the user license of HRVision 3D-Stereo from the supplier, you must notify the “System Serial No” for the Frame Grabber of Cognex to use.
The key code that fits the number provided by the customer will be notified to the user.

After the HRVision 3D-Stereo installation, execute the HRVision 3D-Stereo 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.

Once the license key is inputted, it will be saved, which means that there is no need to input it again. But when you uninstall HRVision 3D-Stereo 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.

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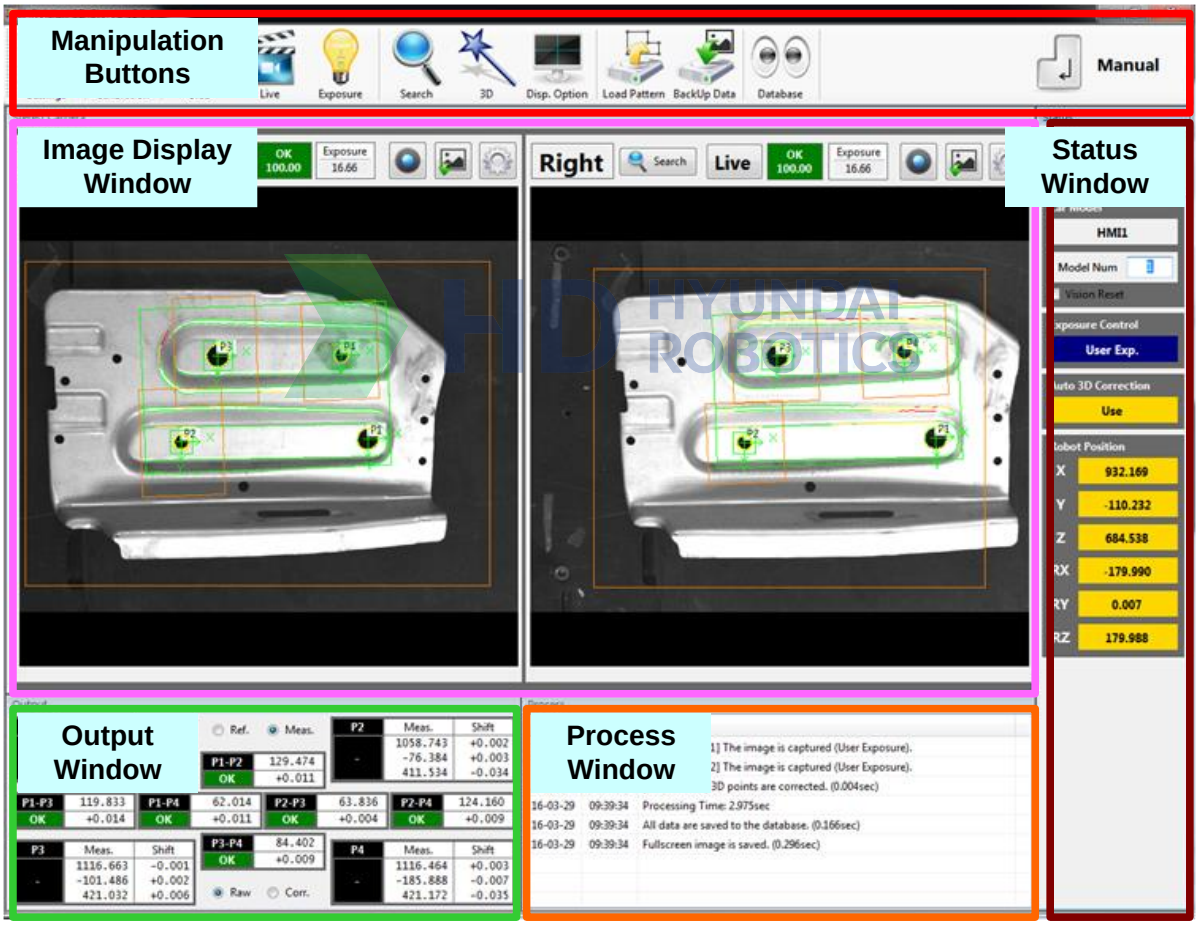
3 Basic Function

3.1. Screen Configuration

HRVision 3D-Stereo 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. Main screen configuration

If the serial key is inputted correctly after executing the program, the following screen will be displayed. The screen of the HRVision 3D-Stereo consists of a total of five windows, and individual programs or setting windows will be displayed according to each menu of the operation program.



The key function of each window is as follows.

Manipulation Buttons	Provides menus for the operation of the HRVision 3D-Stereo such as various settings, image acquisition, calibration, inspection, and auto operation
Image Display Window	This displays the current live or grabbed image.
Process Window	This displays the communication details with the Hyundai Robot, various status display, progress details etc.
Status Window	Displays the results of recognition and the state of communication
Output Window	Displays the 3D position measurement results of the four points of the reference workpiece and the current workpiece, as well as their inter-region distance.

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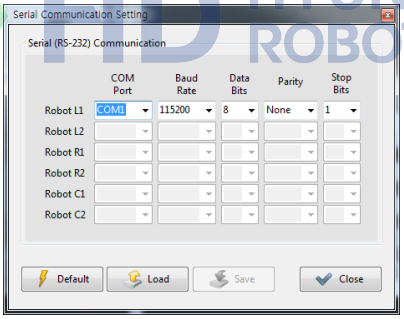
3.1.2. Manipulation Buttons

As the button operating the key function of HRVision 3D-Stereo, each function is as follows.

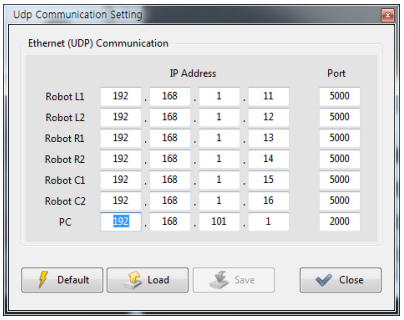
■ Settings
This is a menu for setting/managing various functions and linked hardware. There are 12 sub-menus, as shown below

- System
  Set the camera type, camera calibration method, result outputting method, communication, and others. Select in a way that is suitable for the surrounding facilities and the environment where the installation will be carried out.

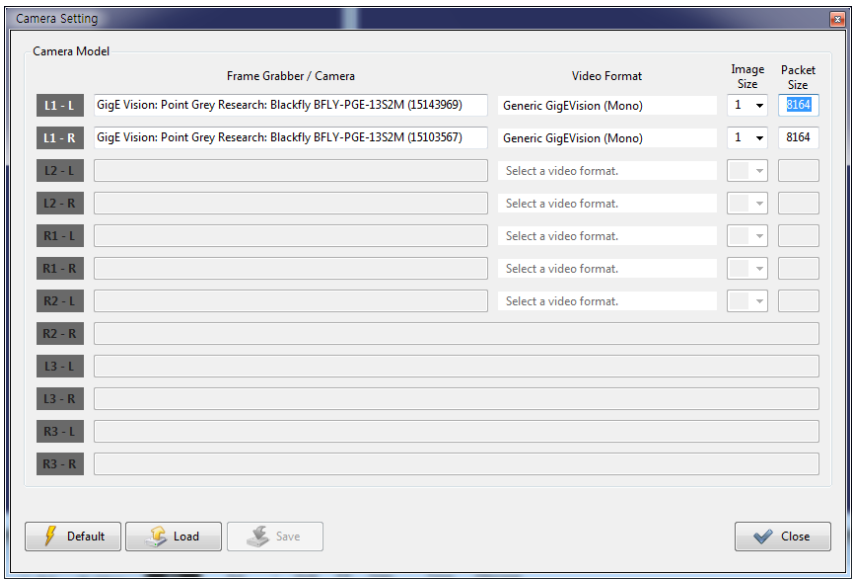
- Serial Communication
  Set the serial communication variable in a way that is suitable for the surrounding facilities and the environment where the installation will be carried out.



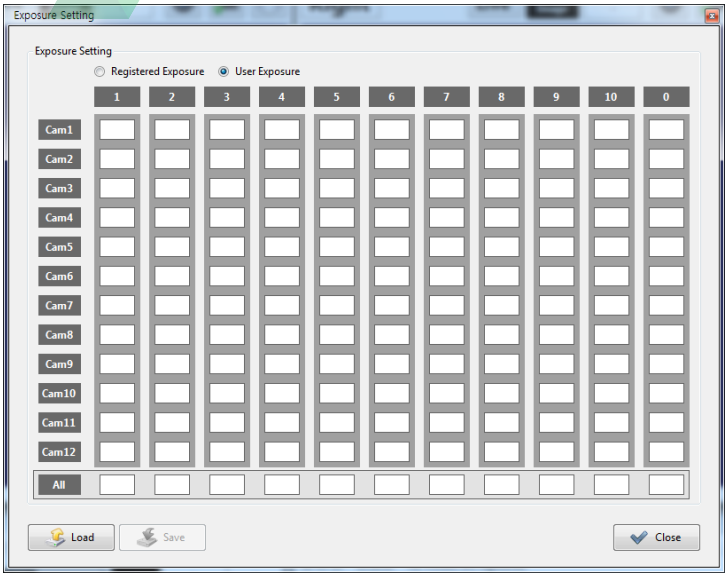
- Ethernet Communication
  Sets the Ethernet communication variable in a way that is suitable for the surrounding facilities and the environment where the installation will be carried out.



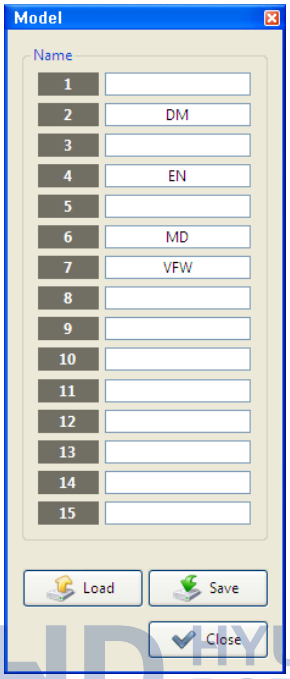
- Camera Setting
  Sets the camera type, connection port, exposure, and others



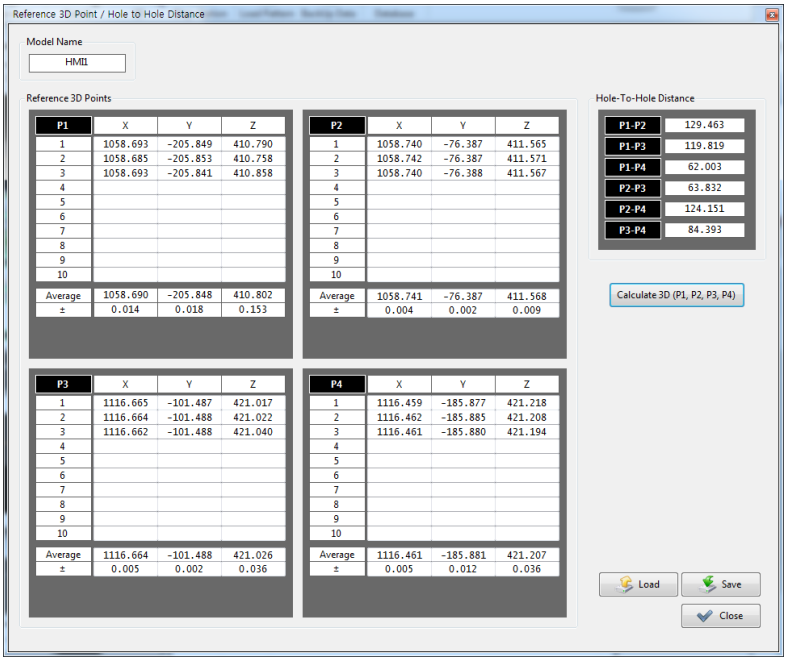
- Exposure Setting
  Sets the user exposure for each type of camera



- Model
  Input the car mode information, and press the “Save” button to store it.

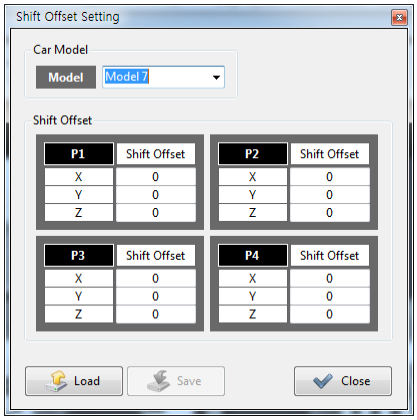


- Reference Points
  Registers the position of the workpiece in relation to the measured four points as the reference position



- Auto 3D Correction
  When “All Points” is selected, the measured 3D data will be calibrated and outputted. On the other hand, when “Non-Use” is selected, the uncorrected data will be outputted. The default is “Non-Use.”

- Shift Offset Setting
  Set the shift offset for each model.



- Limit Setting
  Set the range of the measured data and the error range of the distance between the measured feature points.

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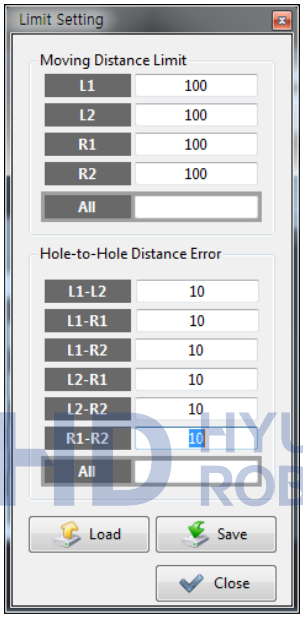
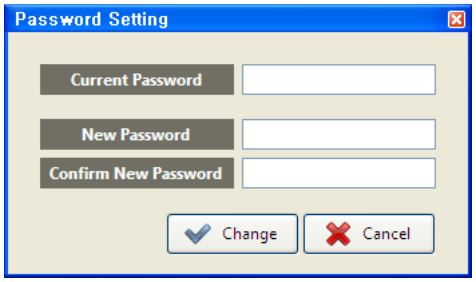
- Limit

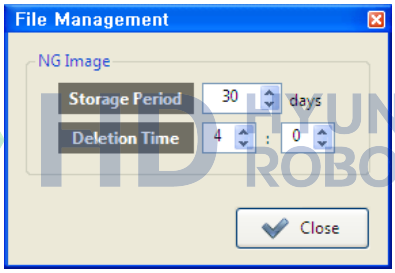
  The “Moving Distance Limit” represents the distance limit within which the measured feature points can move in space. The “Hole-to-Hole Distance Error” represents the error threshold between the measured feature points. If the 3D position of the workpiece moves beyond the “Moving Distance Limit” compared with the reference car body, NG will be outputted. If the distance between the feature points goes beyond the threshold value, NG will also be outputted.



- Password
  Execute password change.



- File Management
  Set the error generation image saving cycle and the deletion time. Considering that data deletion could cause a significant load on the system, it is recommended to set the deletion time at the early hours when the robot is not in operation.

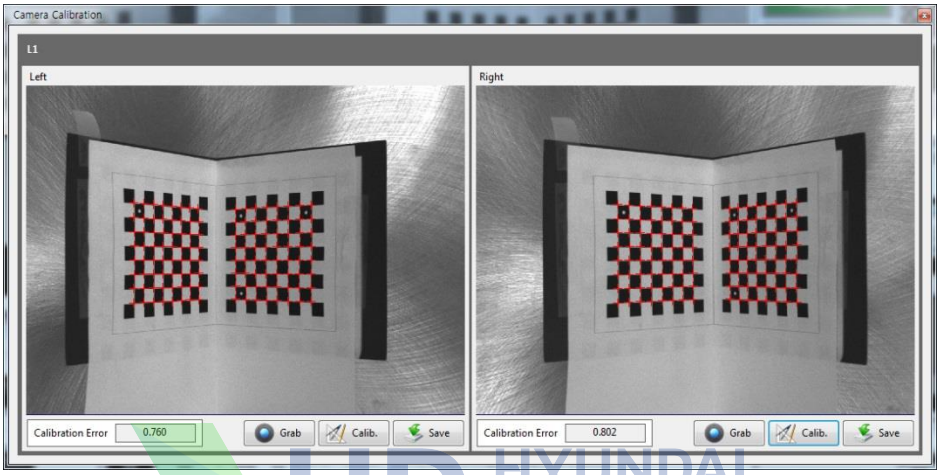


■ Calibration

Loads the camera calibration program, and calculates the relationship between the robot and the camera

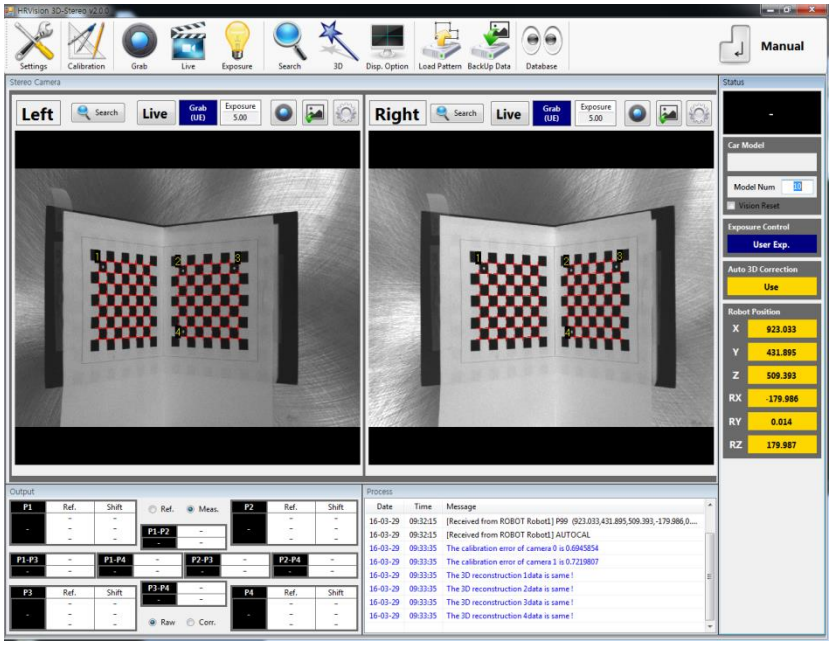
- Camera Calibration

  The stereo camera calibration execution dialog will be loaded, and the camera projection matrix will be calculated. Clicking the [Save] button will save the projection matrix

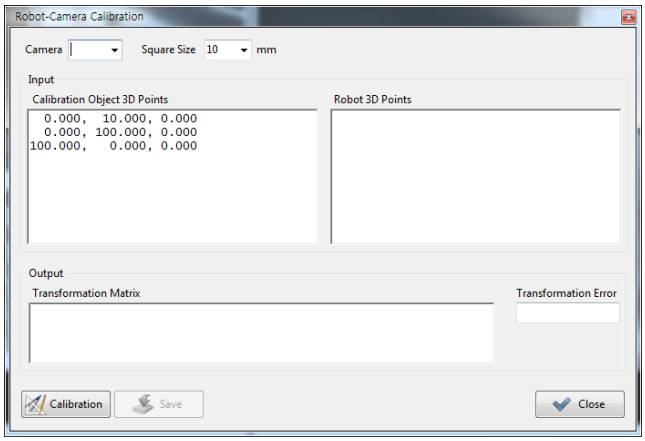


- Automatic Camera Calibration

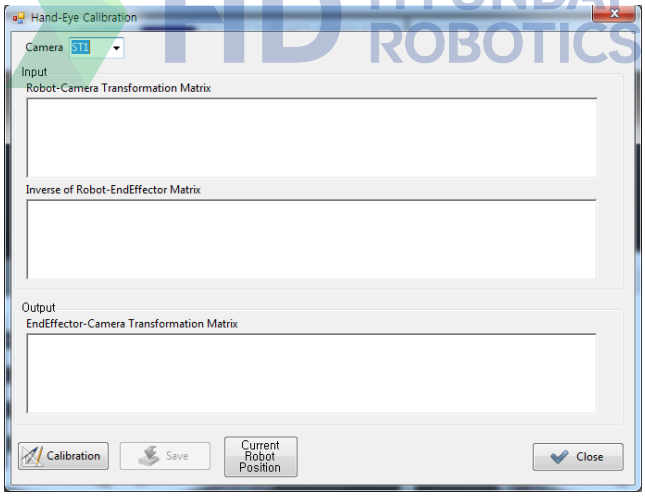
  Executes stereo camera calibration automatically, and calculates and saves the camera projection matrix



- Robot-Camera Calibration
  Calculates the relationship between the calibration plate, which is used for camera calibration, and the robot



- Hand-Eye Calibration
  Calculates the relationship between the robot and the camera attached to it



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

■ Live Display
“Continuous image” will be displayed from the installed camera.

■ Exposure
Provides three types of autoexposure mode

- Registered Exposure
  Acquires the image by applying the exposure used when registering the pattern

- Auto Exposure
  Changes the exposure automatically to ensure that the brightness of the image, which is used when registering the pattern, would be similar to that of the current image When this mode is used, the image acquisition speed will slow down.

- User Exposure
  Acquires the image by applying the exposure used by the user

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■ Search
When there is a pattern registered already, pattern recognition will be performed once after the image is acquired.

■ 3D
When there is a pattern registered already, pattern recognition will be performed once after the image is acquired. After that, the 3D coordinate value will be calculated.

■ Disp. Option
Decides whether to display the output data of the result to be displayed on the image window after the pattern is recognized

- Score
  Displays the matching ratio of the pattern recognition result
- Pattern Region
  Displays the pattern recognition region
- Coordinate Axes
  Displays the coordinate axis of the pattern recognition
- Origin
  Displays the origin of the pattern recognition
- Center and Scale
  Maintains the exposure set in the camera setting window
- Center Guide Line
  Displays a cross at the center of the image

■ Load Pattern
Loads the registered pattern

■ BackUp Data
Saves the currently set pattern data and the calibration data into the “C:₩HRVision Stereo₩Backup” folder

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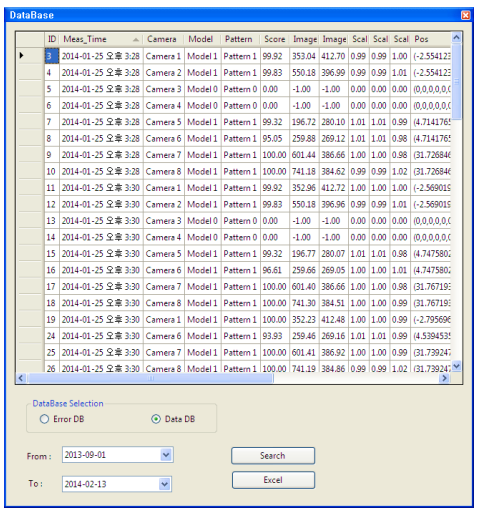
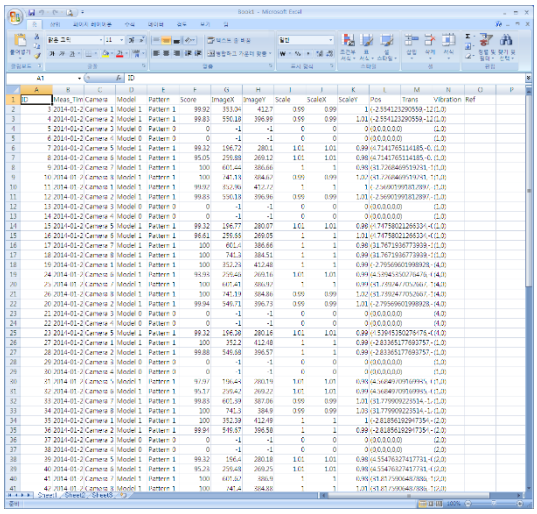
■ DataBase

Displays a search window for the error data base and the measured data base
The search data can be displayed in connection with the “Microsoft Excel” program.





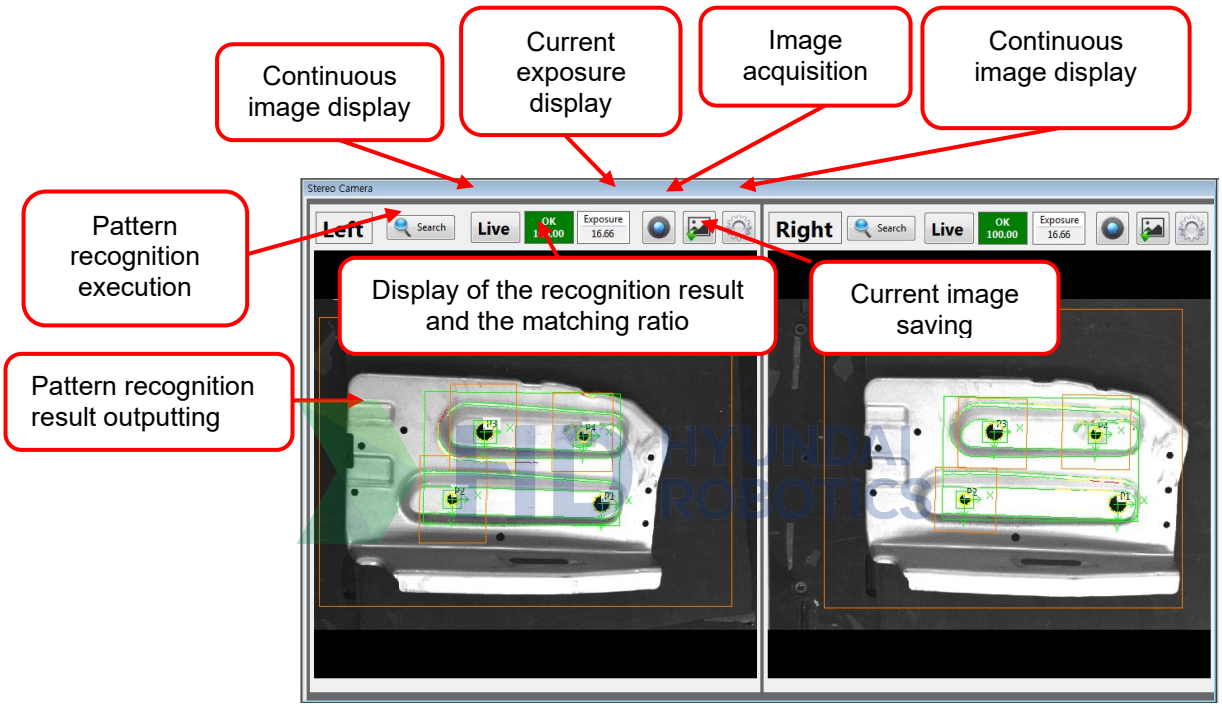
■ Manual/Auto

Change the manual/auto mode. In the auto mode, it is impossible to operate all buttons, and they can be operated through communication with the PLC and the robot.

3.1.3. Image Display Window

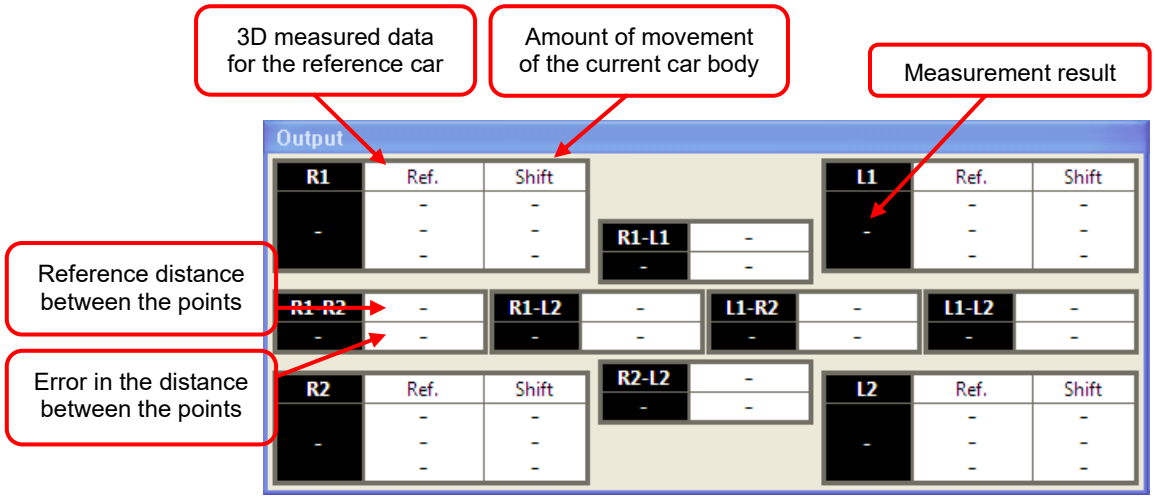
The image window displays the continuous image or the currently acquired image and the pattern recognition result.

In the image window, it is possible to perform zoom in / zoom out, fit image, image shift, and others by operating the mouse.



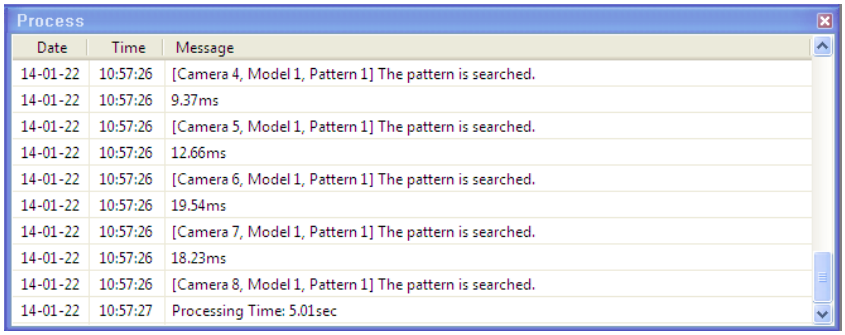
3.1.4. Output

The output window shows the reference car body, the 3D position of the four points of the current workpiece. It also shows the position error in the moving distance and the distance between the points.



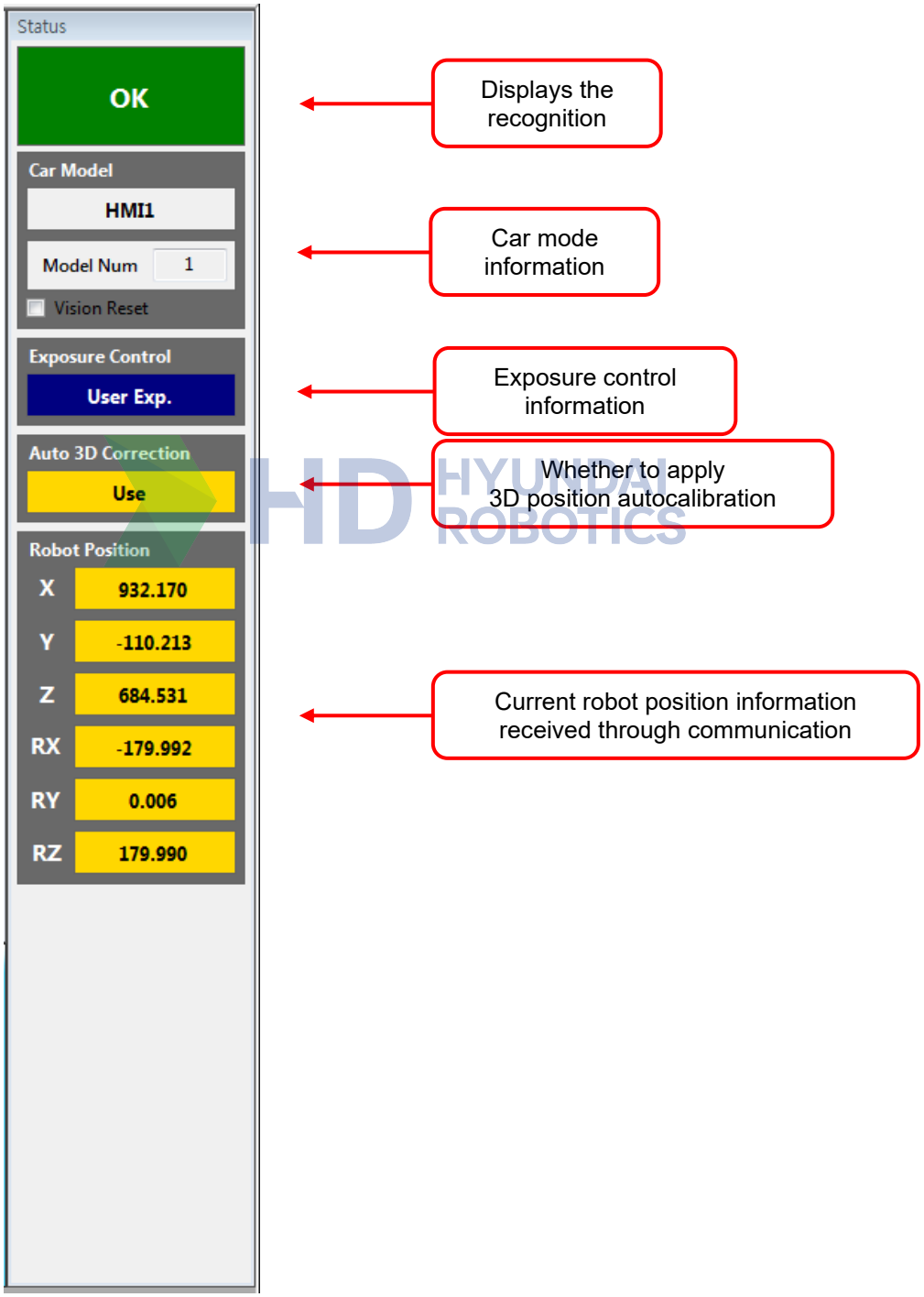
3.1.5. Process Window

Displays the operation status of the HRVision 3D-Stereo



3.1.6. Status Window

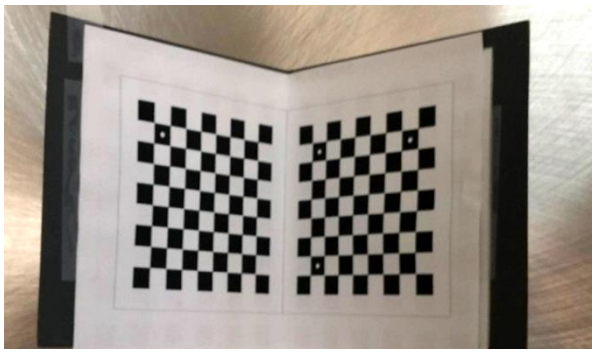
Displays the recognition result, car mode, application of various functions, and the state of communication with the PLC



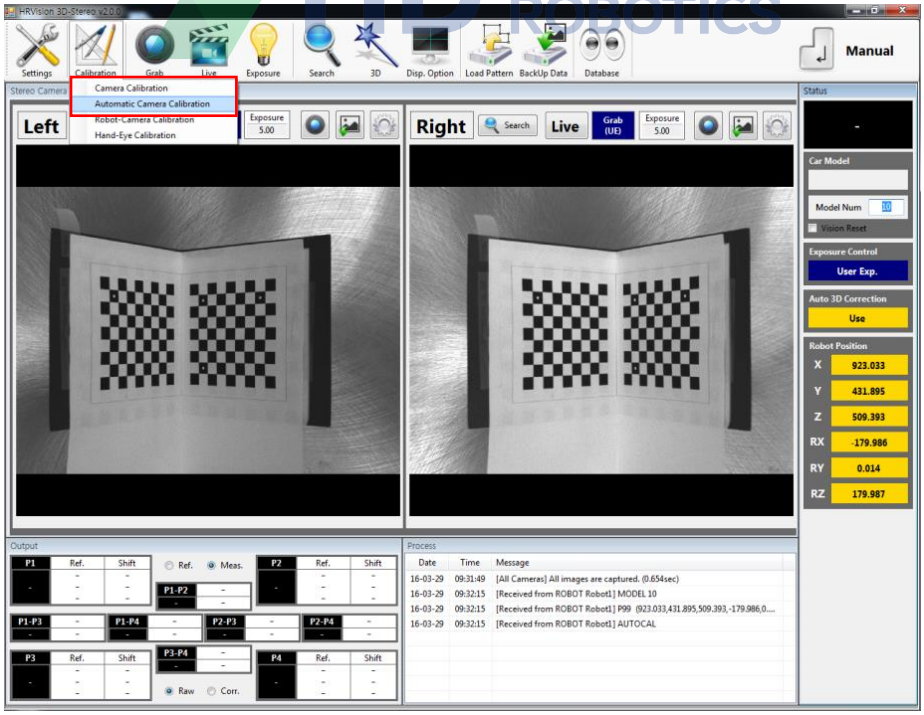
3.2. Key functions

3.2.1. Stereo Camera Calibration

This is a process that performs camera calibration to match the camera coordinate system and the common coordinate system of the process. HRVision 3D-Stereo performs calibration by using the calibration plate, as shown below.

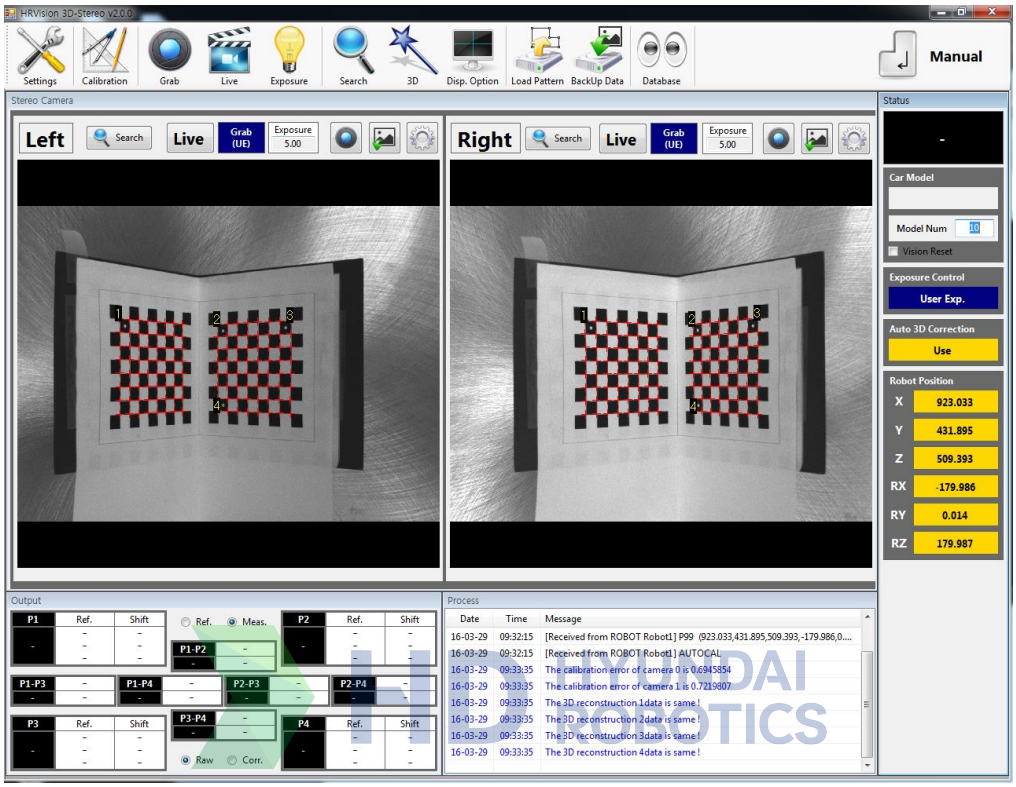


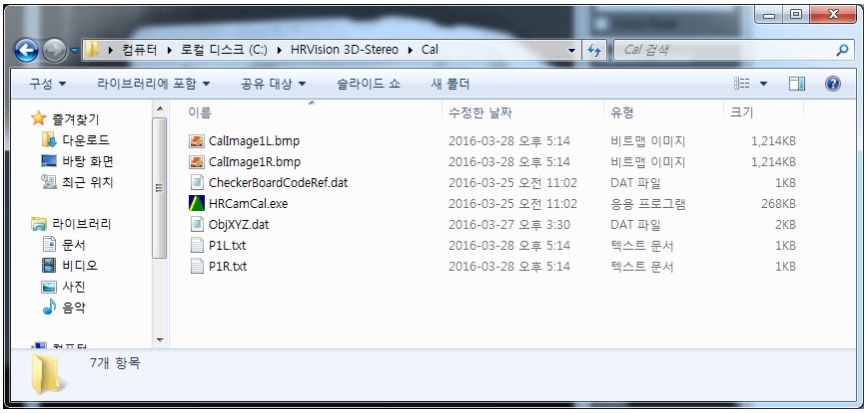
The abovementioned calibration plate needs to be arranged to be positioned inside the quadrangle of the camera.



In the “Calibration” menu of the HRVision 3D-Stereo menu, click “Automatic Camera Calibration.” When there is a calibration plate arranged on the screen, the corner points inside the calibration plate will be detected automatically. Then, the projection matrix will be saved in the “C:₩HRVision Stereo₩Cal” folder. Check whether the “P1L.txt” and “P1R.txt” files relevant to the selected camera models are created. If the files are created, camera calibration will be completed. If not set automatically, move the robot to the

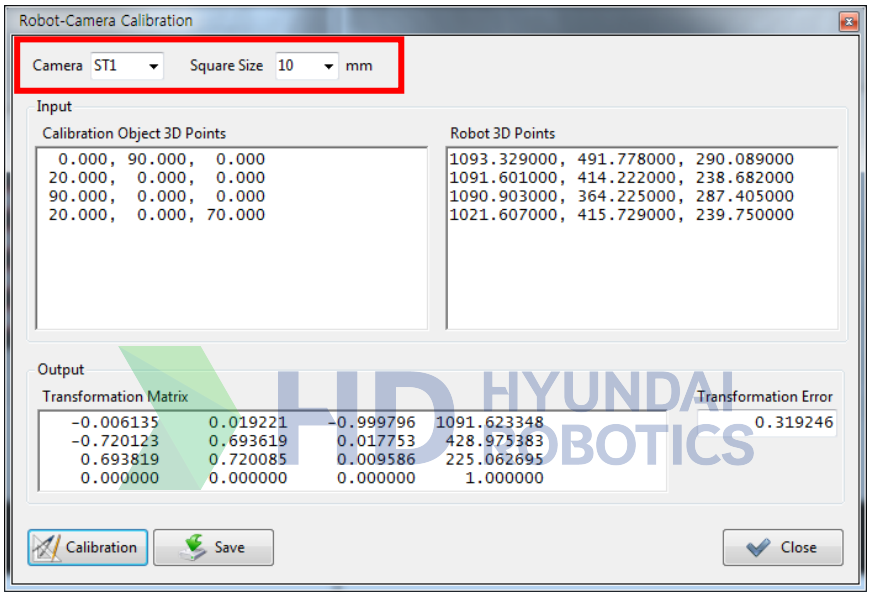
point where the corner points of the calibration plate is clearly visible, and then execute again.



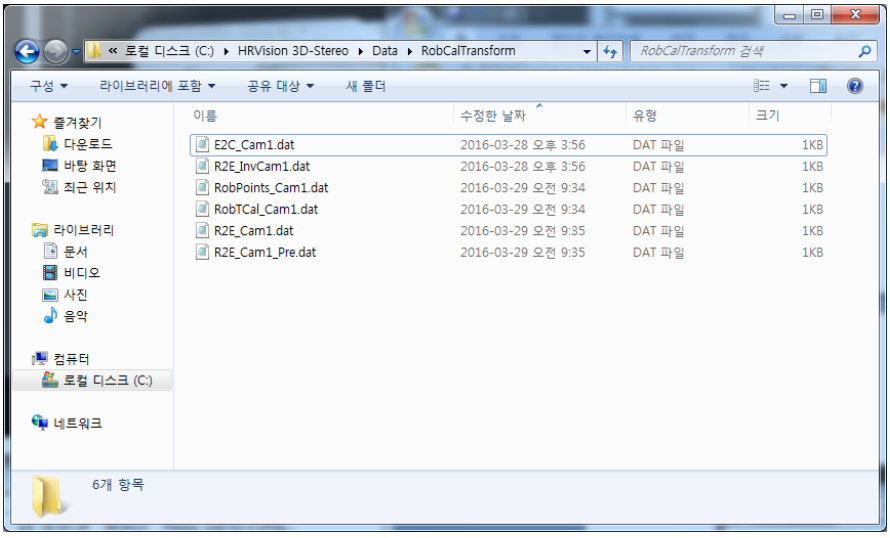


3.2.2. Robot-camera calibration

This is a process that matches the calibration plate coordinate system and the robot coordinate system. When ST1 is selected in the camera combo box and the quadrangle size of the calibration plate is selected, the "Calibration Object 3D Points" will be generated automatically. Input four robot teaching points correspondingly, and then click the "Calibration" button. The relationship between the calibration plate coordinate system and the camera will then be displayed in the transformation matrix. At this time, the transformation error that is to be generated will be displayed through the "Transformation Error" item. If the error exceeds 1, check the robot teaching points again, and, if necessary, perform teaching again.

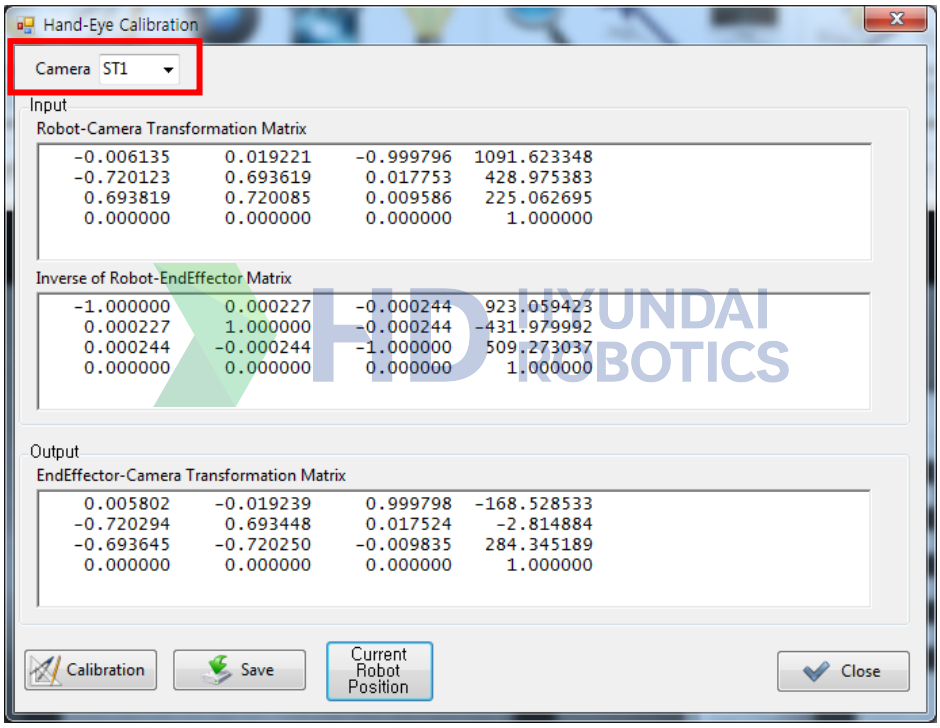


Clicking the "Save" button will store the transformation matrix information into the "C:₩HRVision 3D-Stereo₩Data₩RobCalTransform" folder.



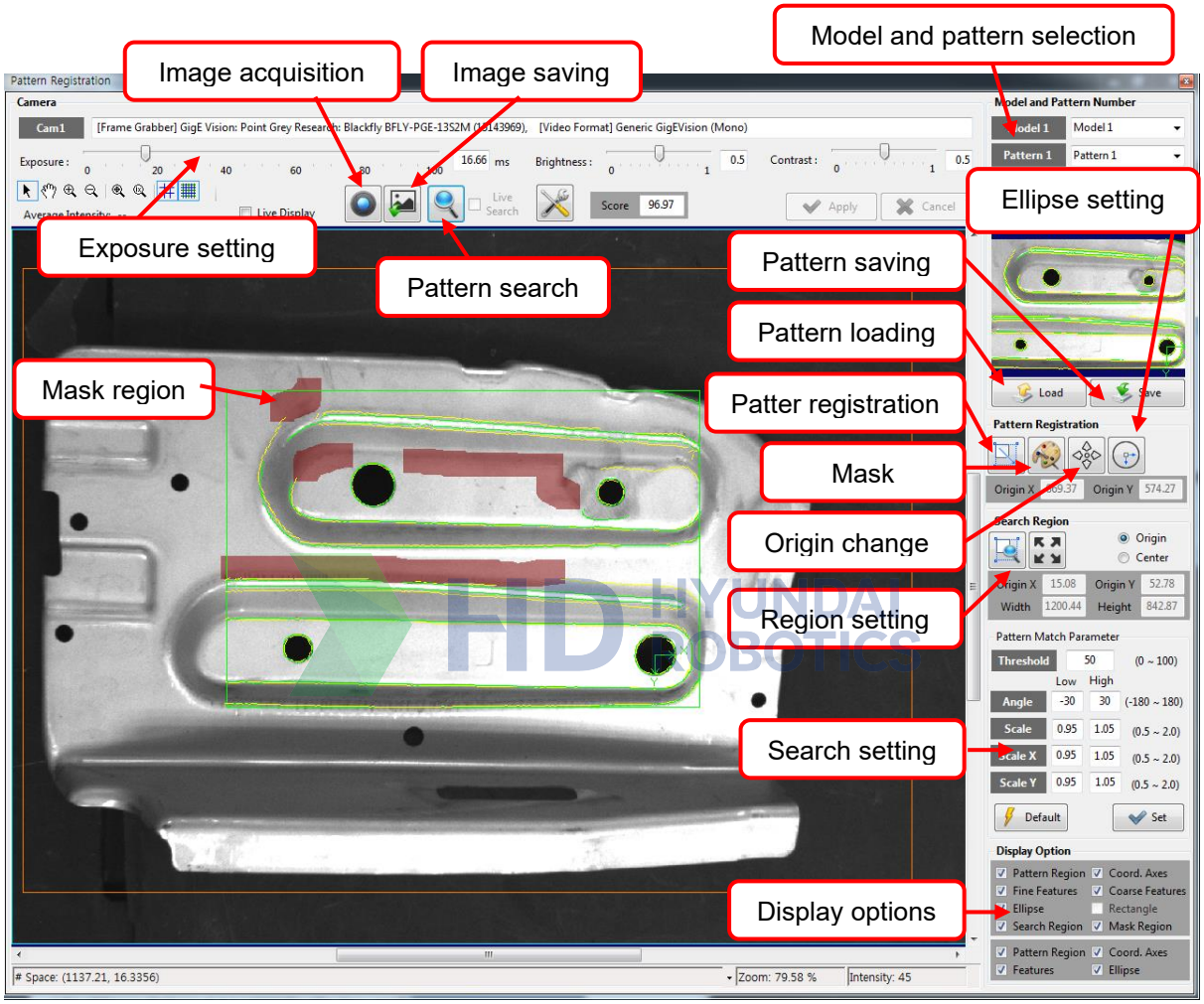
3.2.3. Hand-eye calibration

This is a process that acquires the relationship between the robot and the camera.
Selecting ST1 in the camera combo box will load and display the robot-camera transform matrix acquired in the previous stage. It is required to obtain in advance the input of the robot position resulted when acquiring the calibration plate.
Clicking the “Current Robot Position” button in the dialog box will display the inputted robot position data in the “Inverse of Robot End Effector Matrix.”
Clicking the “Calibration” button and the “Save” button will complete the hand-eye calibration.
The hand-eye calibration information will be saved in the “C:₩HRVision 3D-Stereo₩Data₩RobCalTransform” folder.



3.2.4. Pattern registration

This function helps manage (register/change/delete) patterns for individual models.



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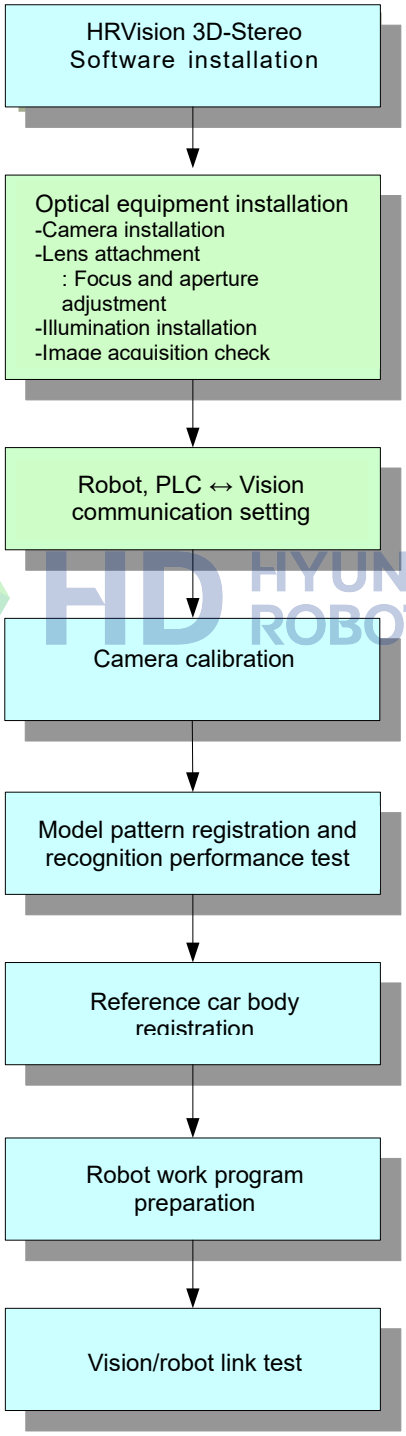
4 Work Procedure

4. Work Procedure

The work procedure of the HRVision 3D-Stereo is as follows.
The detail description of each procedure is provided in the following sections.



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3.3. HRVision 3D-Stereo Software Installation

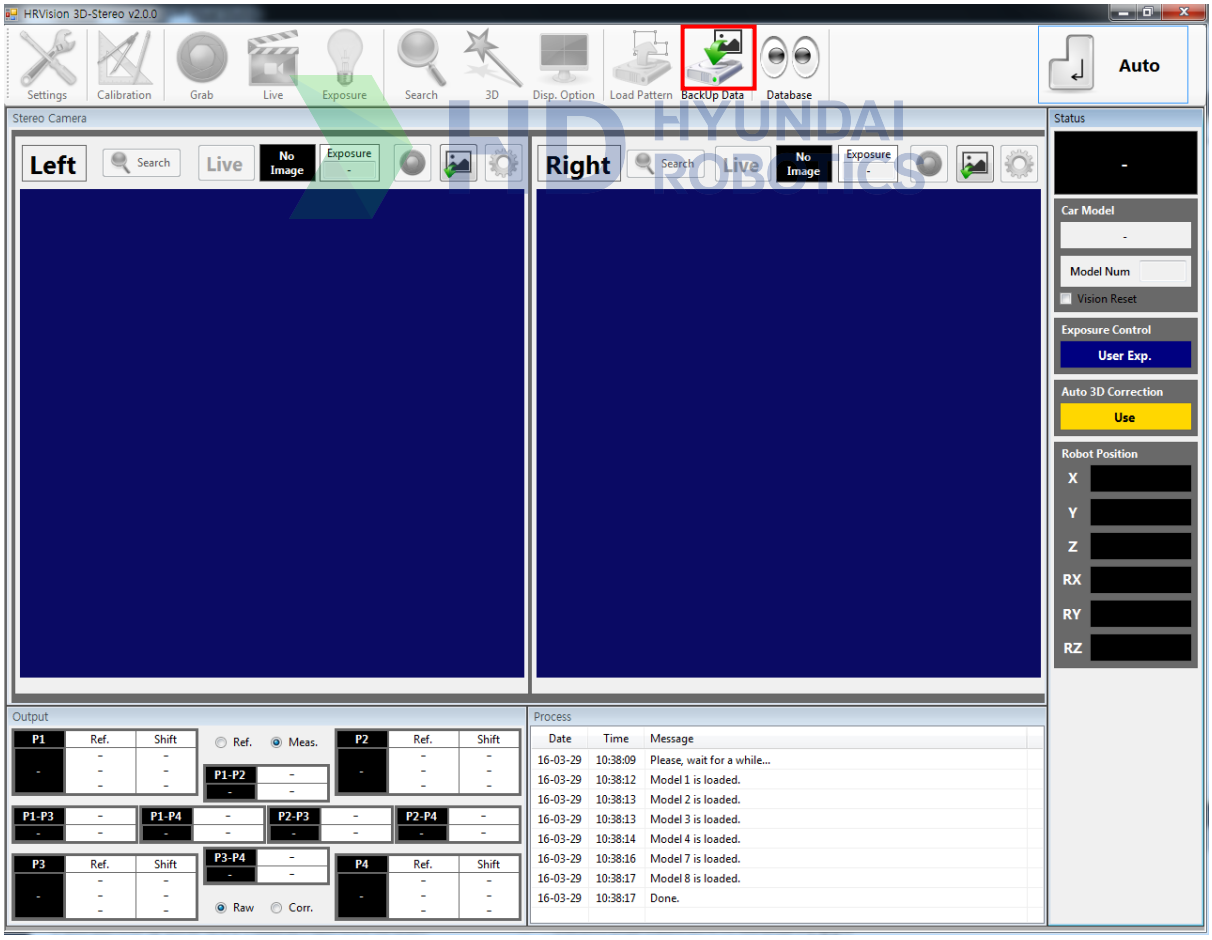
Install VisionPro 8.2, HRVision 3D-Stereo software in accordance with 1.2.2, and register the license key in accordance with 2.1.

본 작업 절차서는 Hi5a 제어기와 연동한 “HRVision 3D-Stereo” 설치 및 조작 절차를 설명합니다.

3.4. Optical Device Installation

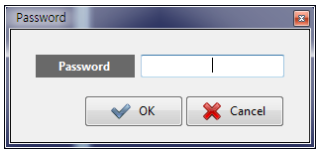
Install the camera and lighting according to the using purpose.

The following figure shows that if HRVision 3D-Stereo is run after the optical equipment and the HRVision 3D-Stereo program are installed, the initial screen of HRVision 3D-Stereo will be generated, as shown below.

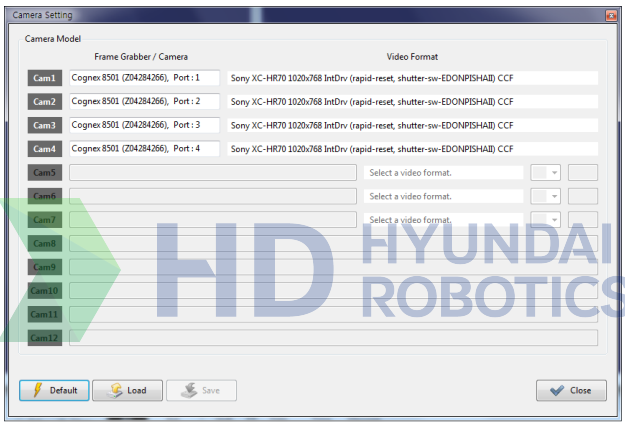


In the initial execution screen, as the camera type is not set, the image may not be acquired normally. Go to the “Setting” menu, and set the camera type.

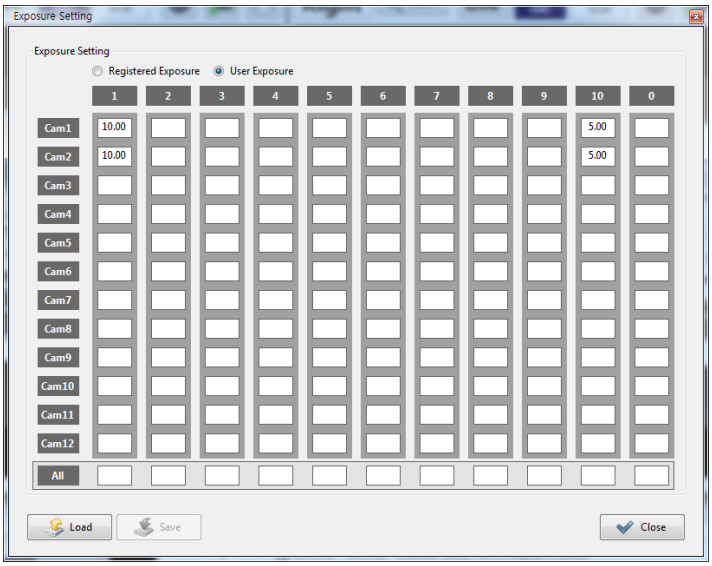
It is required to input a password to go to the setting menu such as “Settings” and “Calibration.” You are kindly required to contact the supplier for inquiries with regard to the password.



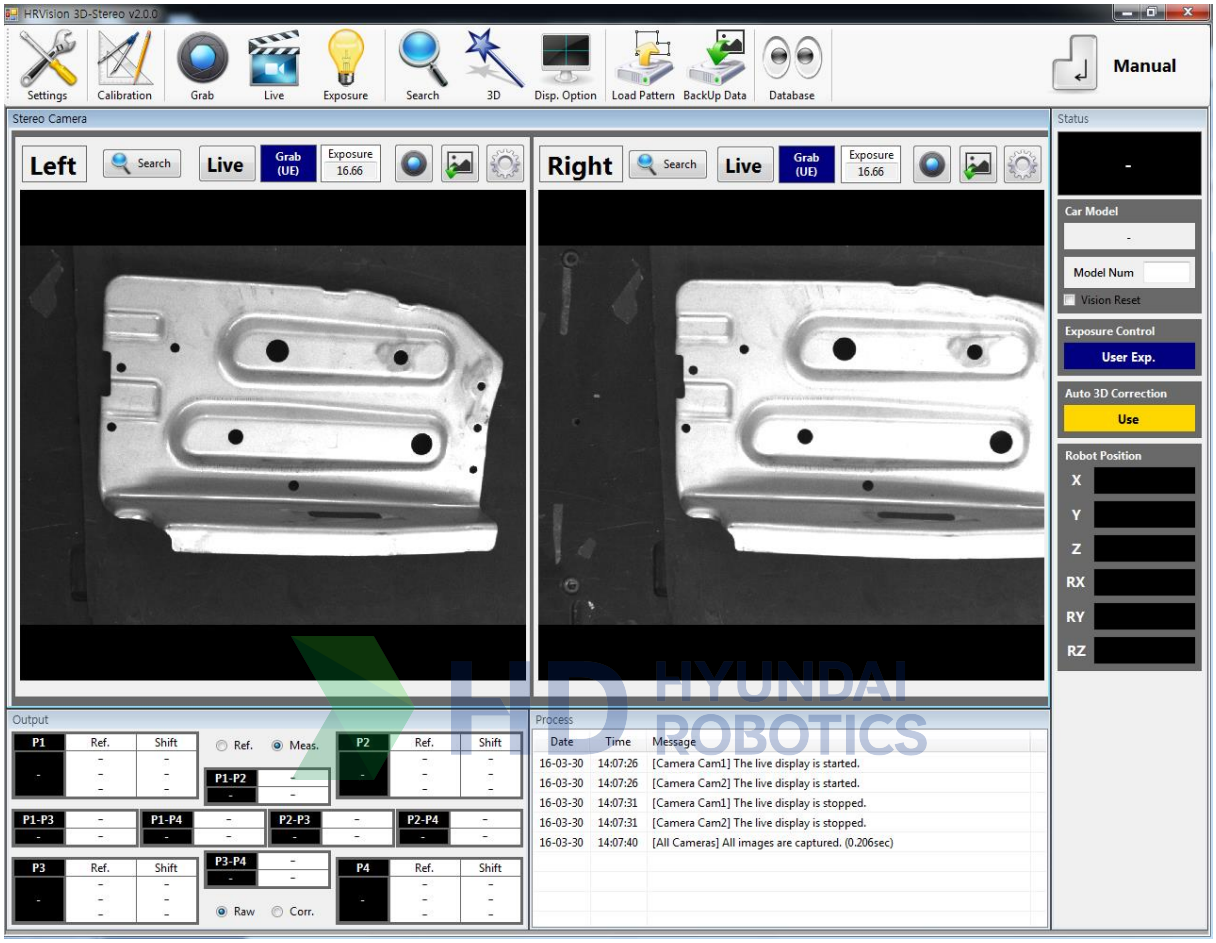
Clicking “Settings → Camera” will generate the following dialog. Set the camera type suitable for the process, and then save it.



Set the type of the installed camera and the exposure by clicking “Settings → Camera.”



Check whether the image is acquired normally by clicking “Grab” or “Live” on the operating button.



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.

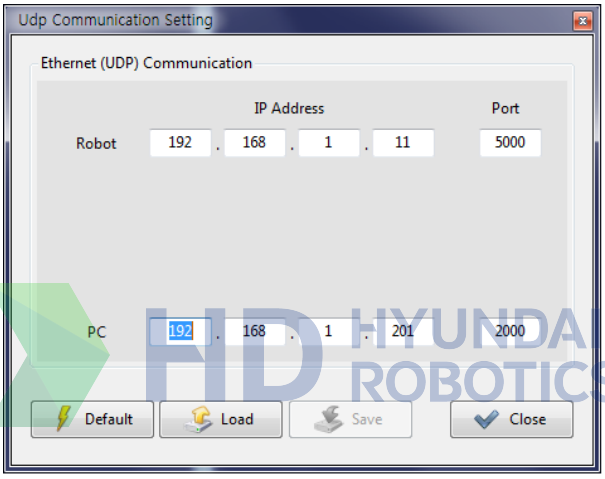
3.5. Communication Setup of Robot and Vision

3.5.1. HRVision 3D-Stereo Communication Setup

When image acquisition is completed, configure communication of HRVision 3D-Stereo.

Set the communication method and the attributes suitable for the process environment by clicking “Settings → Communication.”

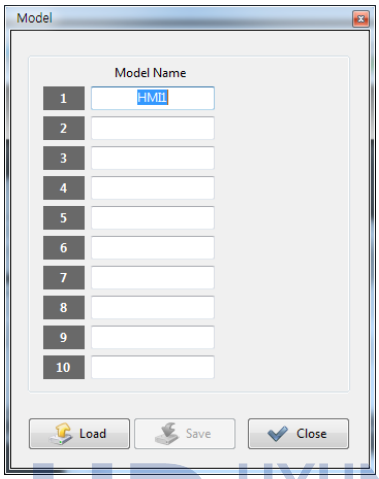
Check whether the vision system communicates with the robot according to the set attributes.



3.6. Camera Calibration

3.6.1. Model Setup

Pattern recognition result and calibration data is managed by model.
First, set the model name by clicking "Setting → Model."



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3.6.2. 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 3D-Stereo uses the calibration board described in 3.2.1 and executes the calibration.

3.6.2.1. 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).

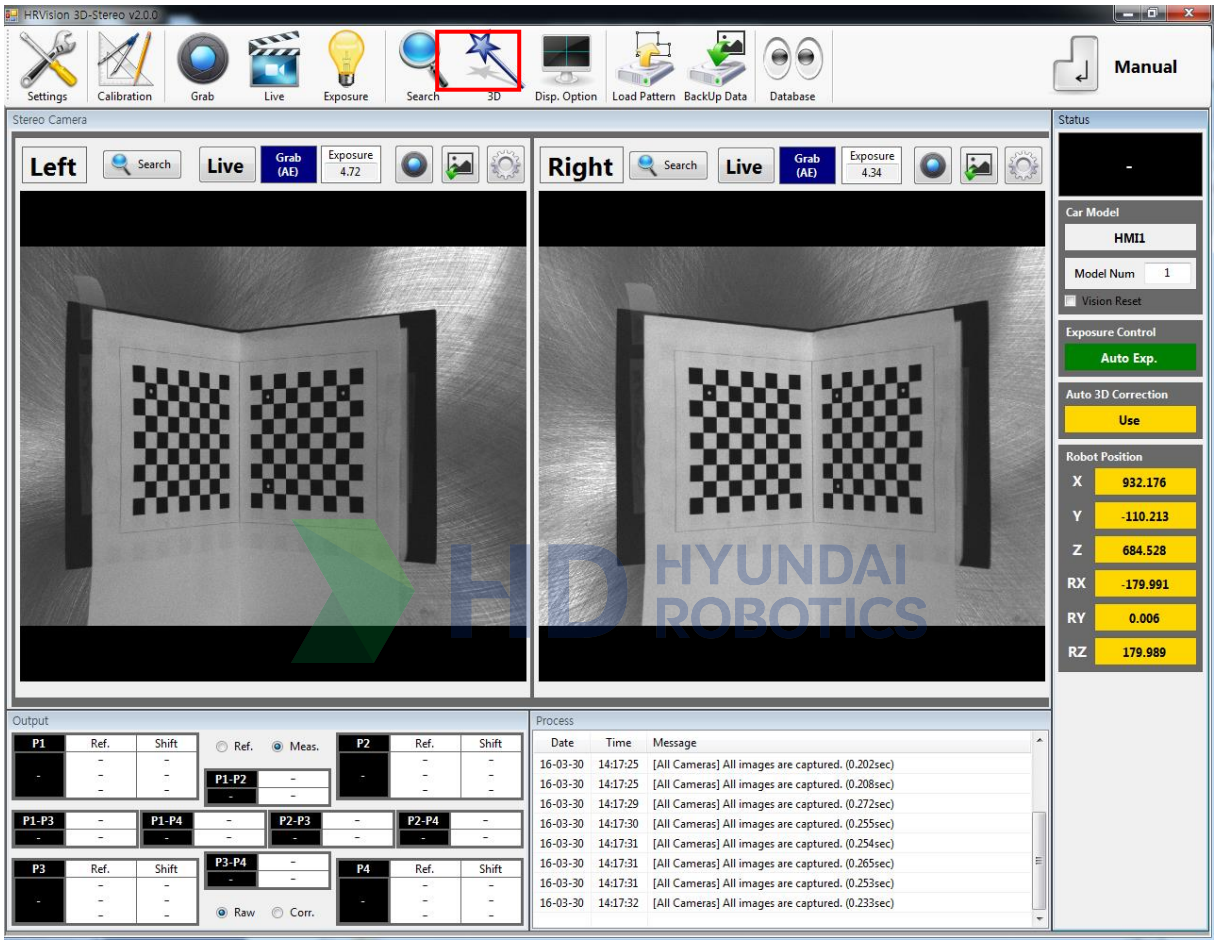
Set the calibration board on the pallet where the workpiece will be put. When required to apply the autocalibration function at the stage of production, the currently installed calibration plate should be in the fixed state without movement at all times.

3.6.2.2. 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.
The position of each calibration point needs to be recorded in the robot work program based on the common coordinate system.

3.6.2.3. Grab Calibration Board Image

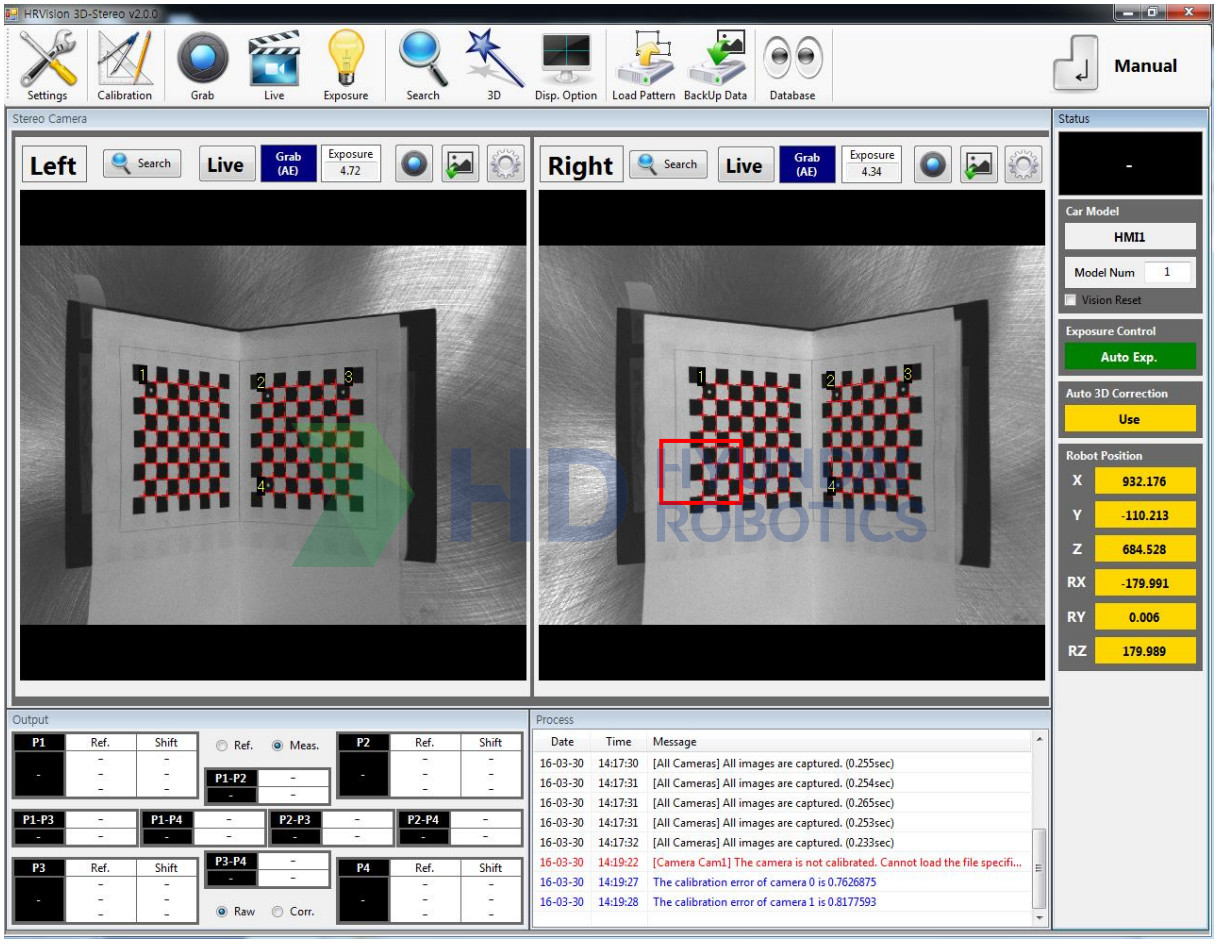
Click the "Grab" button among the manipulation buttons to acquire images including the calibration board.



3.6.2.4. Detect Calibration Point and Enter Coordinate

Execute camera calibration by clicking “Calibration → Automatic Calibration” on the operating button.

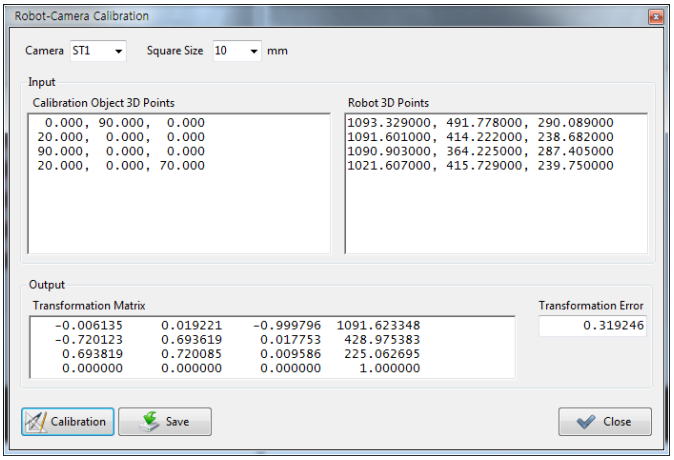
When it comes to the images of the left/right sides, acquire the corner points of the images according to the stereo calibration, as explained in section 3.2.1. Refer to “3.2.1 Stereo Camera Calibration” for more details.

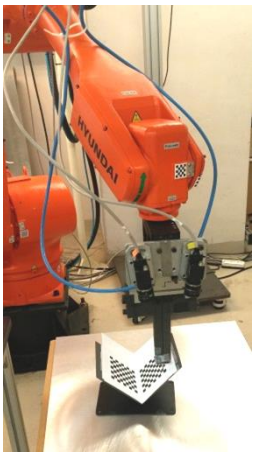


When it comes to the automatic calibration function, click the “P Matrix” button to calculate and save the projection matrix after all the corner points are extracted from the left/right sides. The calibration data will be saved as “P1L.txt, P1R.txt” into the “C:₩HRVision Stereo₩Cal” folder.

3.6.2.5. Robot-camera calibration execution

Perform robot-camera calibration by clicking "Calibration → Robot-Camera Calibration" on the HRVision 3D-Stereo operating button. When the robot number and the rectangle size of the calibration plate are selected, four points will be produced. These four points need to be taught to the robot.

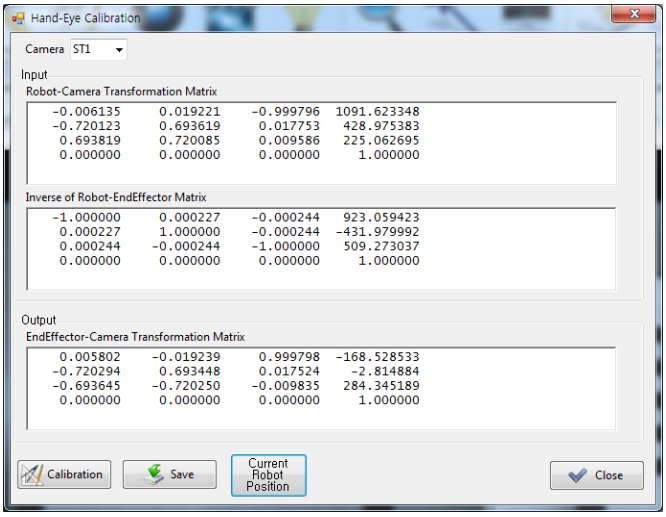




Input the teaching points in the space on the right side in the order of X, Y, and Z, and then press the "Calibration" button to display the transformation matrix and the transformation error. If the error is above 1 mm, then the calibration is incorrect. Camera calibration needs to be performed again. If the error is below 1 mm, click the "Save" button to store the transformation matrix.

3.6.2.6. Hand-eye calibration execution

Perform the robot end effector-camera calibration by clicking "Calibration → Hand-Eye Calibration" on the HRVision 3D-Stereo operating button. Input the camera number, receive the current robot position through communication, and then click the "Current Robot Position" button. Check whether the "Inverse of Robot EndEffector Matrix" item is inputted, and then press the "Calibration" button and the "Save" button to store the transformation matrix.

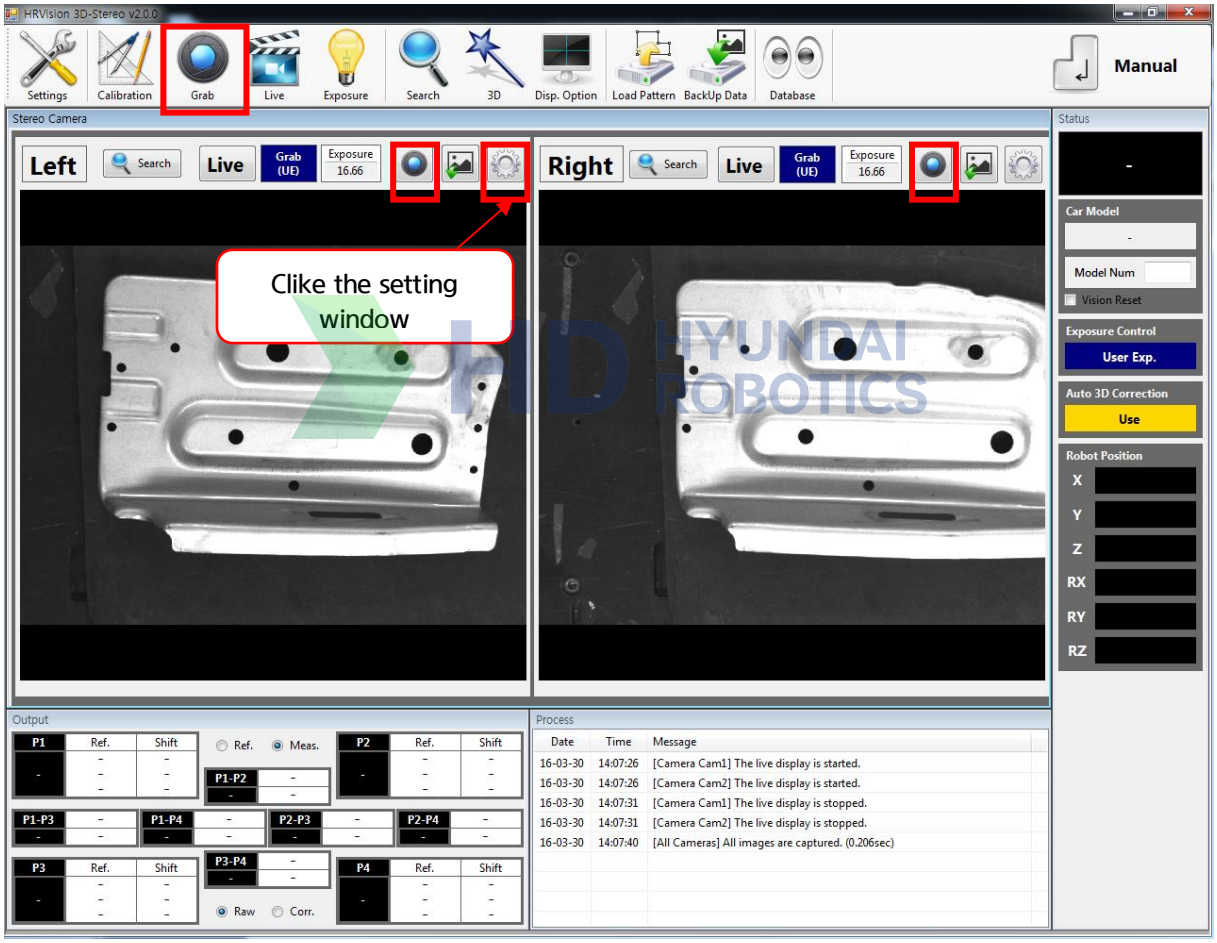


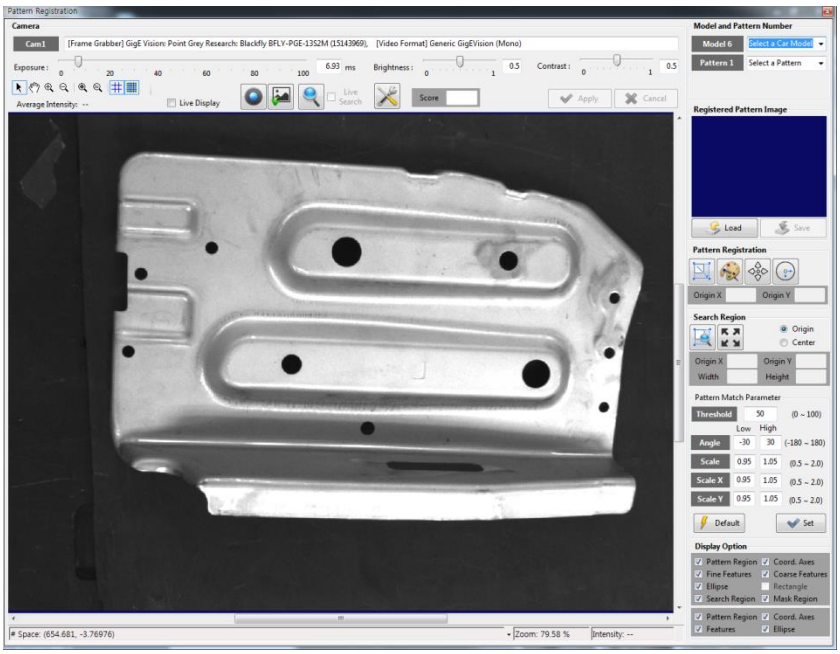
3.7. Model Pattern Addition and Pattern Recognition Test

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

3.7.1. Grab Image

Select the workpiece feature points that need to be registered as patterns, and then click the “Grab” button in the menu or image window.
Clicking the “Pattern Registration” button will generate the “Pattern Registration” window to perform pattern registration.





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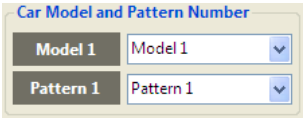
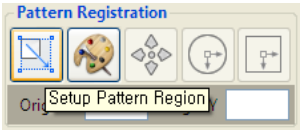
3.7.2. Pattern Addition

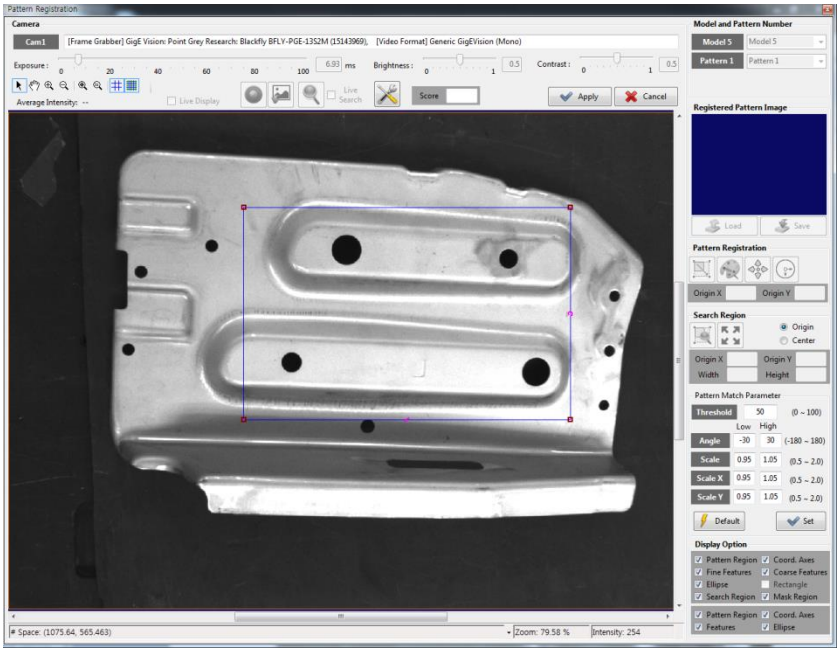
Select the car mode and the pattern number. The pattern number can be used when diverse patterns need to be used for the same car mode. In this case, the origin of the patterns should be identical. In general, select “Pattern 1” as one pattern is to be registered for one car mode.



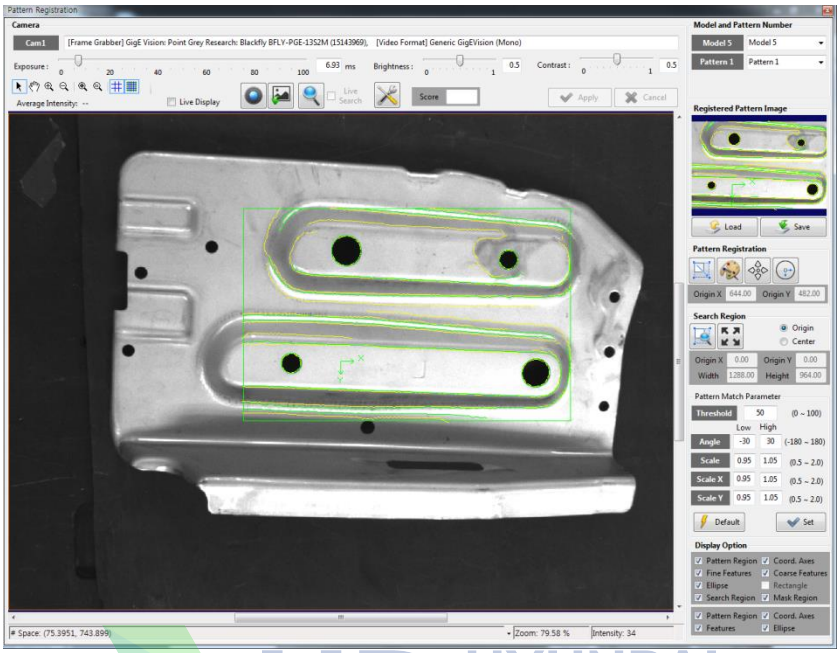
Clicking the “Setup Pattern Region” button will bring up a rectangle for setting the pattern image at the center of the image.



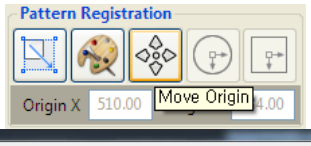
Change the size and position of the pattern setting rectangle as suitable for the region where the pattern needs to be extracted. Individual patterns should have characteristics that can differentiate individual models easily and need to be selected by taking into consideration the visual region of the camera (FOV), the precision required for the work and others.

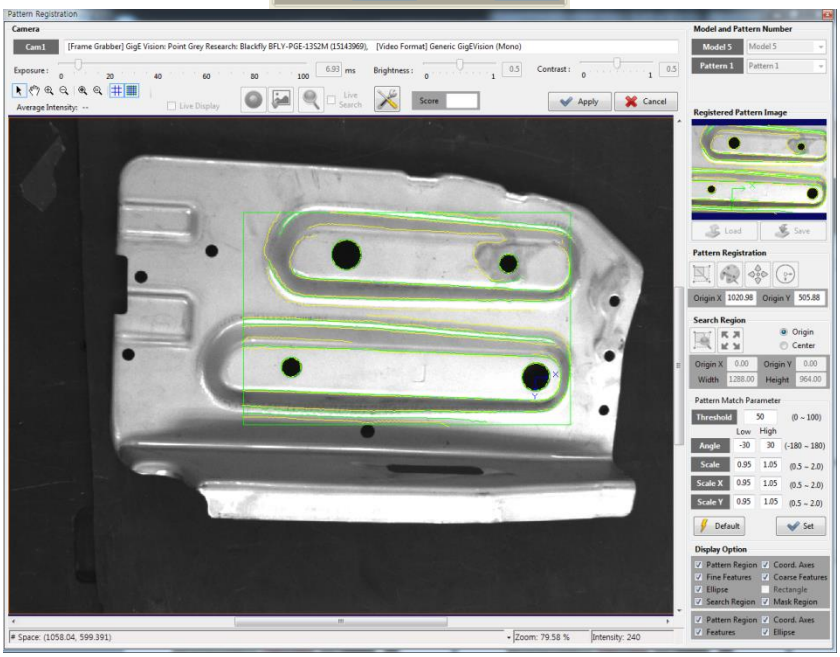


Press the “Apply” button to extract the pattern inside the rectangle.

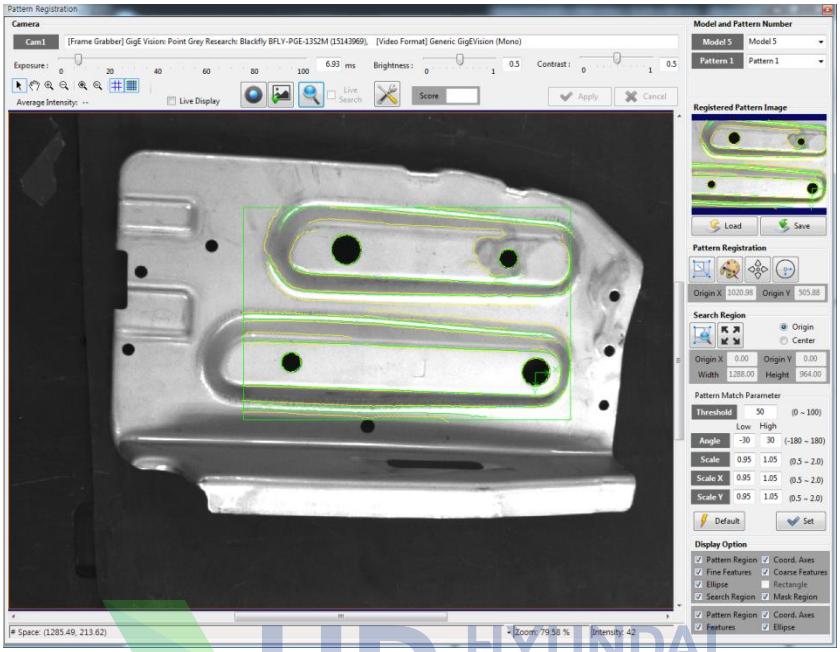


As the origin of the pattern is positioned at an arbitrary position, it is required to change it to the desired position. Pressing the “Move Origin” button will turn the state into a state in which the coordinate axis can be moved.



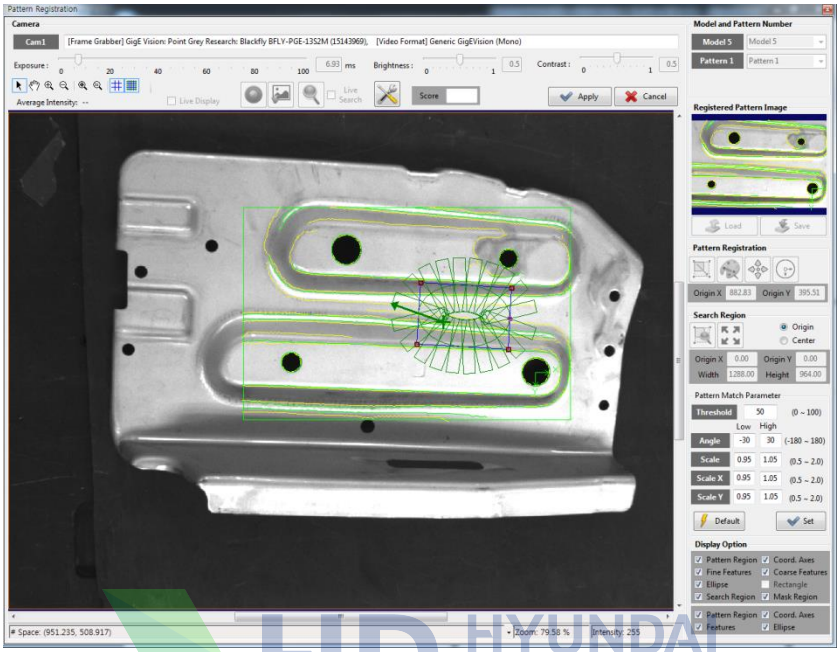


Decide the hole that needs to be registered as the origin, move the coordinate axis, and then press the “Apply” button.



For locating the center of the hole, press the “Find Hole Center” button.

There will be a caliper for detecting the ellipse around the hole.



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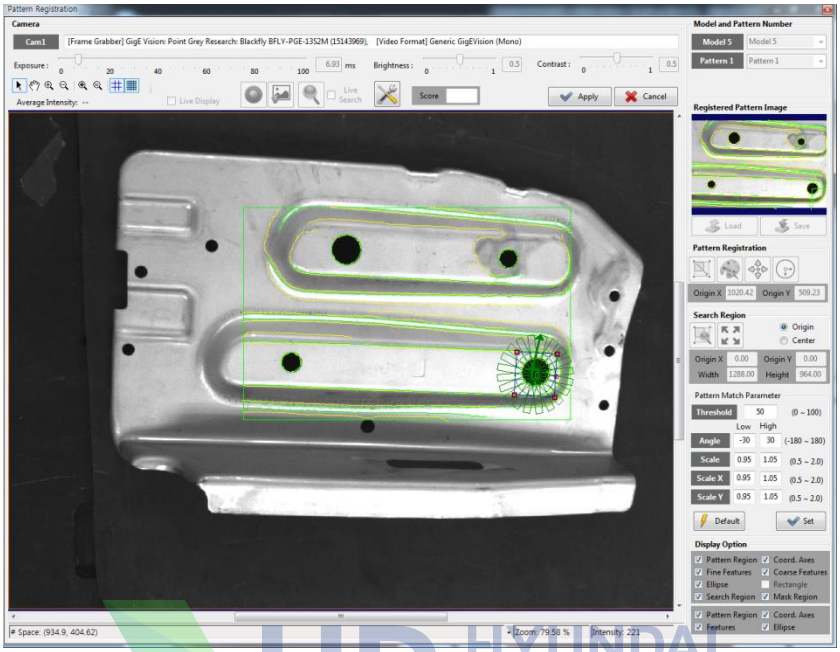
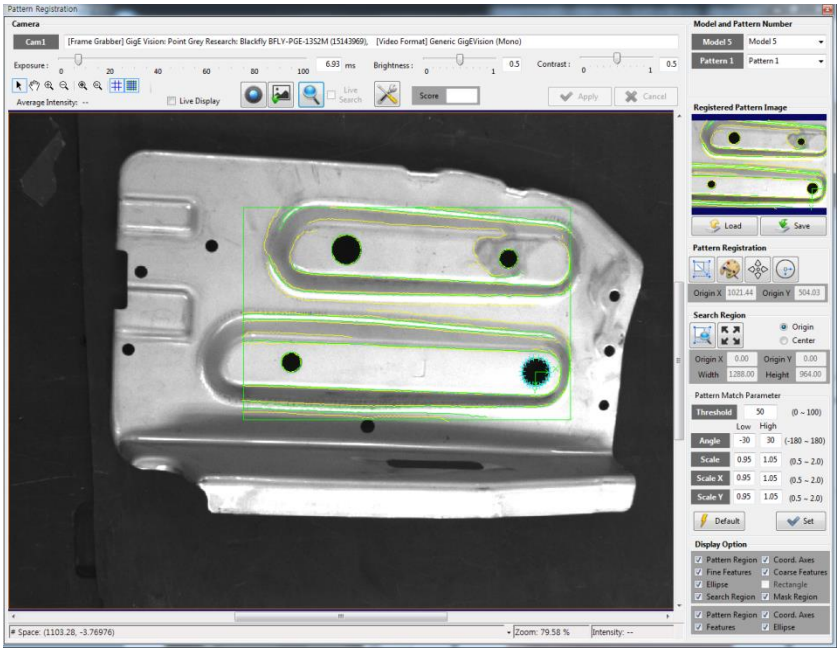
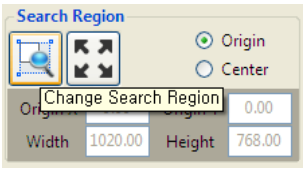
Enlarge the screen by turning the mouse wheel. Check whether the caliper is positioned around the hole. If the caliper is not positioned around the hole, the user is required to change the shape of the caliper.



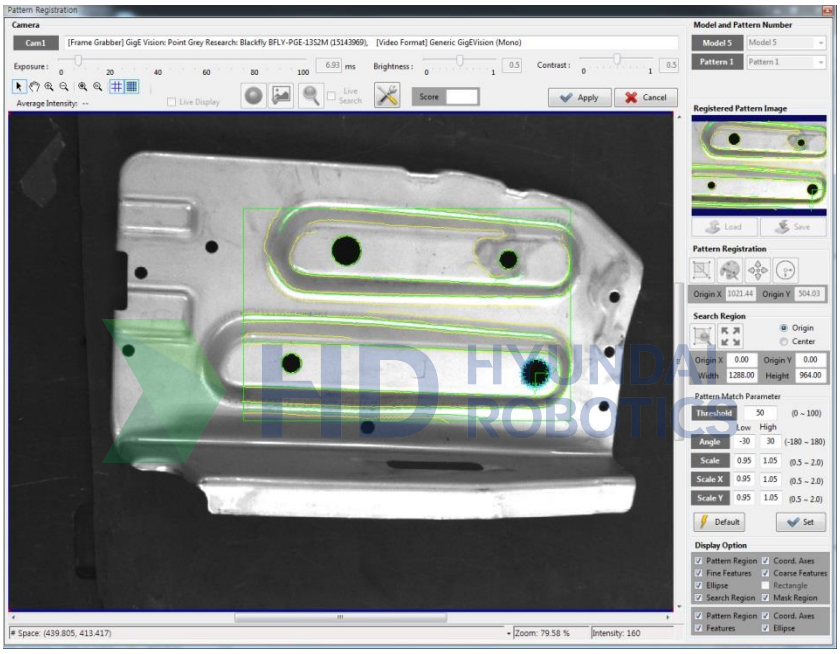
When the “Apply” button is pressed, the center of the ellipse will be extracted, and the point that is used to detect the ellipse will be marked with “+.”



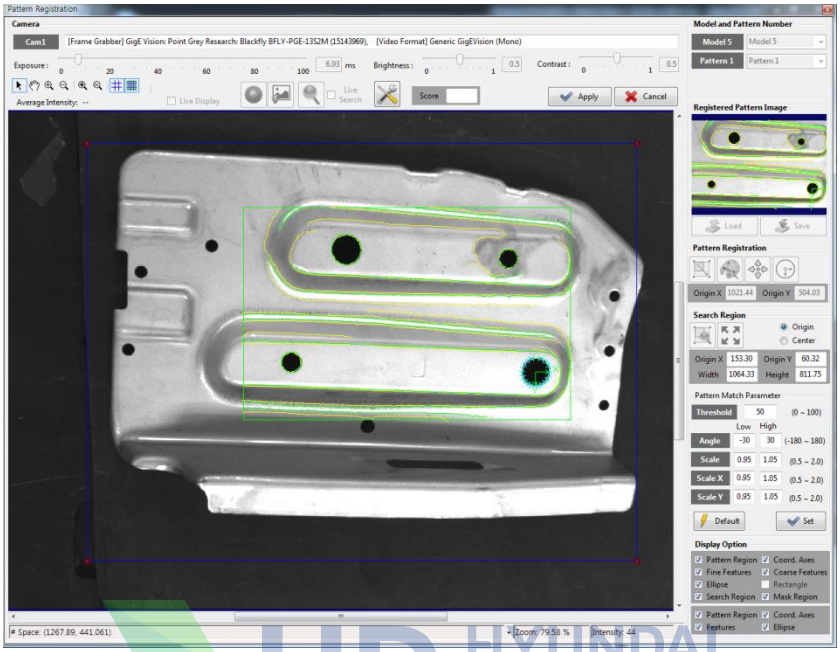
The initial pattern search region is the entire image, and when required to change the search region, press the “Change Search Region” button.



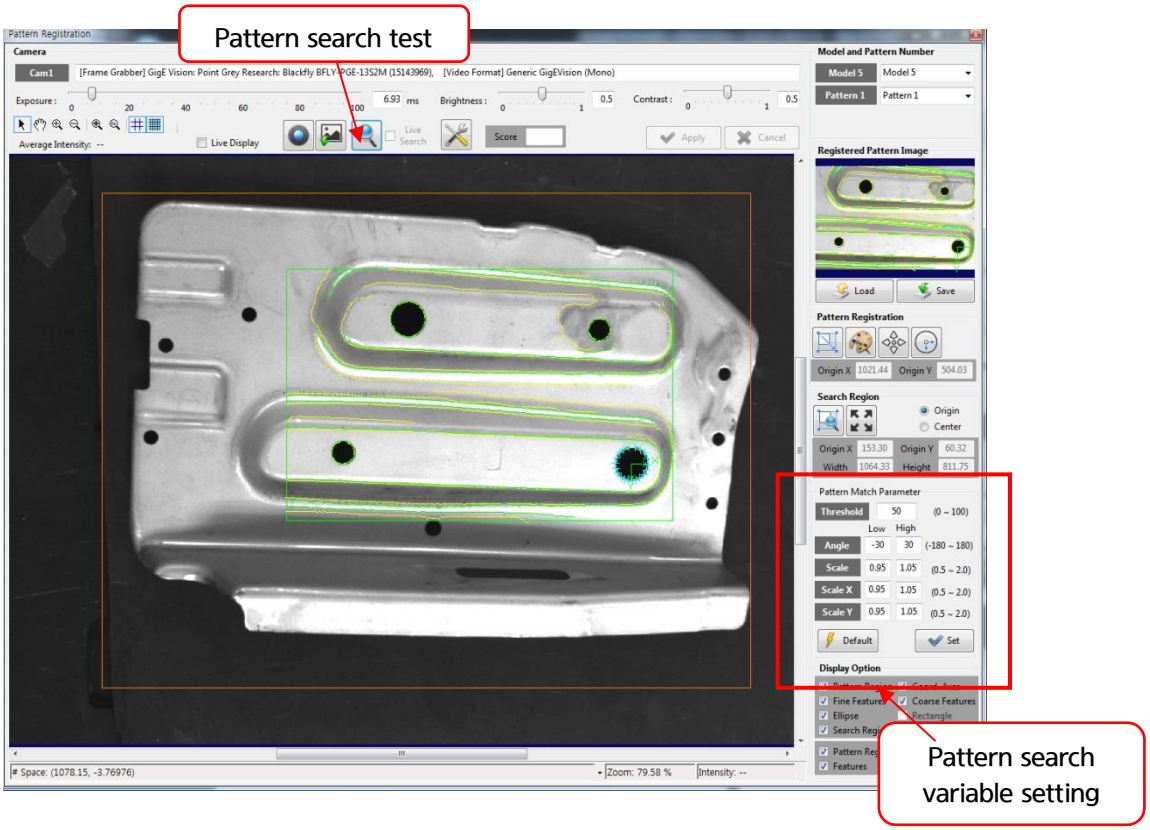
The state will change into a state in which the pattern search region can be moved.



Change the pattern search region.



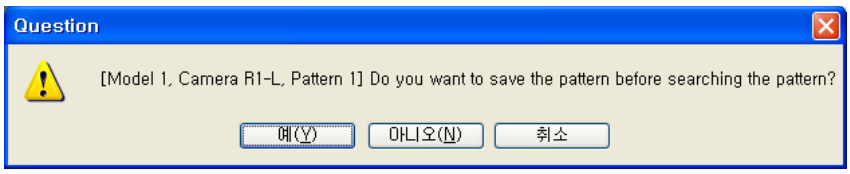
Pressing the “Apply” button will set the pattern search region.



Press the “Advanced Setting” button to set, for example, the pattern detection threshold value.

When the pattern setting is completed, press the “Save” button to register the pattern. Then, press the “Search Pattern” button to check whether the registered pattern can be searched well.

If a pattern is not registered, the following message window will be displayed.



In the same manner, perform the Pattern Registration work for four other patterns.

If the pattern registration work is completed for the left camera, perform the same camera registration for the right camera.

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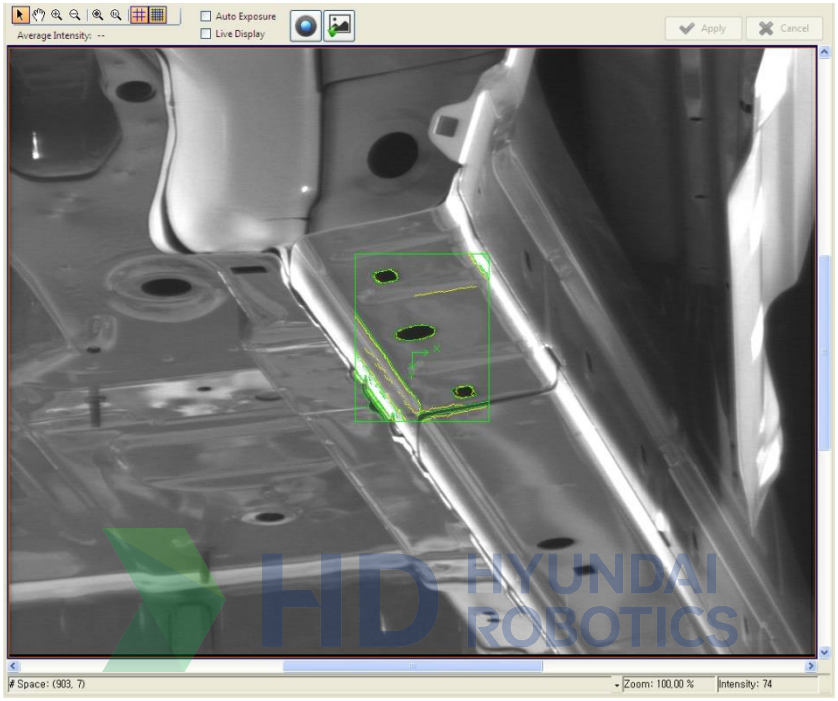
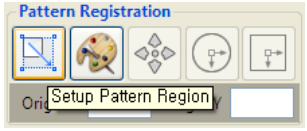
3.7.2.1. Others: Pattern mask setting method

If pattern registration is performed normally, the searched pattern will be displayed on the screen.

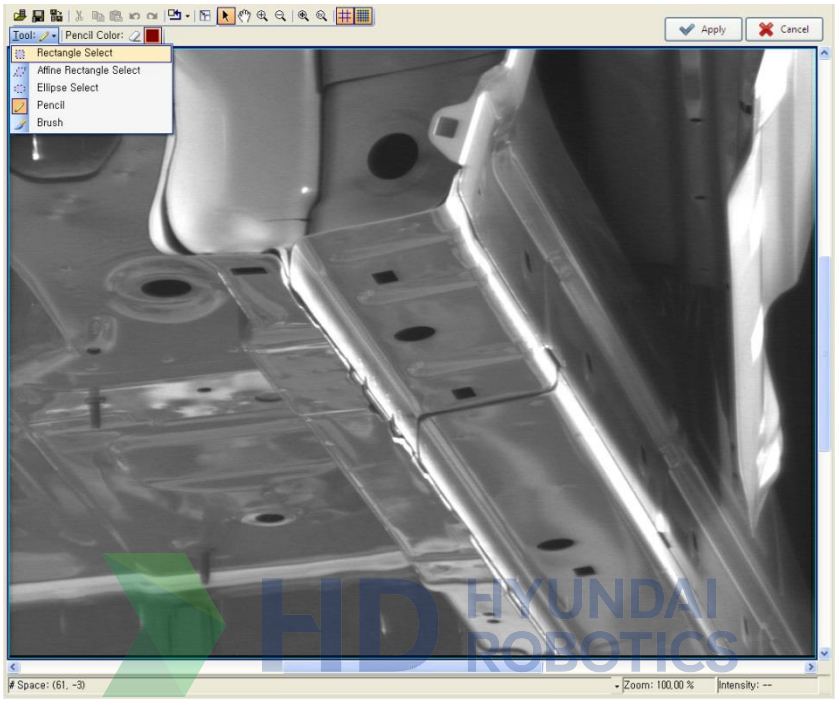


Press the “Mask Image” button to remove unwanted features.



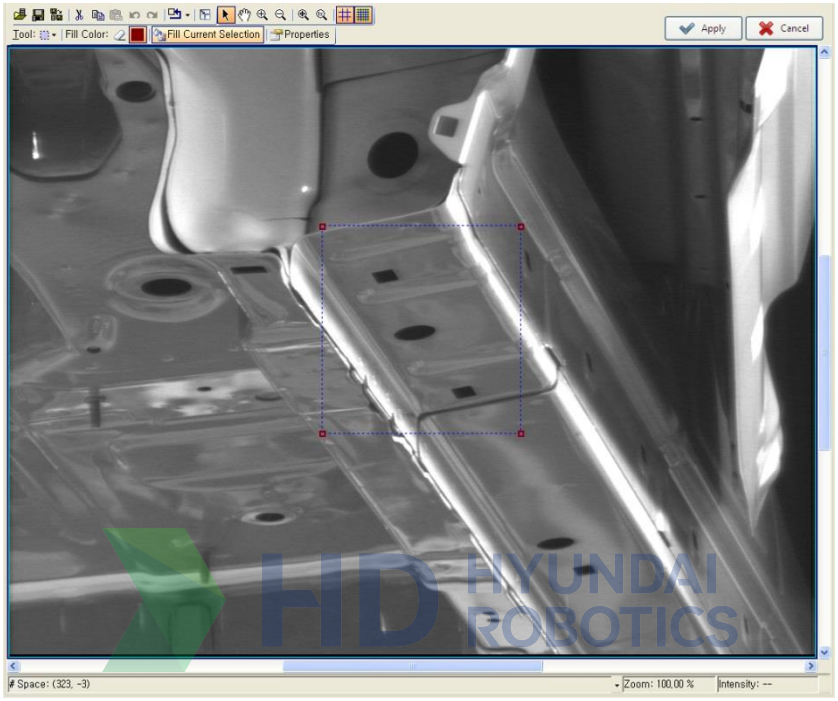
The screen will shift to the menu for setting the mask.

To set a mask region, select one among “Rectangle Select,” “Affine Rectangle Select,” and “Ellipse Select.” In general, “Rectangle Select” is sufficient. However, there will be no problem with selecting another shape.

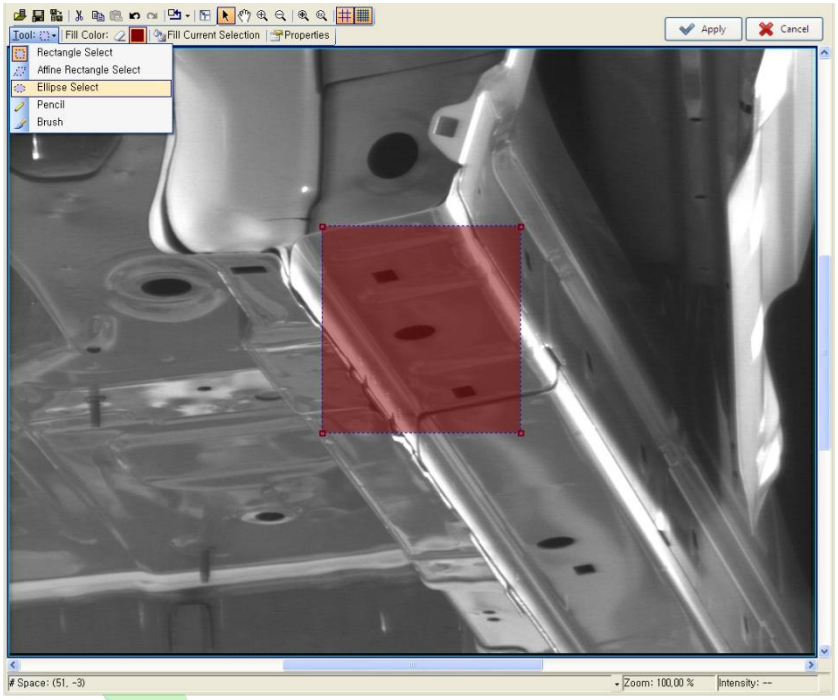


On the left side of the image, there will be a shape formation to set the mask region. When “Rectangle Select” or “Affine Rectangle Select” is selected, a rectangle will appear, and when “Ellipse Select” is selected, a circle will appear, as shown below.

Change the size and position of the mask setting rectangle suitable for the region for which the mask needs to be designated, and then press the “Fill Current Selection” button.



However, the section that needs to be extracted for patterning will also be filled with mask. That is why it is required to exclude the region that needs to be extracted for patterning by selecting one among “Rectangle Select,” “Affine Rectangle Select,” and “Ellipse Select” from “Tool” again.



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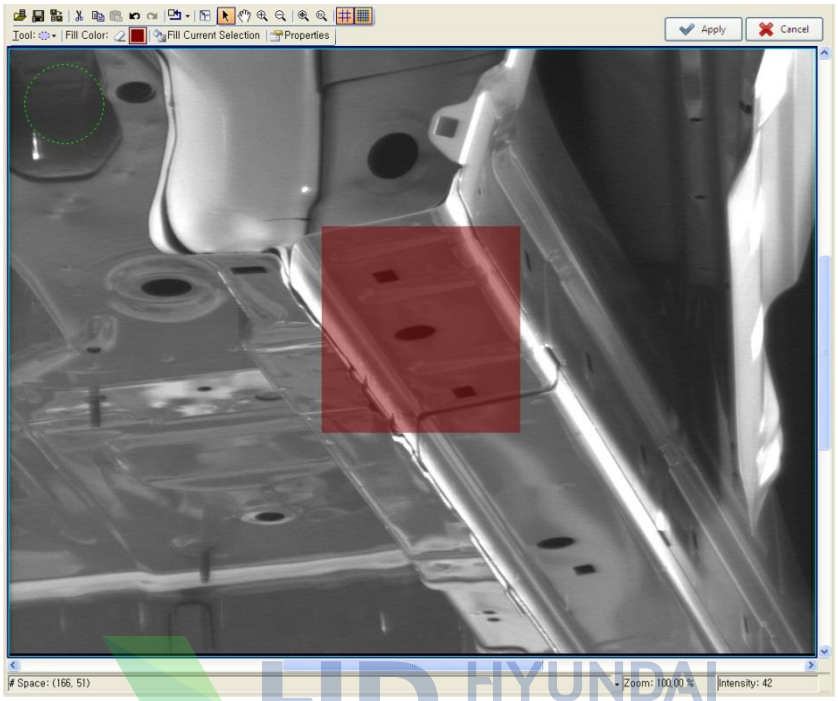
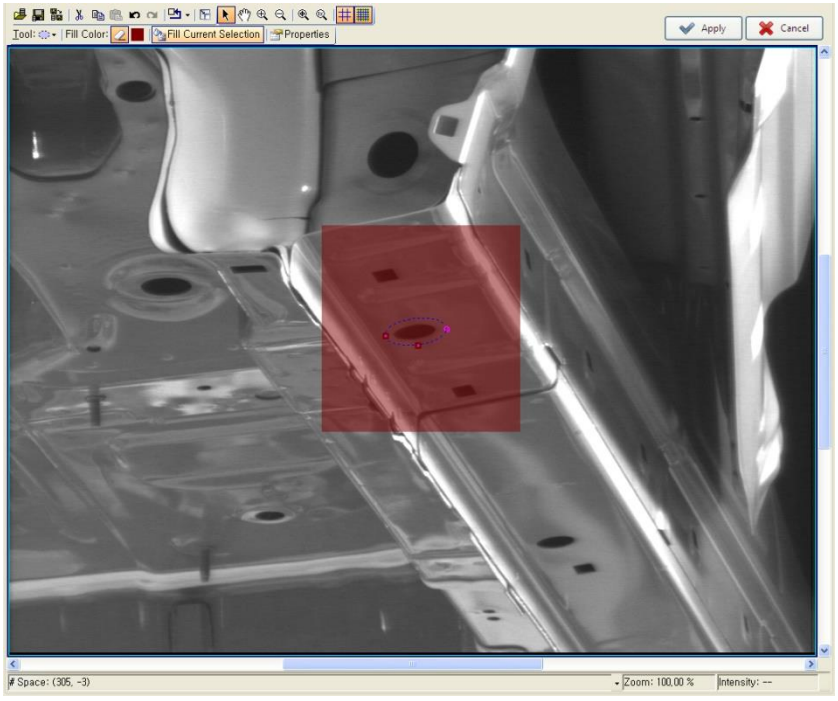
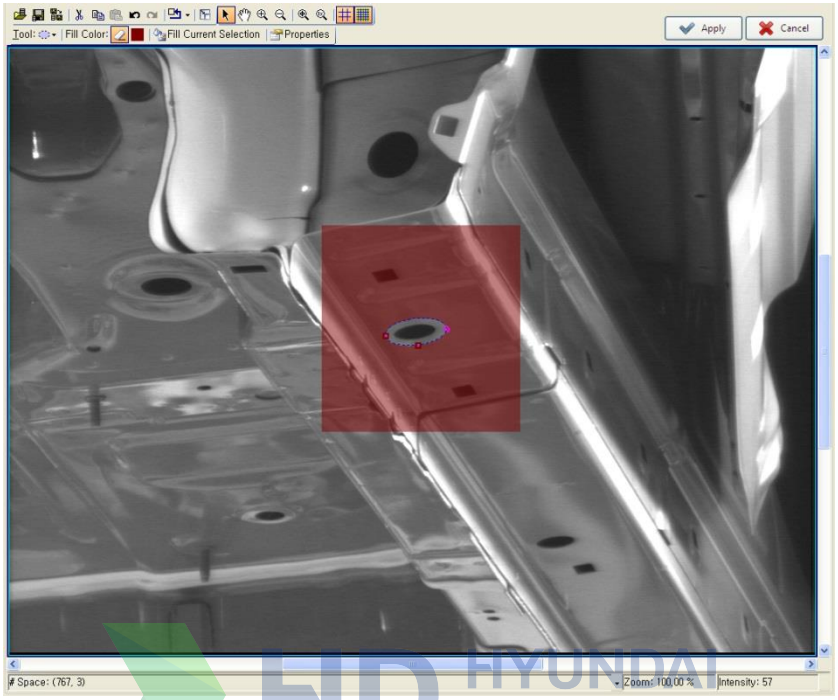
Selecting “Ellipse Select” will bring up a circle on the top left on the image.



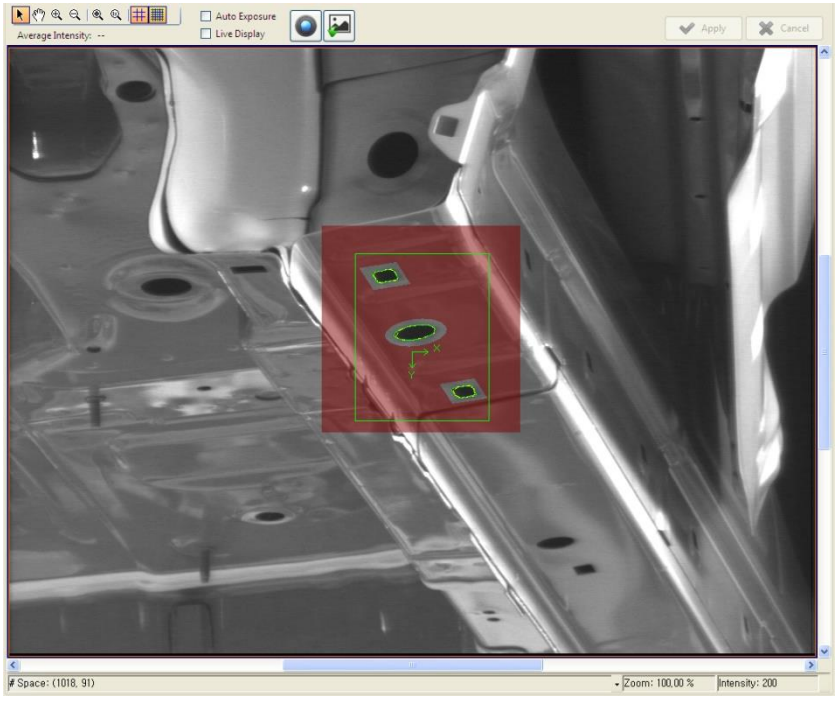
Move the circle to the region that needs to be unmasked. In the menu, select the eraser (“Care (Unmasked) Pixel Color”), and then press the “Fill Current Selection” button.



The set region will be removed from the masked region.



To unmask a region using a different shape, select one among “Rectangle Select,” “Affine Rectangle Select,” and “Ellipse Select.” When the unmasking work is completed, press the “Apply” button.

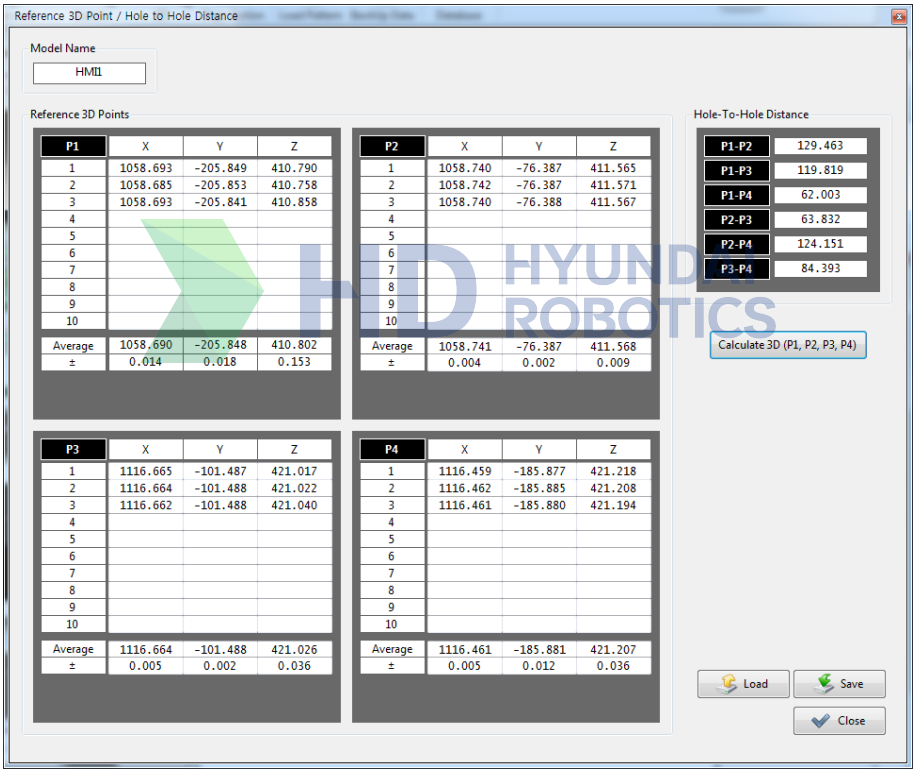


3.7.3. Pattern recognition and 3D position measurement test

Perform the pattern recognition and 3D position measurement work for the registered specific patterns. Press the “3D” button of the image window, or the “Search” or “3D” button of the “Operating” button. The pattern recognition region and the recognition result will be displayed on the image window. Review the pattern recognition result, and then change/add a pattern to set the optimal pattern model.

3.8. Reference point registration

If the 3D position measurement for each stereo camera is completed, register the measured points as the reference points. Click “Settings → Reference Point” on the operating button.Select the car model in the “Car Model” panel, and press the “3D” button of the camera corresponding to individual robots. For example, in order to acquire the 3D position measured from the camera corresponding to robot L1, press the “3D (L1)” button. Each time the button is pressed, the measured 3D average position and accuracy will be calculated. It is recommended to perform measurement for 10 times for the accuracy of the reference car body position. Taking into consideration that the accuracy will be influenced by various factors, it is recommended to check the external illumination, camera aperture, cable, and registered patterns again if the ± value is large. Perform the process repetitively for the L2, R1, and R2 robots. Pressing the “Save” button will store it as the reference car body.



3.9. Workpiece coordinate system creation and teaching/transformation of the operating points

If the registration of the reference position is completed, the robot controller will receive the information of the reference points and create the workpiece coordinate system.

The operator needs to record the position of the work, which is to be performed by teaching the Hyundai Robotics robot, into the robot work program based on the workpiece coordinate system.

If there are work points already taught based on the base coordinate or encoder coordinate system, it is required to change the coordinate system of the robot work program to the generated workpiece coordinate system by using the record coordinate transformation function of the Hi5a controller.

Refer to the provided sample of the work program for more details.

3.10. Auto Operation

When all the setup is completed, HRVision 3D-Stereo 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 3D-Stereo can only be operated through the PLC and communication with the Hyundai Robot.

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