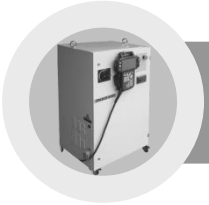
HYUNDAI ROBOTICS

Warning

All installation works must be performed by a qualified installer and must comply with applicable laws and regulations.

Hyundai Robot

Hi5aVL230630FMEN2



Hi5a Controller Function Manual

HRVision 3D-MultiLine

HD HYUNDAI ROBOTICS

HD HYUNDAI ROBOTICS

Printed in Korea – Jun 2023, 2nd Edition.

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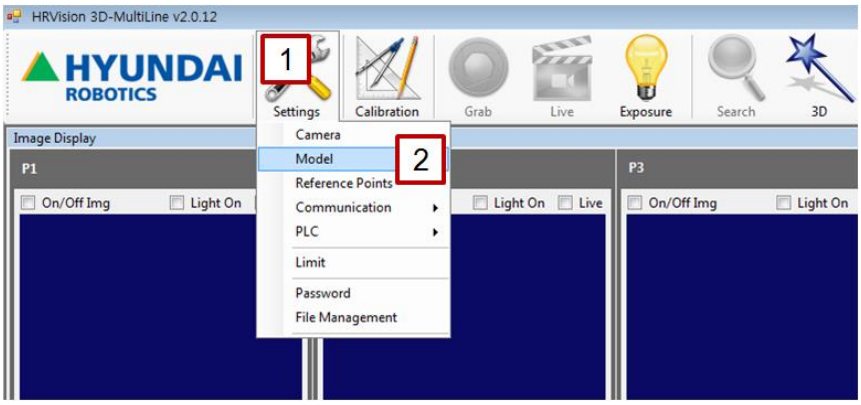
1 Basic Settings

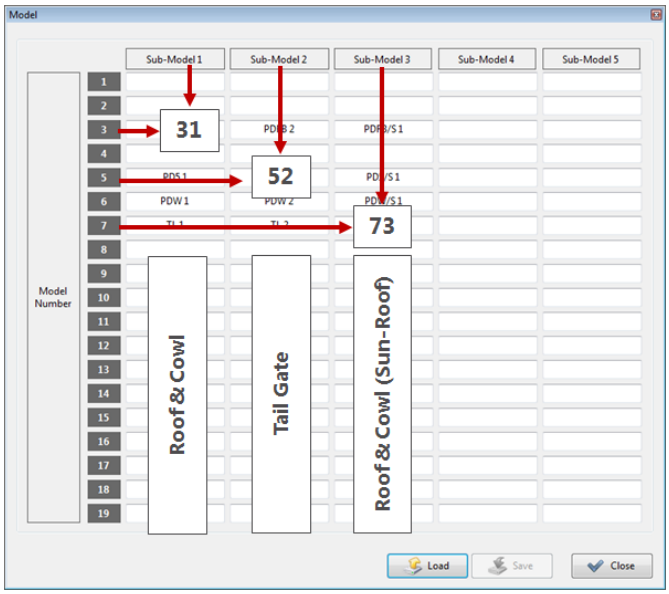
1.1. Model Name

This section describes the process of setting model names.



[Step 1]

(1) In the main menu, click the [Settings] button.
(2) Select the [Model] menu.

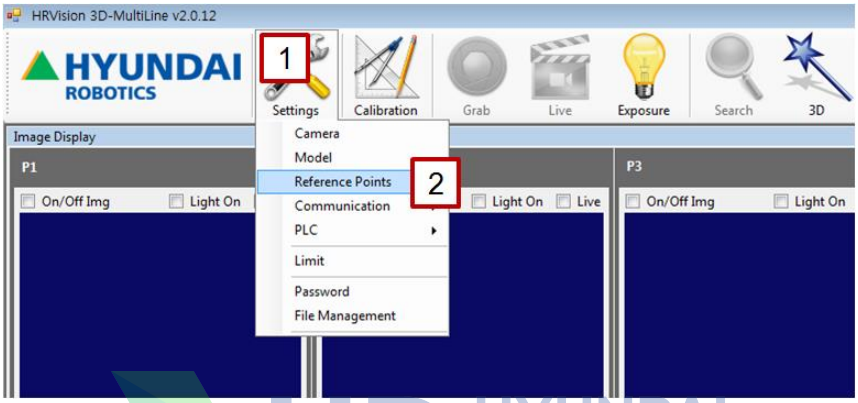


[Step 2]

(1) Model numbers can be assigned only in two or three digits (e.g., 11–15, 21–25, 31–35, and 121–125). You can assign only 1–5 to the unit's digit.
(2) Enter a model name in the relevant column, and save it by clicking the [Save] button. For example, the model number corresponding to row 3 and column 1 is 31.

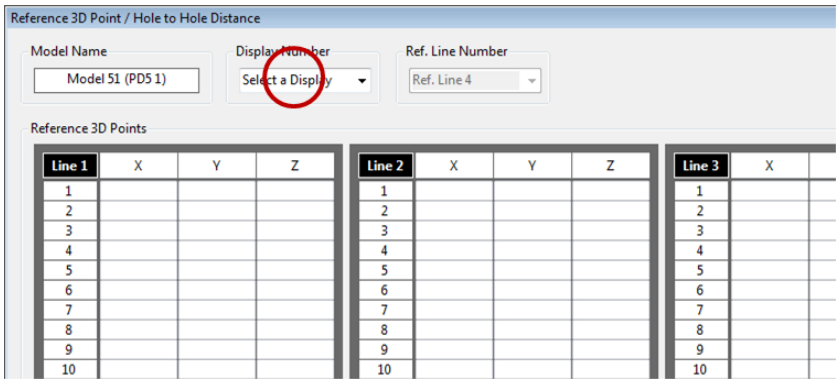
1.2. Reference Point Registration

This section describes the process of registering reference points for workpieces.



[Step 1]

(1) In the main menu, click the [Settings] button.
(2) Select the [Reference Points] menu.



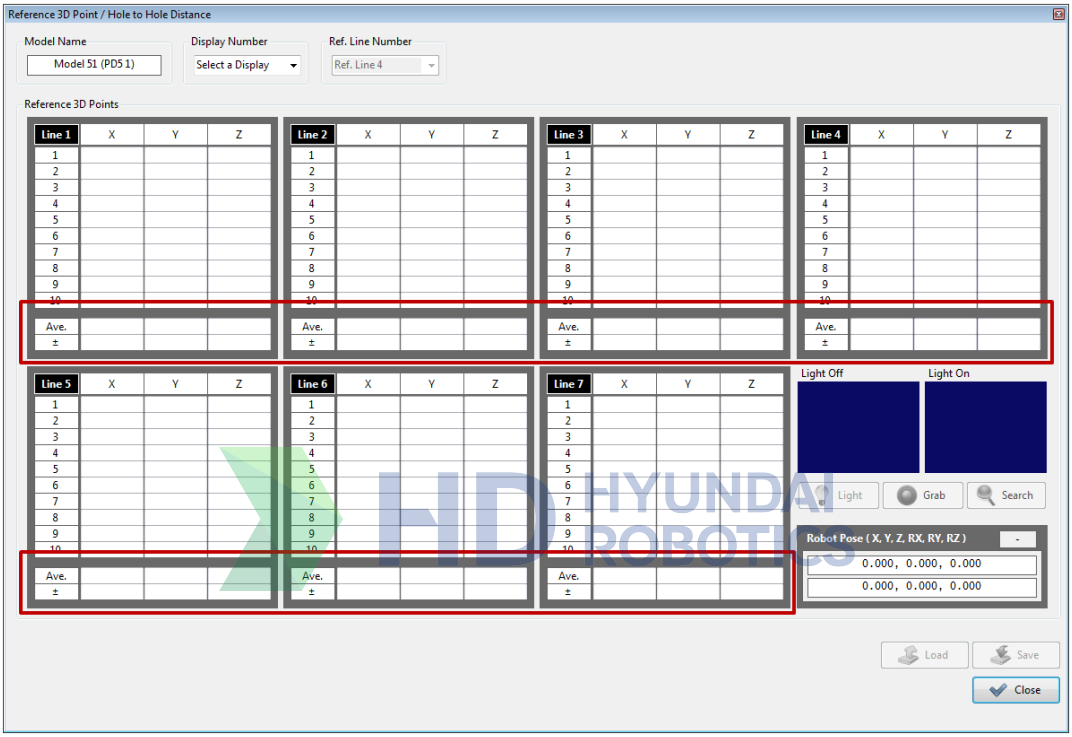
[Step 2]

(1) Select [Display Number].
(2) The [Display Number] matches the number of the point measured by the camera.

```
Program File Format Version : 1.6  MechType: 70(HA020-01)  Tota
    'LIGHT ON/OFF
    'PATTERN SEARCH
    '====================
    CLR_RBUF ENET1
    V10$=""
    V11$=""
    V12$=""
    P99=P* 'ROBOT POSE
    PRINT ENET1,P99
    V2$=STR$(V2%) 'CAMERA POSITION
    '====================
    DO3=0 'LIGHT OFF
    DELAY 0.2
    PRINT ENET1,"LIGHTOFF "+V2$ 'SEND LIGHTOFF TO PC
    INPUT ENET1,V10$,3,*ERROR 'RECEIVE ACK SIGNAL FROM PC
    V10$=LEFT$(V10$,3)
    IF V10$<>"ACK" THEN
    GOTO *ERROR
    ENDIF
    '====================
    DO3=1 'LIGHT ON
    DELAY 0.2
    PRINT ENET1,"LIGHTON "+V2$ 'SEND LIGHTON TO PC
    INPUT ENET1,V11$,3,*ERROR 'RECEIVE ACK SIGNAL FROM PC
    V11$=LEFT$(V11$,3)
    IF V11$<>"ACK" THEN
    GOTO *ERROR
    ENDIF
    '====================
    PRINT ENET1,"SEARCH "+V2$
    INPUT ENET1,V12$,3,*ERROR 'RECEIVE OK/NG SIGNAL FROM PC
    V12$=LEFT$(V12$,2)
    IF V12$="NG" THEN
    GOTO *ERROR
    ENDIF
    DO3=0
    '====================
    END
    *ERROR
    END
```


[Step 3]

(1) Referring to the example, write a robot job program that turns on/off the line pattern light of the projector and detects a pattern.

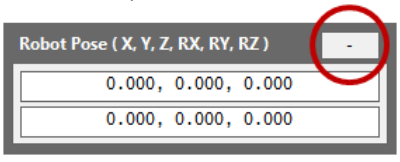


[Step 4]

(1) Repeat the written robot job program for 10 times. The average value will appear in the [Ave.] section, and the accuracy of repeatability will appear in the [±] column.

(2) If the accuracy of repeatability exceeds 1 mm, which means that the pattern detection is inaccurate, decrease the value of the accuracy of repeatability by changing either the registered position of the pattern or the set value.

(3) If the camera is mounted on the robot, check whether the correct pose value is displayed in [Robot Pose]. In addition, check whether the correct [Coordinate System] is displayed at the upper right part of [Robot Pose], as shown in the following figure. Check whether the robot pose is received in the desired coordinate system: [-] will be displayed for the base coordinate system, [R] for the robot coordinate system, and [Un] for the user coordinate system.



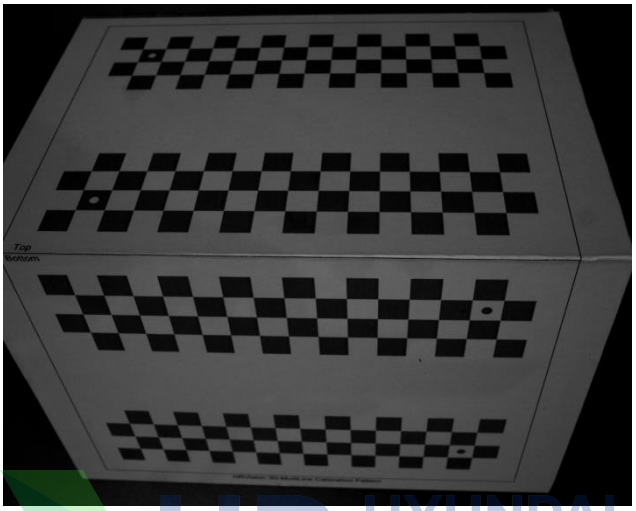
(4) If there are no problems, save the setting by clicking the [Save] button. Repeat the same procedure for the cameras in other points.

HYUNDAI ROBOTICS

2 Calibration

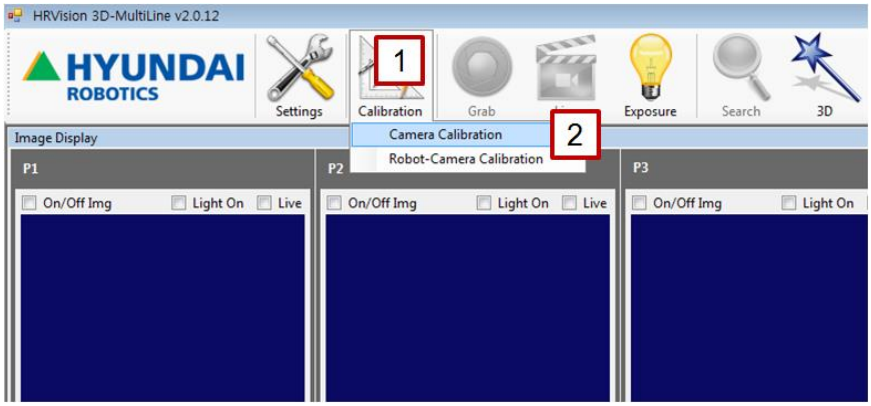
2.1. Wrist-Held Vision

The instructions given in this section apply only to V2.0.12 or lower.



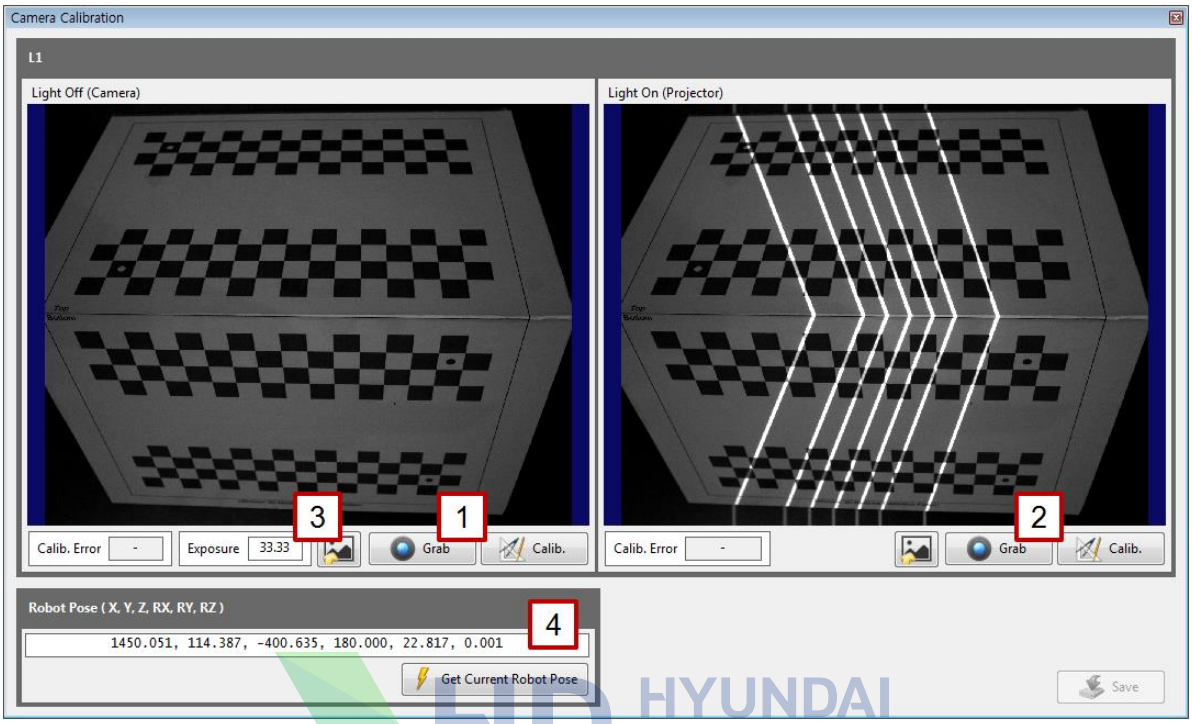
[Step 1]

(1) Securely position the correction plate on the outside.
(2) The correction plate should not move until the calibration is complete. (The relationship [position and orientation] between the correction plate and the robot base shall be fixed at all times.)



[Step 2]

(1) In the main menu, click the [Calibration] button.
(2) Select the [Camera Calibration] menu.



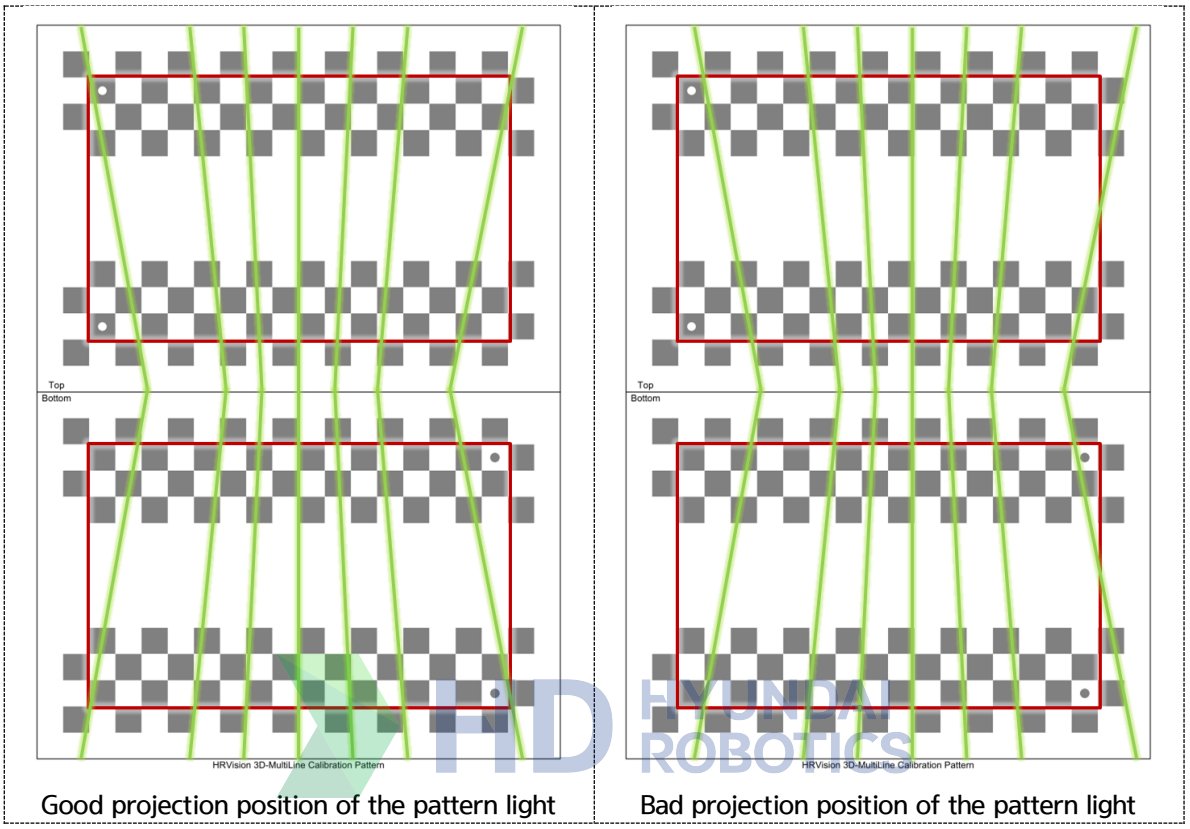
[Step 3]

(1) Turn off the pattern light of the projector, click the left [Grab] button, and check the focus and brightness of the image.

(2) Turn on the pattern light of the projector, click the right [Grab] button, and check the focus and brightness of the image.

(3) As needed, enter a camera exposure value in the [Exposure] column to adjust the exposure to an adequate brightness.

(4) Enter the current pose of the robot in the [Robot Pose] column. If only one robot is used, enter the robot's pose recorded in the base coordinate system. If multiple robots share a coordinate system, enter the robot's pose recorded in the user coordinate system.



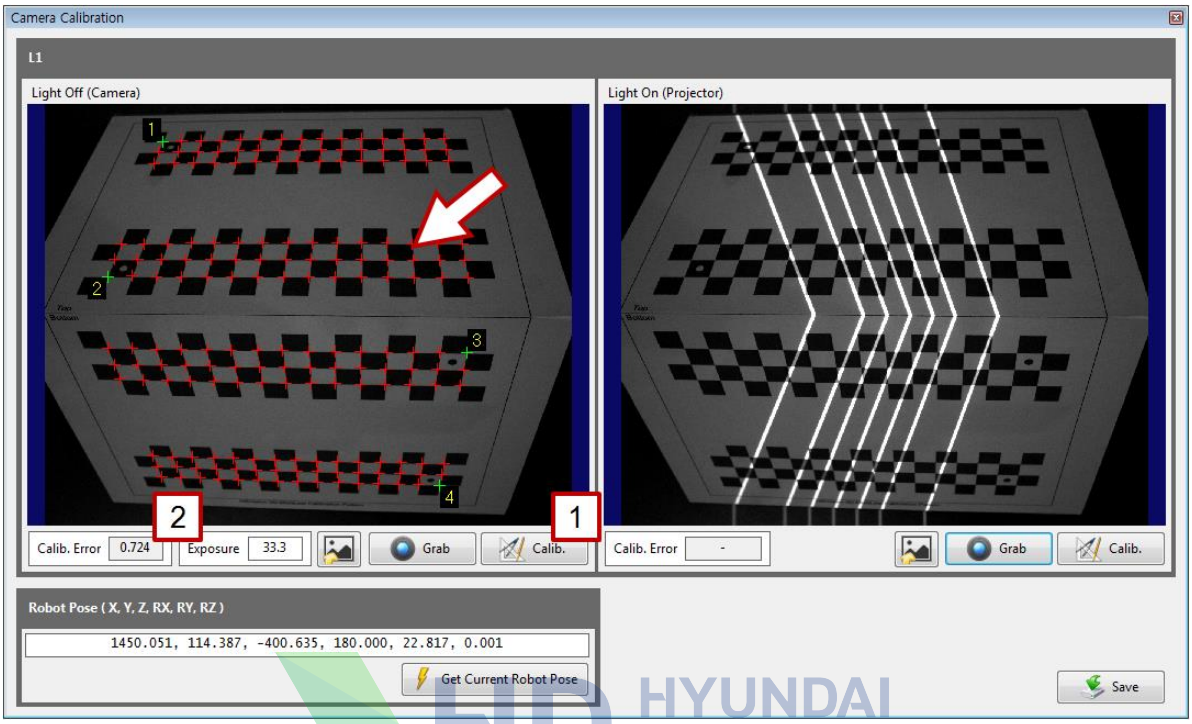
Good projection position of the pattern light

Bad projection position of the pattern light

[Step 4]

(1) Check whether the seven lines shown by the projector are in the effective area (between the red rectangles) of the correction plate.

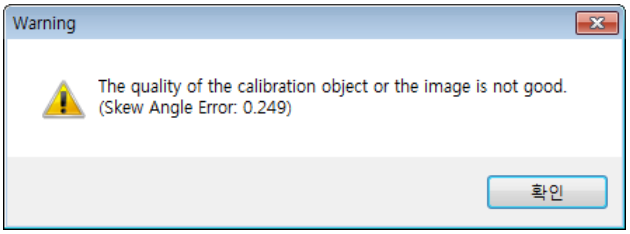
(2) If any line is out of the effective area, adjust the correction plate to an adequate position and orientation, and repeat the procedure starting from [Step 3].



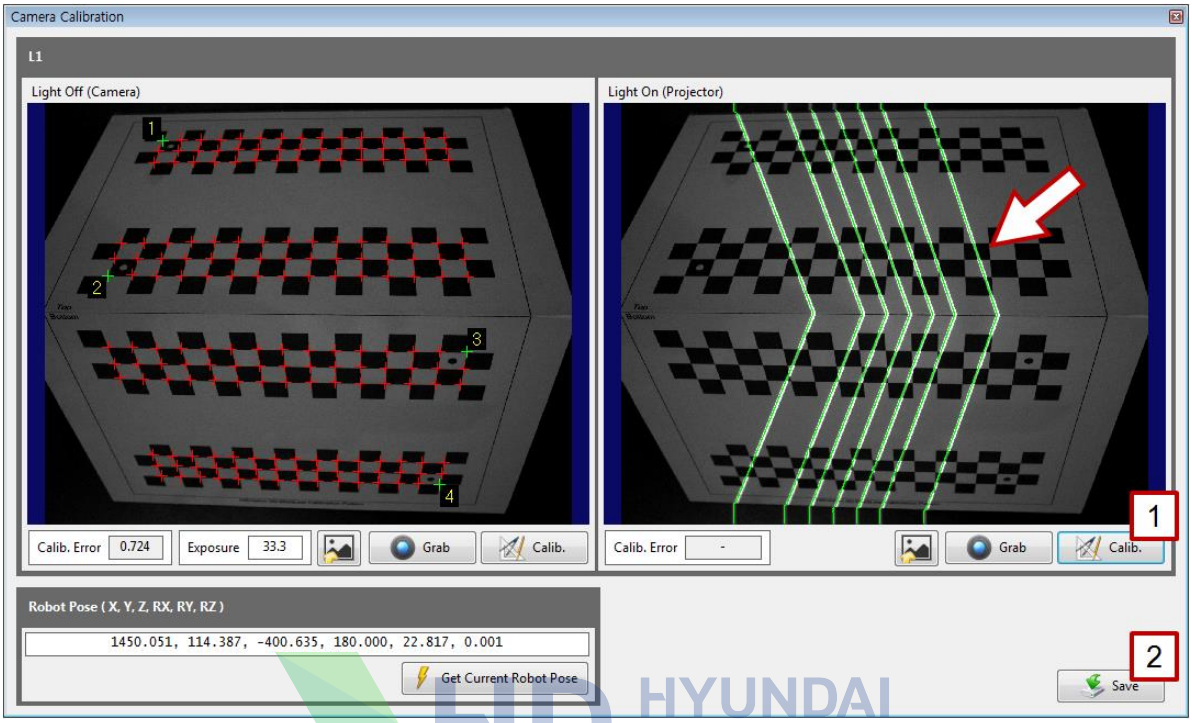
[Step 5]

(1) Click the left [Calib.] button, and check whether the corners of the correction plate are properly detected on the left window. (They are indicated by red cross marks.)

(2) Typically, the value of [Calib. Error] will not exceed 1.0. When the value exceeds 1.0, the detection accuracy of the correction plate may be low because the focus and brightness of the camera are not adequate or because the position and orientation of the correction plate are not adequate. In such cases, recheck the focus and brightness of the camera or adjust the position and orientation of the correction plate, and repeat the procedure starting from [Step 3].



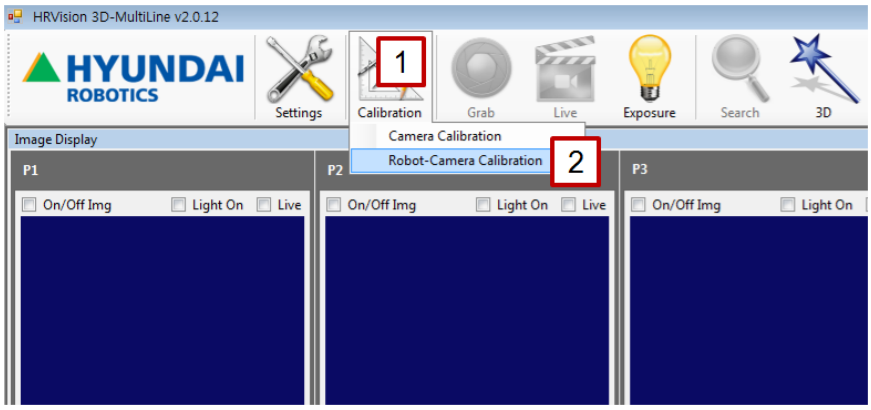
(3) When the warning shown above appears, the mechanical fabrication of the correction plate or the attachment of the correction plate paper is incorrect. Therefore, the correction plate should be prepared again before conducting the calibration.



[Step 6]

(1) Click the right [Calib.] button.

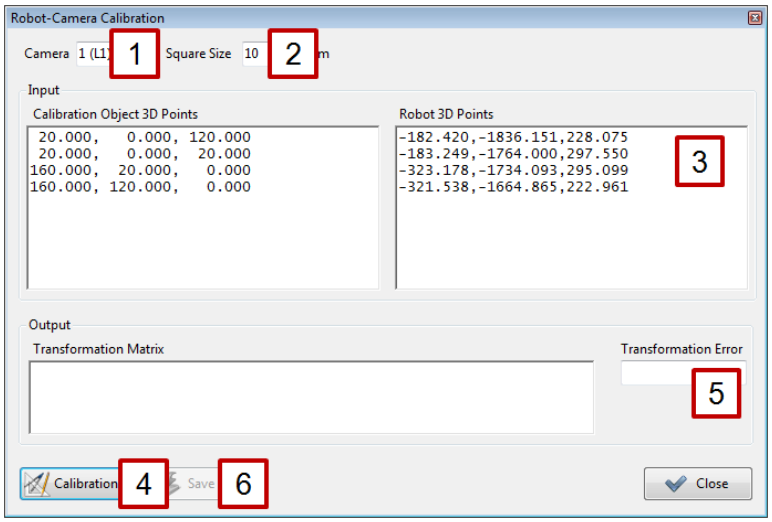
(2) On the right window, check whether the pattern light is properly detected. If it is properly detected, click the [Save] button, and close the window. If not, repeat the procedure starting from [Step 3].



[Step 7]

(1) In the main menu, click the [Calibration] button.

(2) Select the [Robot-Camera Calibration] menu.

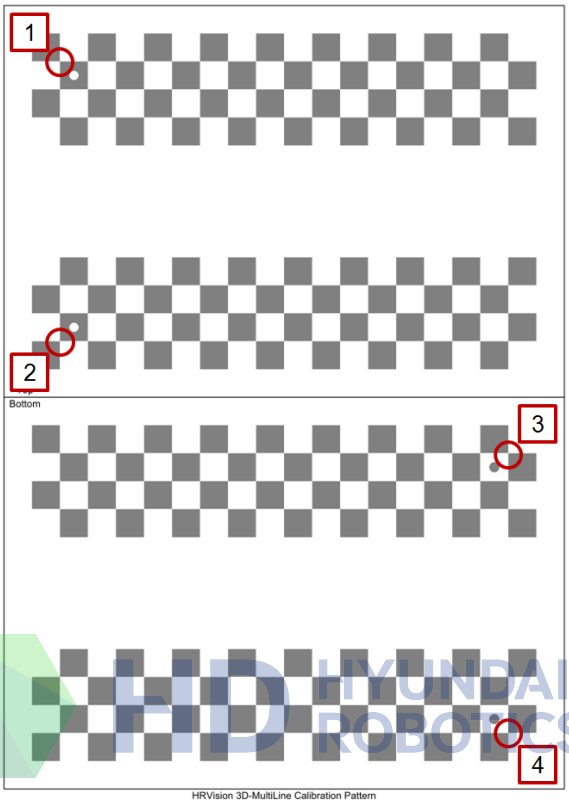


[Step 8]

(1) Select a camera number. If only one camera is used, select [1 (L1)].

(2) Select the square size of the correction plate. Typically, [10 mm] is selected. If the user has fabricated a different-sized correction plate, select a matching square size.

(3) Teach the four points of the correction plate; extract only the values of X, Y, and Z; and enter them in the [Robot 3D Points] column. For the positions and sequence of teaching, refer to the following figure.



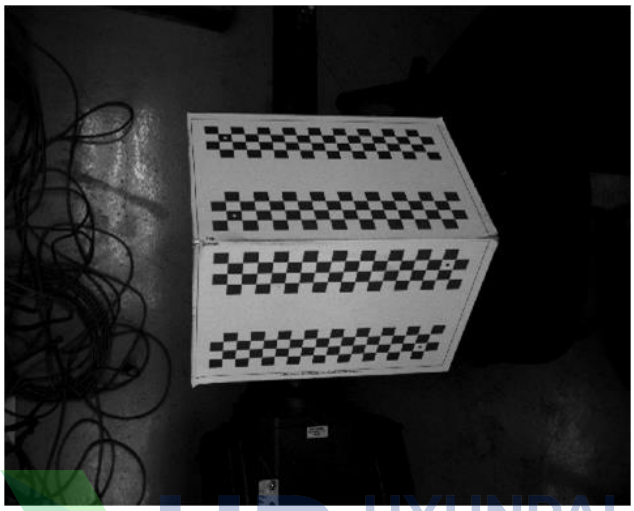
(4) Select the [Calibration] button.

(5) Typically, the [Transformation Error] will not exceed 1 mm. When the value is larger, the correction plate may be incorrectly printed (the size of the checkered rectangle of the correction plate does not conform to the specified value), the teaching may be incorrectly executed, or the robot may be incorrectly calibrated. As such, recheck these points.

(6) If all the settings are correct, save the setting by clicking the [Save] button, and close the window.

2.2. External Fixed Vision

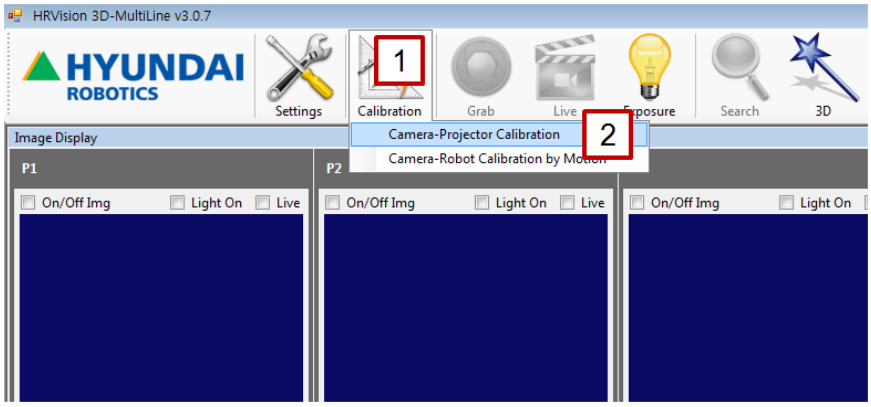
The instructions given in this section apply only to V2.3.0 or higher.



[Step 1]

(1) Attach the correction plate properly to the correct robot's axis. (The correction plate shall be attached to the R1 axis of the robot. Do not attach it to another axis.)

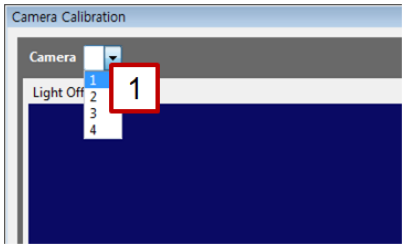
(2) The correction plate should not move on the robot's axis until the calibration is complete. (The relationship [position and orientation] between the correction plate and the robot tool shall be fixed at all times.)



[Step 2]

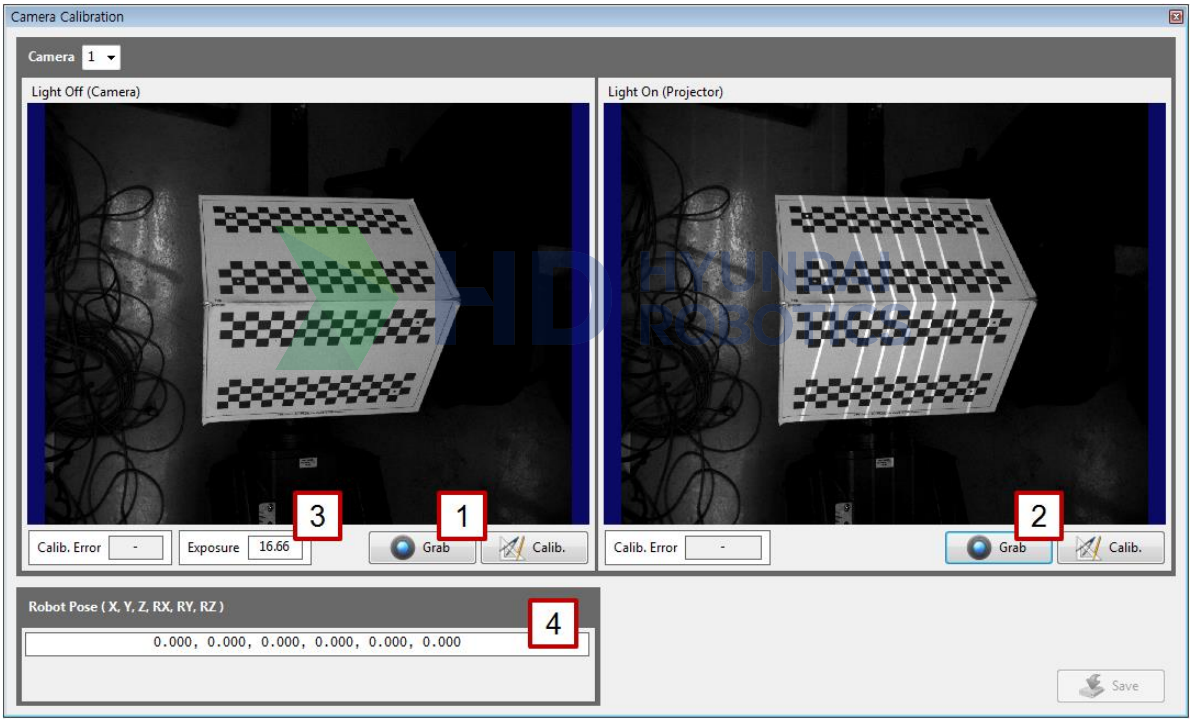
(1) In the main menu, click the [Calibration] button.

(2) Select the [Camera-Projector Calibration] menu.



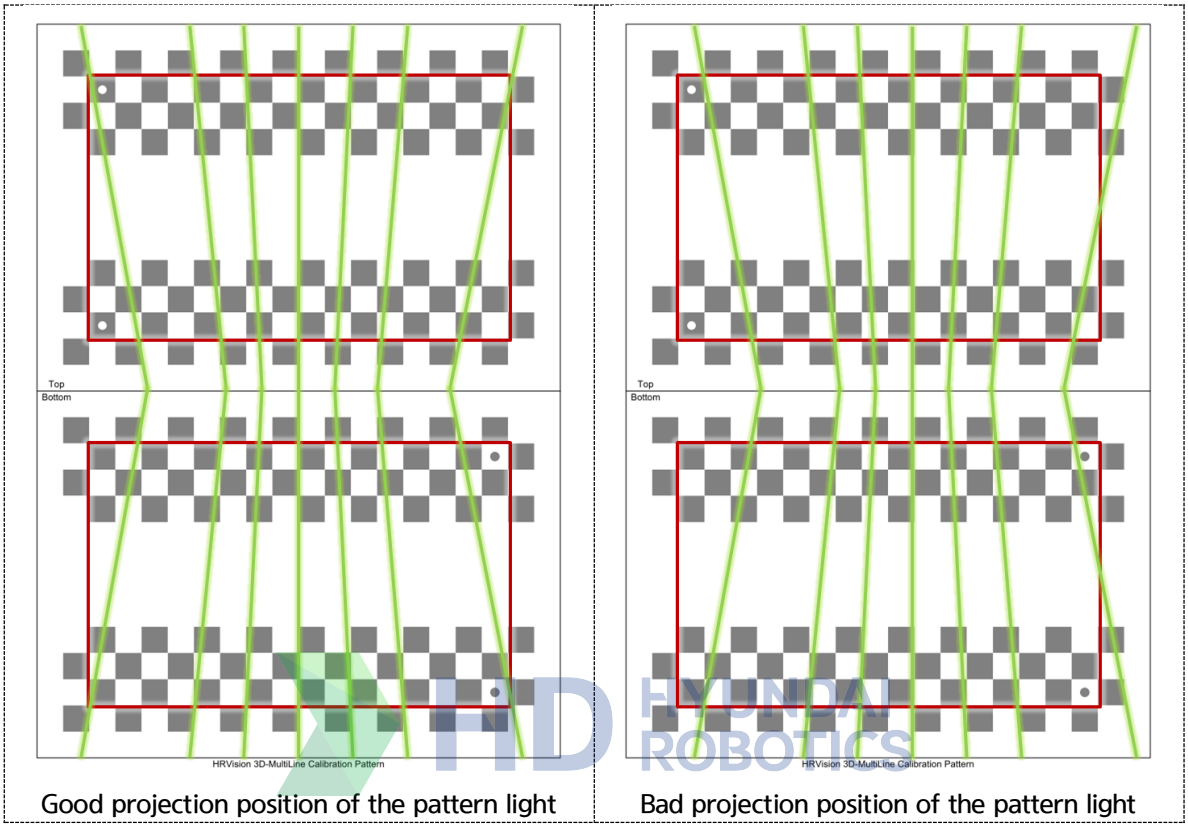
[Step 3]

(1) Select the number of the camera to be calibrated.



[Step 4]

(1) Turn off the pattern light of the projector, click the left [Grab] button, and check the focus and brightness of the image.
(2) Turn on the pattern light of the projector, click the right [Grab] button, and check the focus and brightness of the image.
(3) As needed, enter a camera exposure value in the [Exposure] column to adjust the exposure to an adequate brightness.
(4) Do not enter any values in [Robot Pose] if the camera is fixed on the outside.

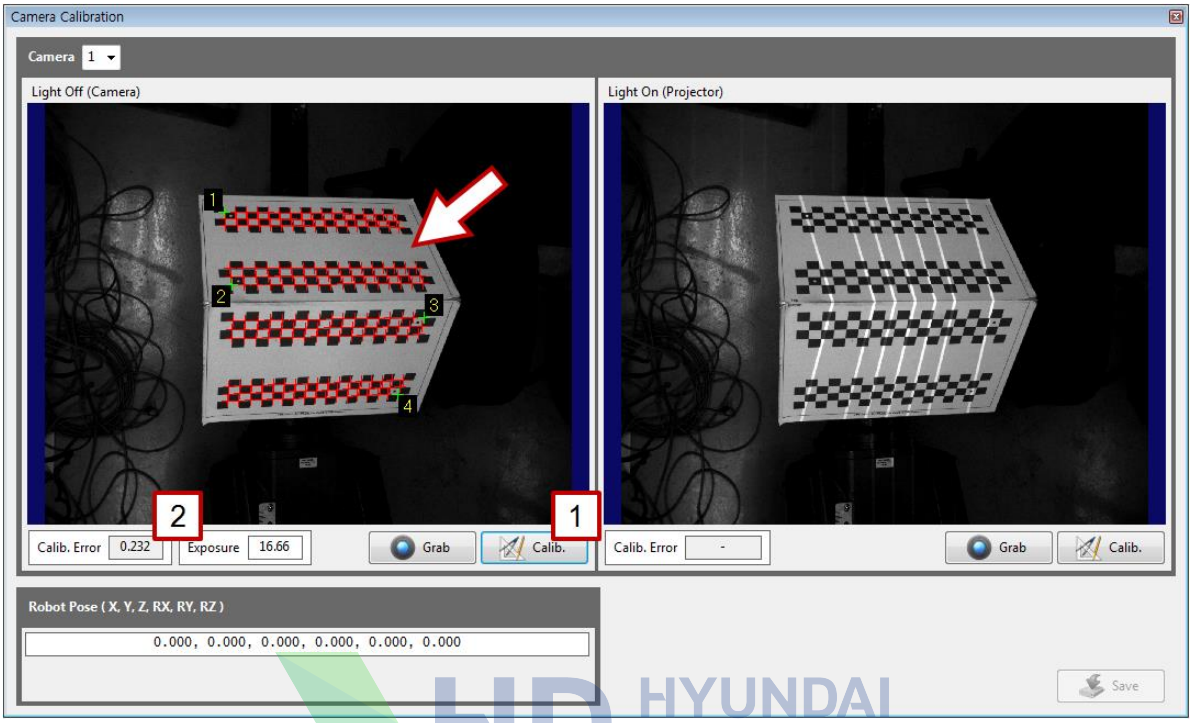


Good projection position of the pattern light | Bad projection position of the pattern light

[Step 5]

(1) Check whether the seven lines drawn by the projector are in the effective area (between the red rectangles) of the correction plate.

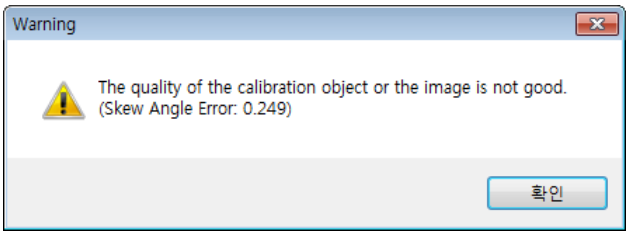
(2) If any line is out of the effective area, adjust the correction plate to an adequate position and orientation, and repeat the procedure starting from [Step 4].



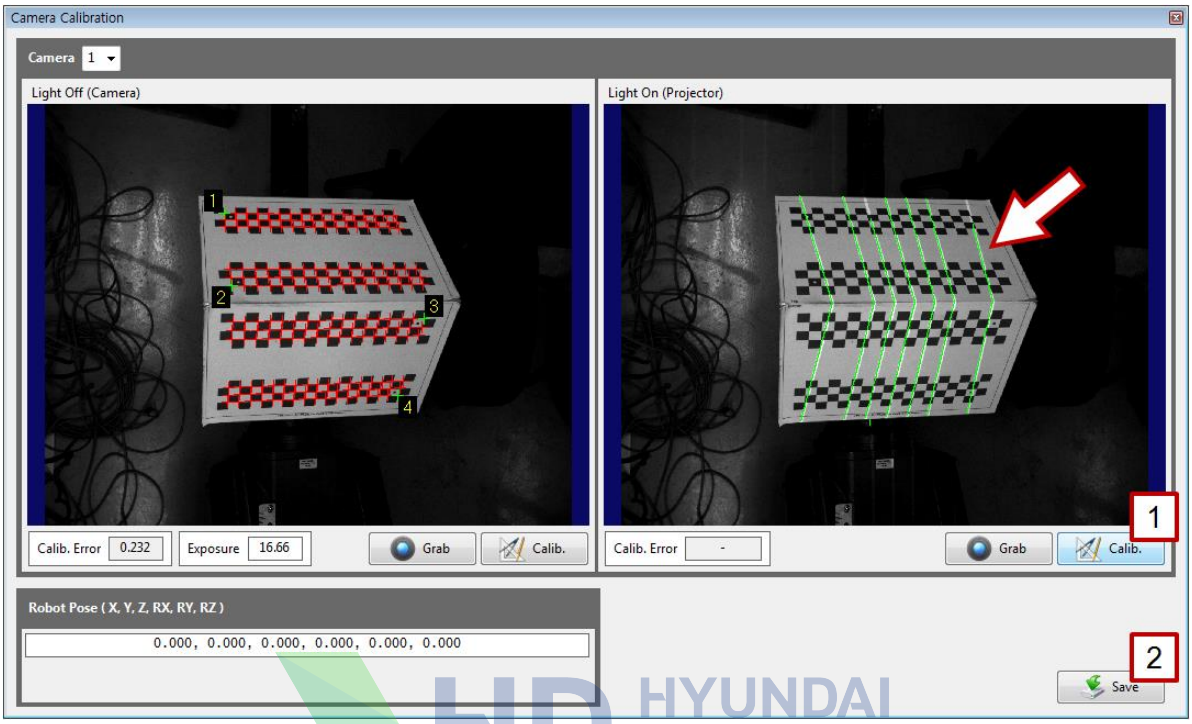
[Step 6]

(1) Click the left [Calib.] button, and check whether the corners of the correction plate are properly detected on the left window. (They are indicated by red cross marks.)

(2) Typically, the value of [Calib. Error] does not exceed 1.0. When the value exceeds 1.0, the detection accuracy of the correction plate may be low because the focus and brightness of the are not adequate or because the position and orientation of the correction plate are not adequate.
In such cases, recheck the focus and brightness of the camera or adjust the position and orientation of the correction plate, and repeat the procedure starting from [Step 4].



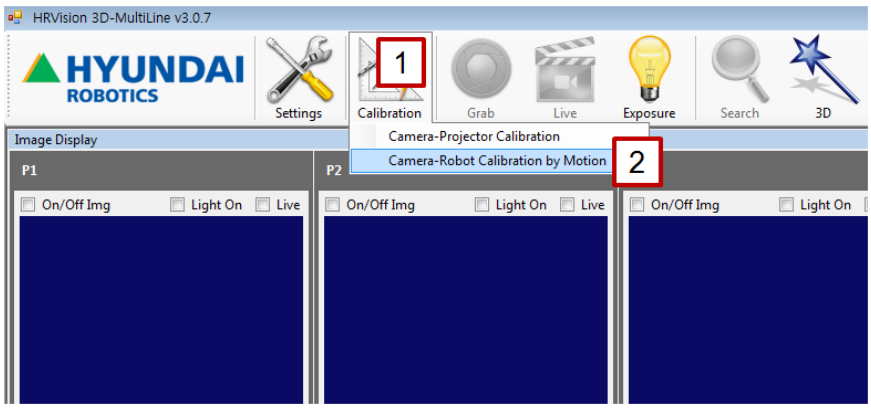
(3) When the warning shown above appears, the mechanical fabrication of the correction plate or the attachment of the correction plate paper is wrong. Therefore, the correction plate should be prepared again before conducting the calibration.



[Step 7]

(1) Click the right [Calib.] button.

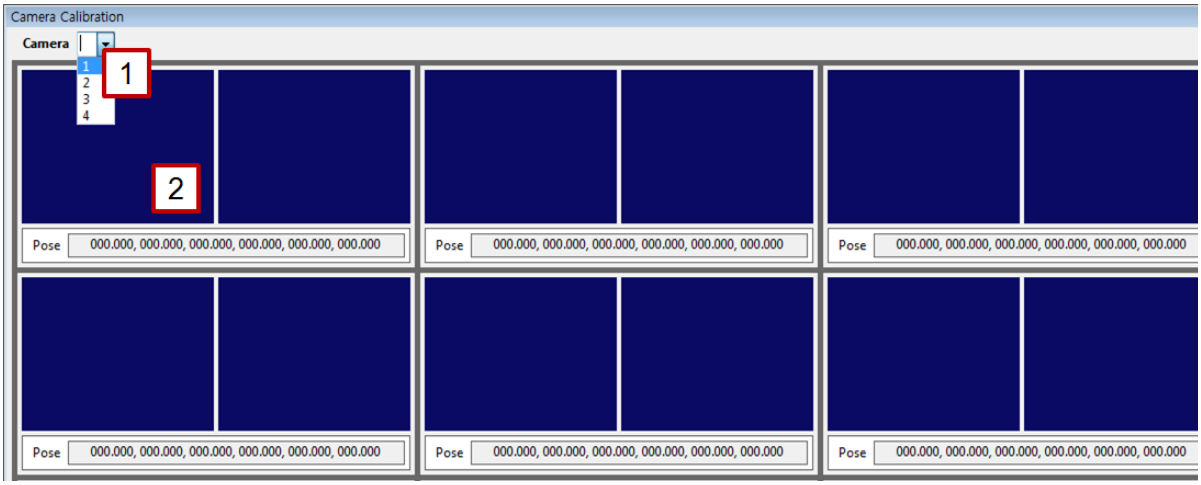
(2) On the right window, check whether the pattern light is properly detected. If it is properly detected, click the [Save] button, and close the window. If not, repeat the procedure starting from [Step 4].



[Step 8]

(1) In the main menu, click the [Calibration] button.

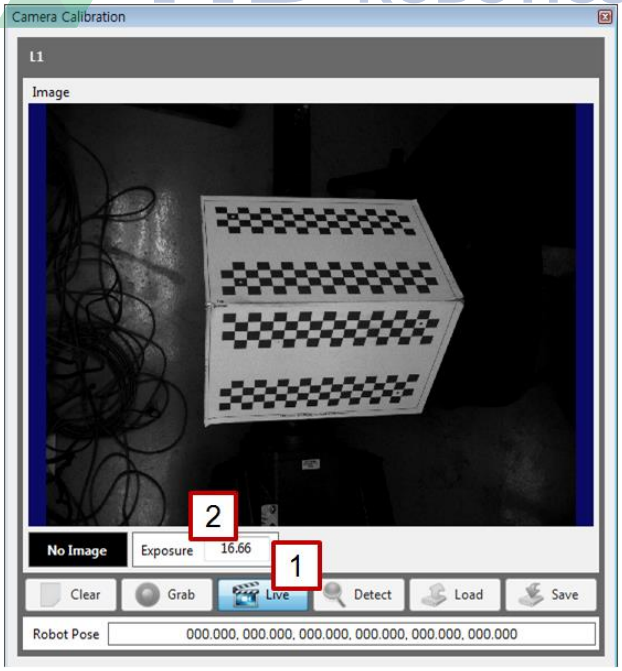
(2) Select the [Camera-Robot Calibration by Motion] menu.



[Step 9]

(1) Select the number of the camera to be calibrated.

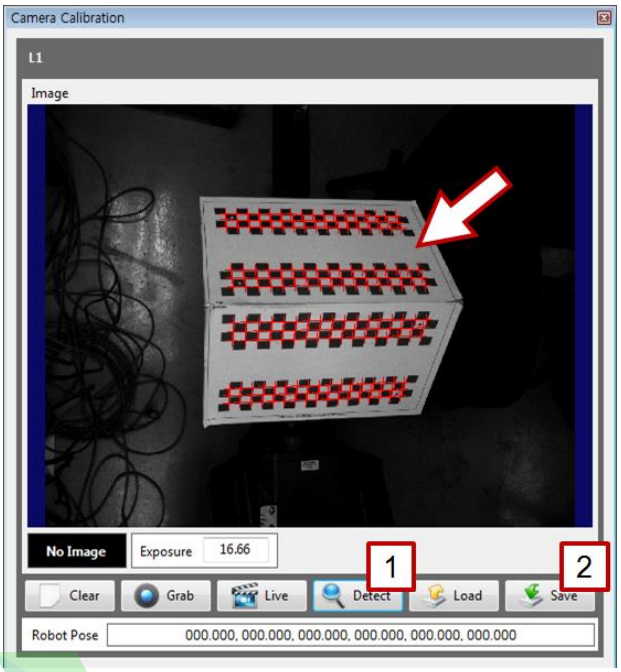
(2) Click the left image on the first window to open a new window. The position of the robot and the correction plate for the first image shall be the same as those used in [Steps 2–7]. In other words, the robot or the correction plate should not be moved to another position or orientation.



[Step 10]

(1) Click the [Live] button, and check the focus and brightness of the image.

(2) As needed, enter a camera exposure value in the [Exposure] column to adjust the exposure to an adequate brightness.

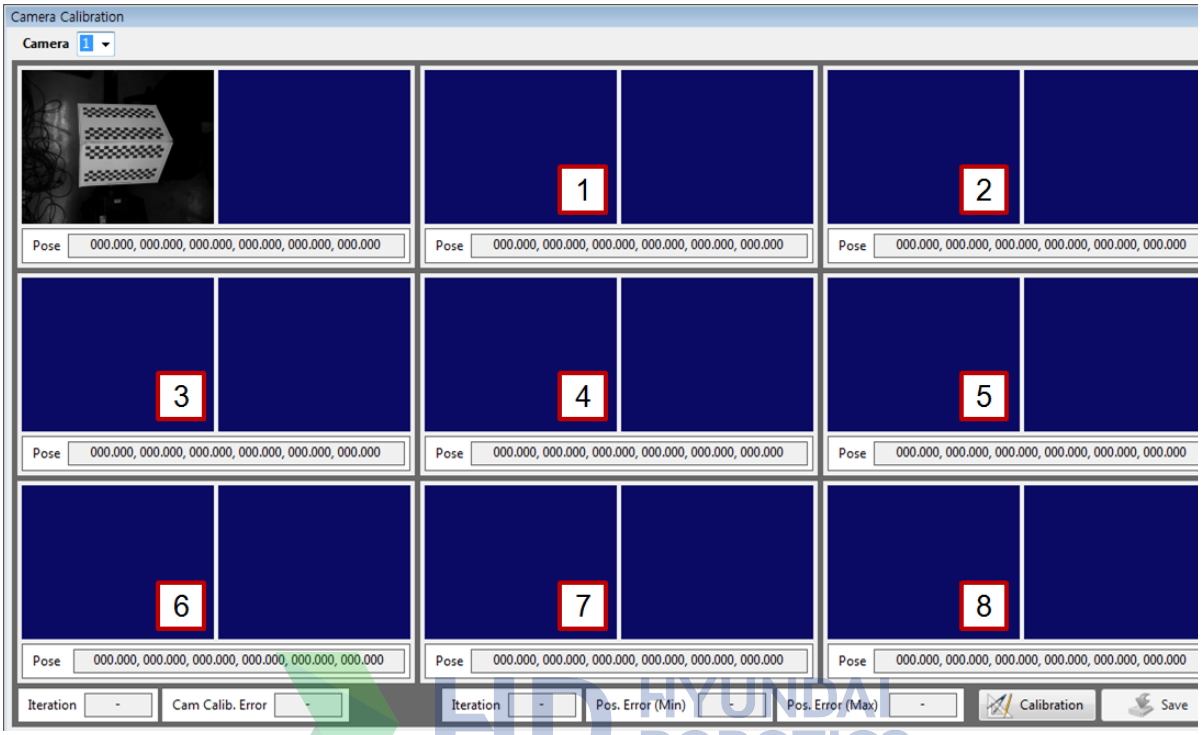


[Step 11]

(1) Click the [Detect] button, and check whether the correction plate is properly detected on the screen.

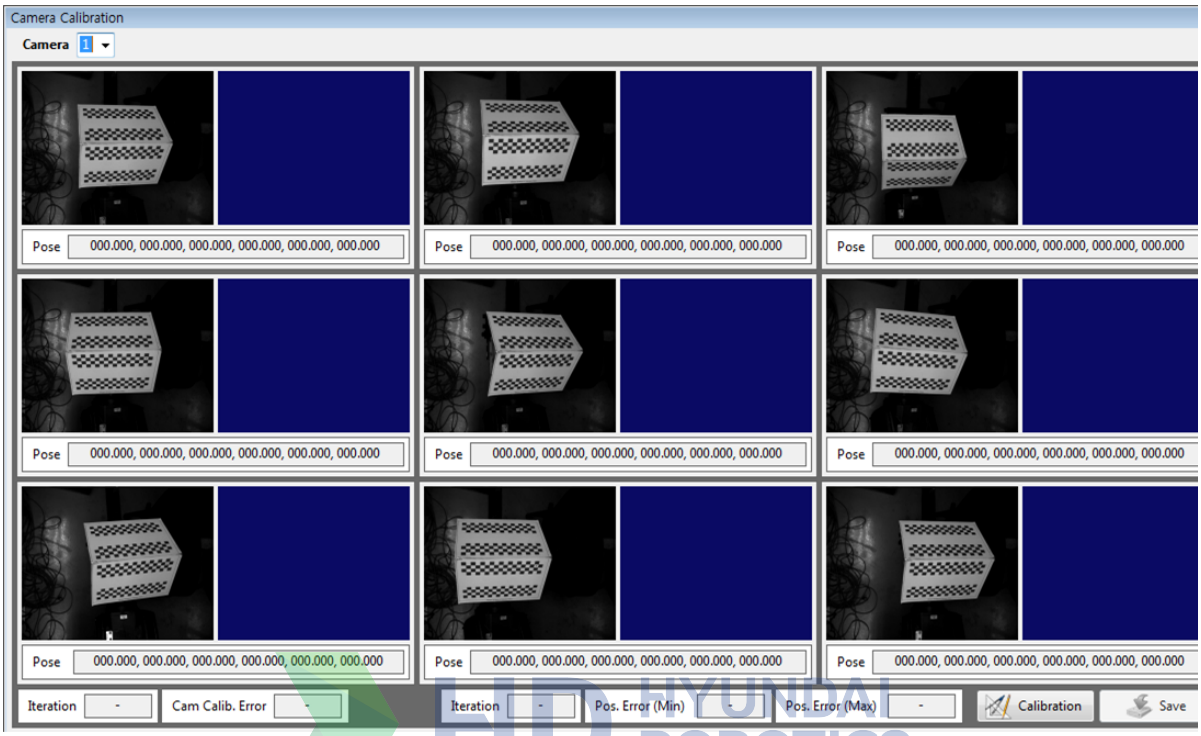
(2) If it is properly detected, click the [Save] button, and close the window. If not, repeat the procedure starting from [Step 10].

(3) Record the current position of the robot with the teach pendant.



[Step 12]

(1) Perform the procedures in [Steps 10–11] for the other eight points by moving the robot to change the position and orientation of the correction plate.
The correction plate for the different poses (position and orientation) should be detected at no less than three points.
The calibration will not run if only the position of the correction plate is changed without any changes in its orientation.
It is recommended to detect the correction plate at no less than seven points by changing its orientation using the RX-, RX+, RY-, RY+, RZ-, and RZ+ buttons on the teach pendant.

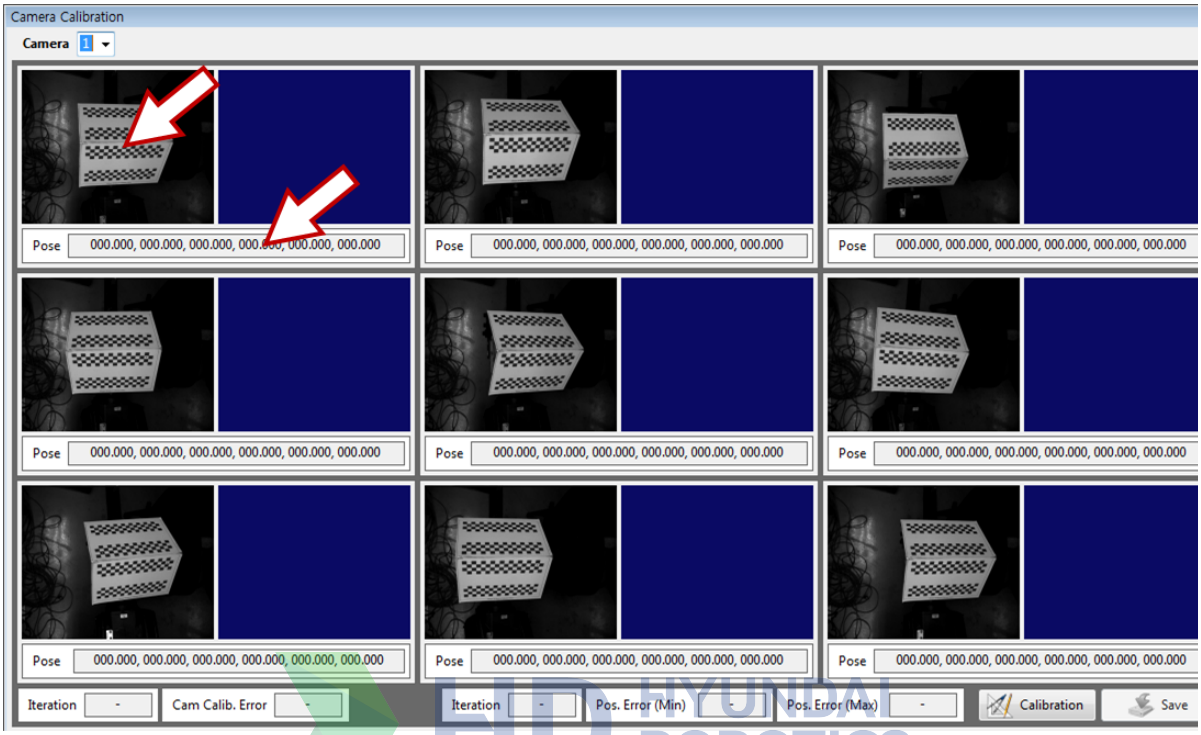



```
Program File Format Version : 1.6  MechType: 70(HA020-01)  TotalAxis: 6  AuxAxis: 0
S1    MOVE P,S=60%,A=1,T=6  (-57.730,1224.563,916.311,90.325,-43.570,-179.566,&H0040)
S2    MOVE P,S=60%,A=1,T=6  (-57.753,1224.572,916.328,95.980,-43.463,176.539,&H0040)
S3    MOVE P,S=60%,A=1,T=6  (-57.779,1224.578,916.354,75.603,-42.536,-169.483,&H0040)
S4    MOVE P,S=60%,A=1,T=6  (-57.761,1224.568,916.320,90.400,-35.406,-179.612,&H0040)
S5    MOVE P,S=60%,A=1,T=6  (-57.766,1224.572,916.326,90.236,-50.743,-179.499,&H0040)
S6    MOVE P,S=60%,A=1,T=6  (-57.747,1224.568,916.342,90.322,-43.571,175.874,&H0040)
S7    MOVE P,S=60%,A=1,T=6  (-57.756,1224.571,916.331,90.323,-43.572,-175.045,&H0040)
S8    MOVE P,S=60%,A=1,T=6  (-113.693,1224.576,916.342,90.322,-43.572,-179.562,&H0040)
S9    MOVE P,S=60%,A=1,T=6  (-14.037,1224.601,916.396,90.316,-43.576,-179.555,&H0040)
      END
```

[Step 13]

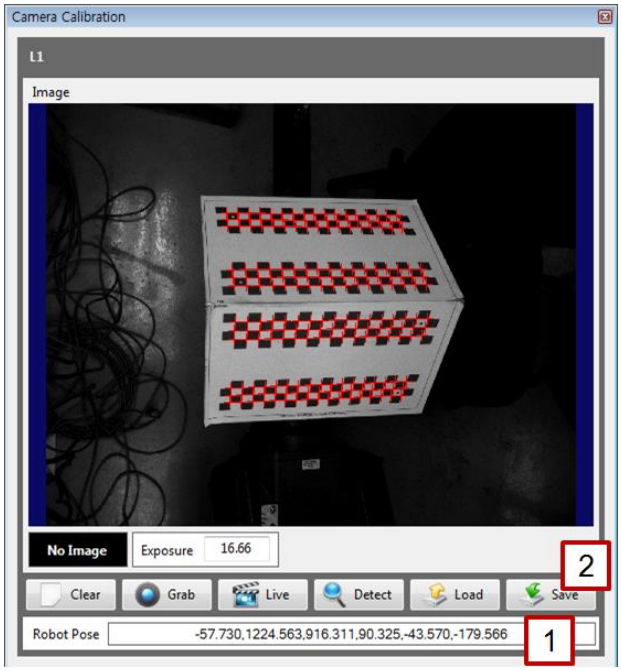
(1) When the images of the correction plate have been acquired, store the robot's job file corresponding to the images of the correction plate in the PC using a USB flash drive or an application such as HRView.

(2) If the coordinate system of the recorded points is set at axial angle or encoder, convert it to another adequate coordinate system.
Typically, the points should be recorded in the base coordinate system if only one robot is used. Meanwhile, the points should be recorded in the user coordinate system if multiple robots share a coordinate system.



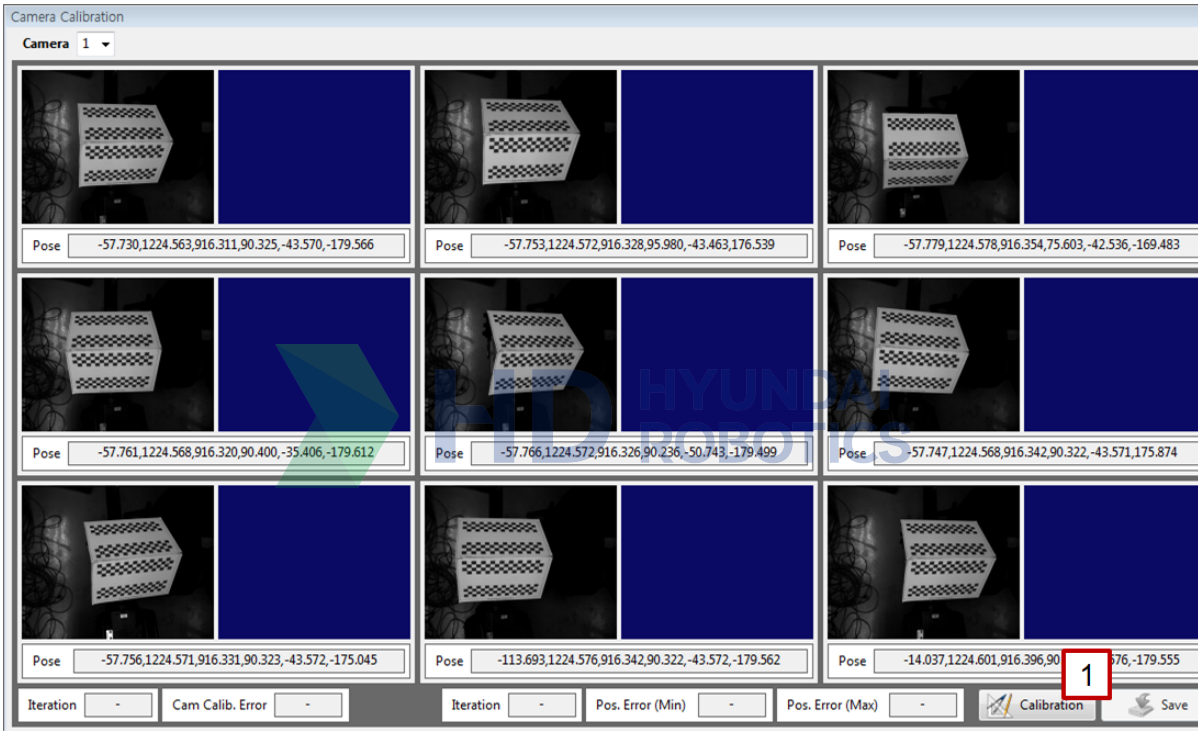
[Step 14]

(1) Click the window where the correction plate is detected or the [Pose] section.



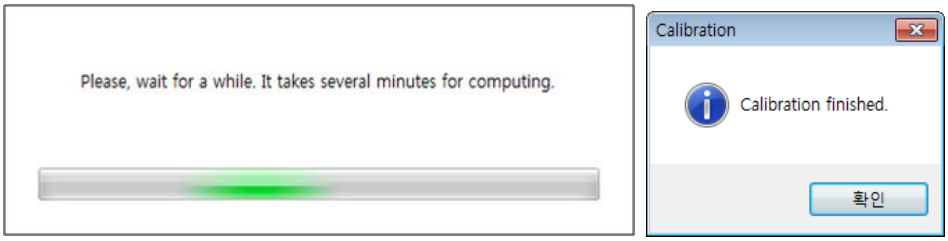
[Step 15]

(1) Enter the robot's pose corresponding to the image of the correction plate in the [Robot Pose] section. In the case of a robot with seven or more axes, enter only up to six axes (X, Y, Z, RX, RY, and RZ).
(2) Click the [Save] button, and close the window.



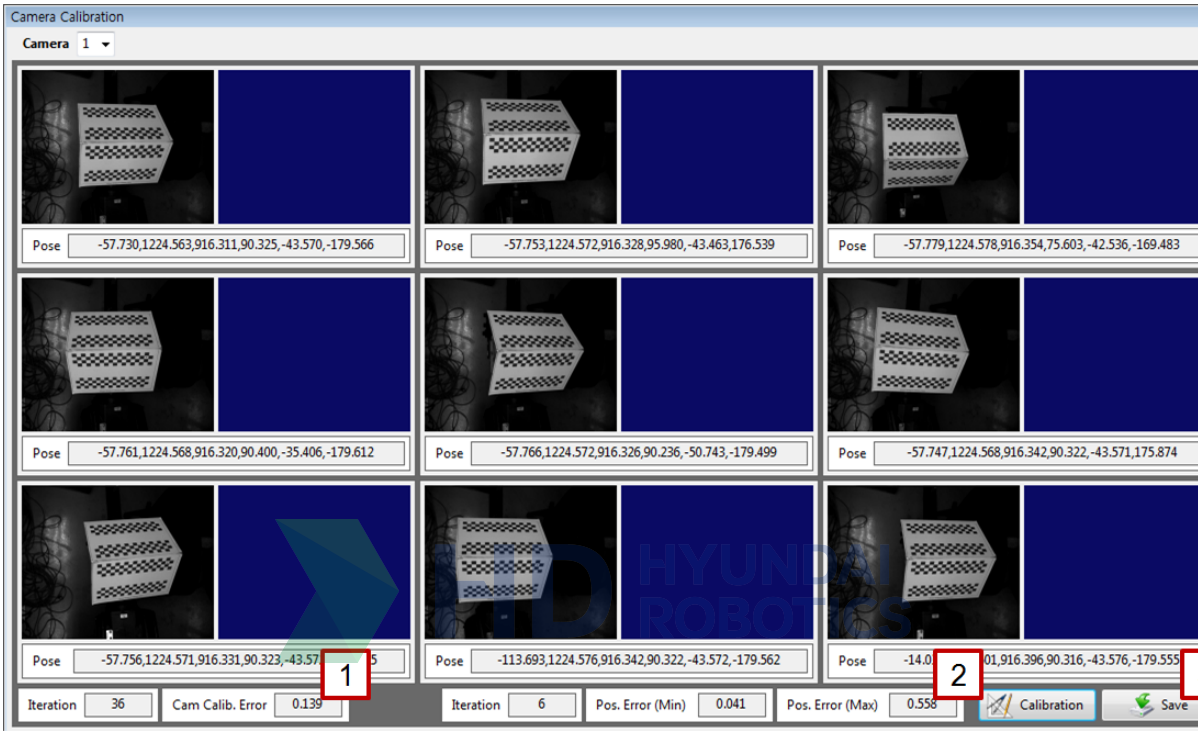
[Step 16]

(1) For the remaining images of the correction plate, repeat [Steps 14–15], and click the [Calibration] button.



[Step 17]

(1) The arithmetic operation may take some time. Wait until the “Wait for a while.” message window disappears and the “Calibration finished.” window appears.



[Step 18]

(1) Typically, the value of [Cam Calib. Error] will be no larger than 0.5.

(2) The error between a pose calculated by the camera and that recorded in the robot will not typically exceed 1 mm. Check the [Pos. Error (Max)] value. A high pose error may occur if the robot manipulator is not properly calibrated, if the robot is of a large size, if the distance between the camera and the correction plate is large, or if the angle of the correction plate is highly slanted.
The permissible error value of calibration should be determined depending on site conditions.

(3) Click the [Save] button to store the calibration result.

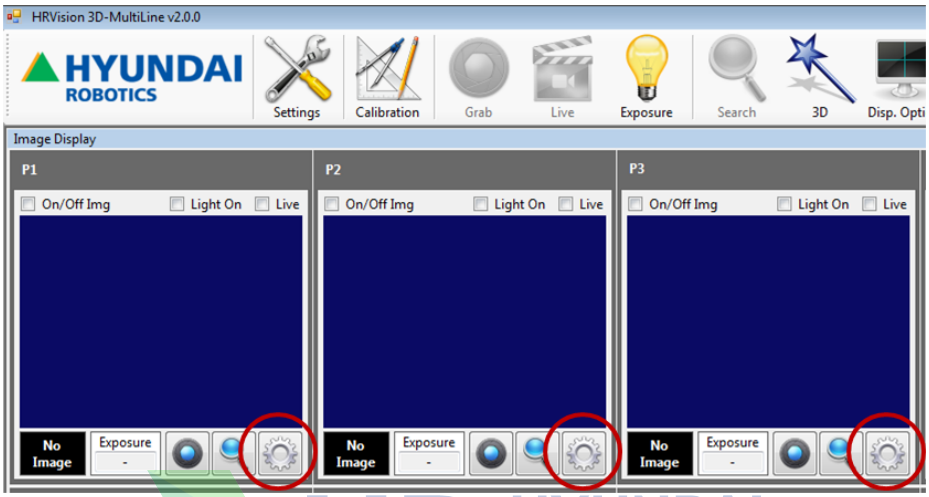
(4) Return to [Step 9], and repeat the same procedure for the remaining cameras.

HYUNDAI ROBOTICS

3 Pattern Registration

3.1. Pattern Registration Procedure

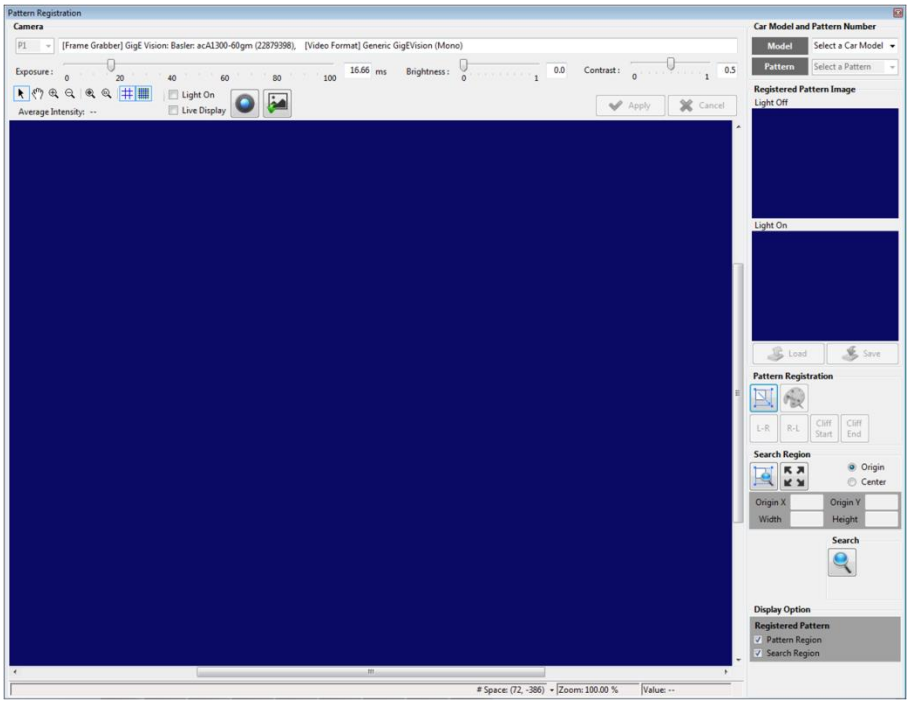
This section describes the process of registering patterns.

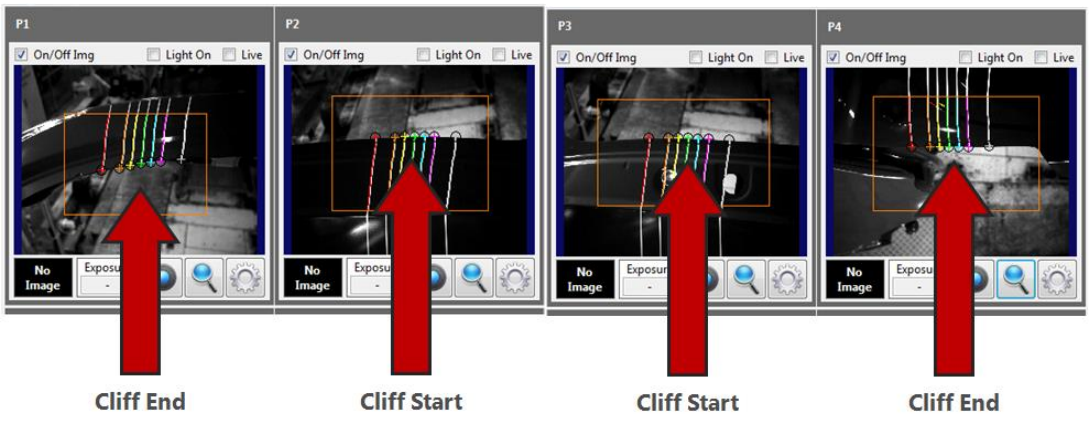


[Step 1]

(1) If the camera is wrist-held, move it to the point for pattern registration.

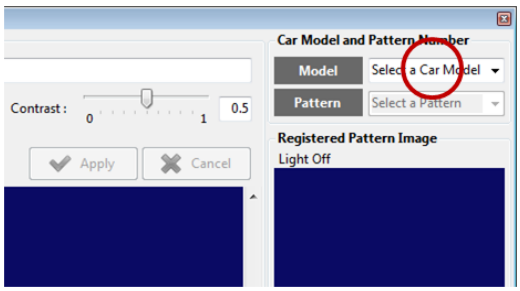
(2) When the point's pattern registration button (encircled in the above figure) is clicked, a window will appear as shown in the following figure:





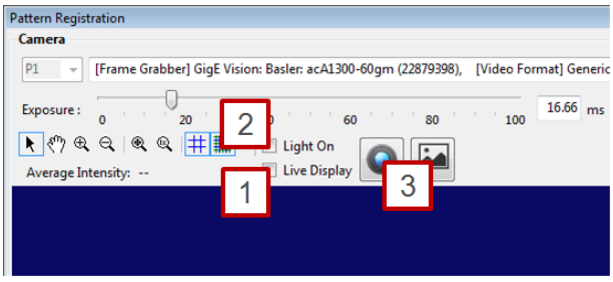
[Step 2]

(1) In pattern registration, select the camera location so that the bent/cut surface of the workpiece can be clearly detected.
(2) In the camera image, the starting point of the bent/cut surface will be expressed in [Cliff Start], and the end point will be expressed in [Cliff End].
(3) As shown in the above figure, a [Cliff Start] for detecting the starting point of a line pattern and a [Cliff End] for detecting the end point must be registered.
(4) When the line pattern projected on the workpiece overlaps the background, no [Cliff Start] or [Cliff End] will be detected. Therefore, the camera location must be adjusted so that [Cliff Start] and [Cliff End] can be clearly distinguished.
(5) The end point will not be detected clearly depending on the camera location if the curvature (R value) of the bent surface is large. Therefore, it is recommended to detect a surface of a small curvature or a cut surface.



[Step 3]

(1) Select a model number.



[Step 4]

(1) Click [Live Display], and check whether the focus of the camera on the projected pattern is clear and the position is adequate.

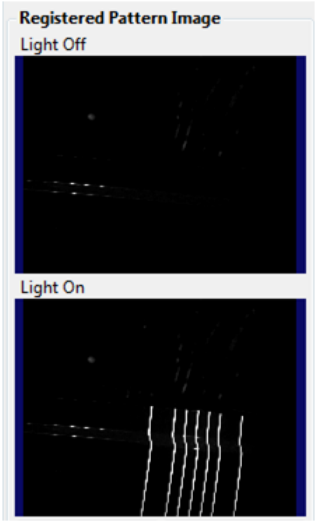
(2) Turn off the line pattern light of the pattern projector, and disable the [Light On] checkbox. For example, set [DO3=0] to turn off the line pattern light if the On/Off status of the pattern projector is controlled by DO3 of the robot controller.

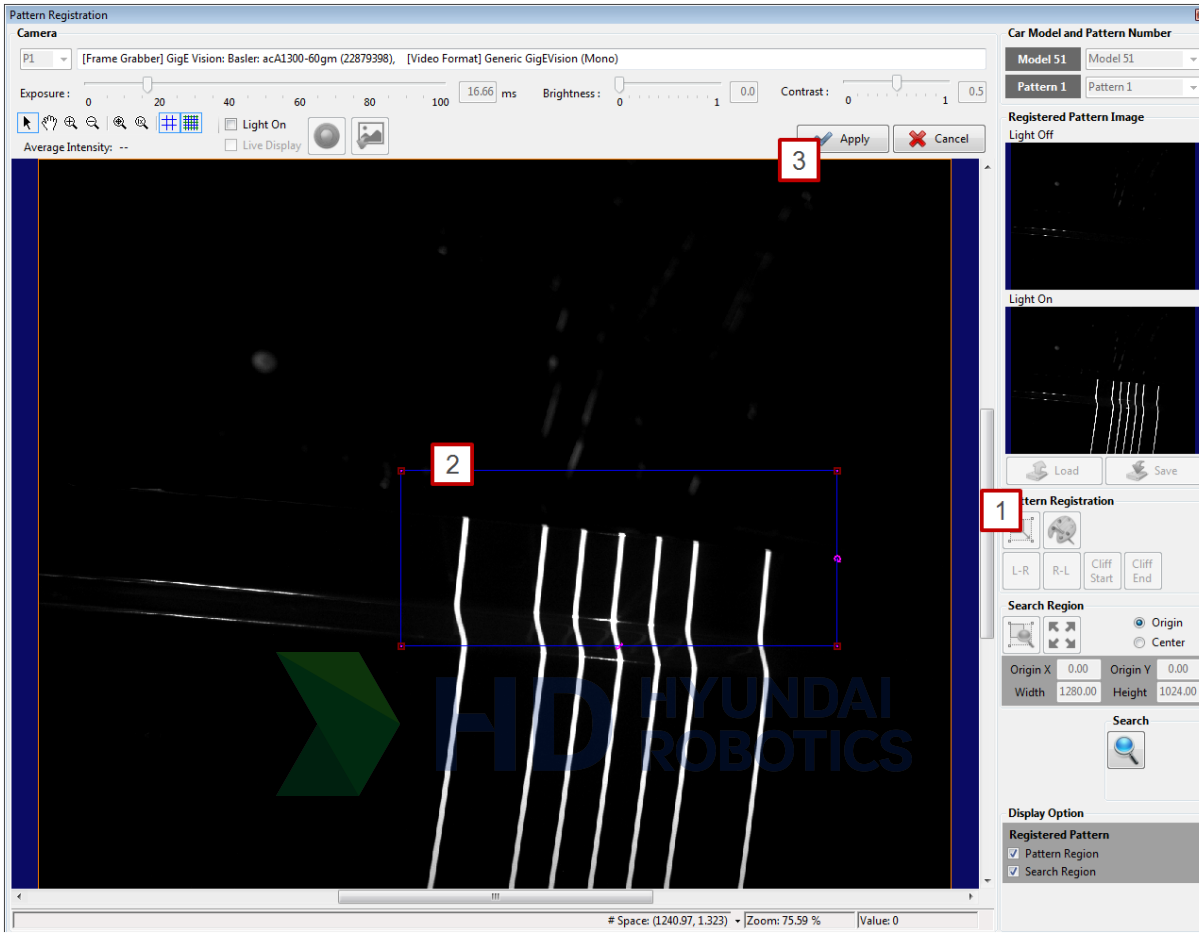
(3) Click the [Grab] button to acquire an image.

(4) Turn on the line pattern light of the pattern projector, and enable the [Light On] checkbox. For example, set [DO3=1] to turn on the line pattern light if the On/Off status of the pattern projector is controlled by DO3 of the robot controller.

(5) Click the [Grab] button to acquire an image.

(6) If images are acquired properly when the projector is on and off, an image with the line pattern light off will appear in [Light Off], and an image with the light on will appear in [Light On], as shown in the following figure.



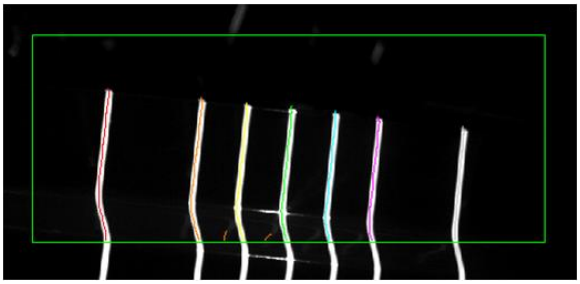


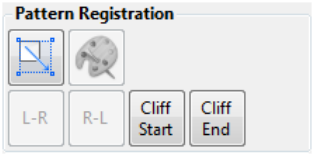
[Step 5]

(1) Click the pattern setting button.

(2) Adjust the pattern setting area using the mouse so that the starting point or the end point of the line pattern appears in the image window.

(3) When the [Apply] button is clicked, the line patterns will appear in various colors, and the pattern setting area will be indicated by a green rectangle, as shown in the following figure.

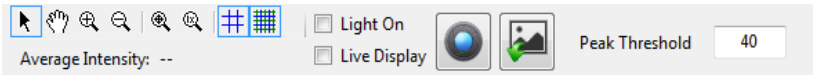




[Step 6]

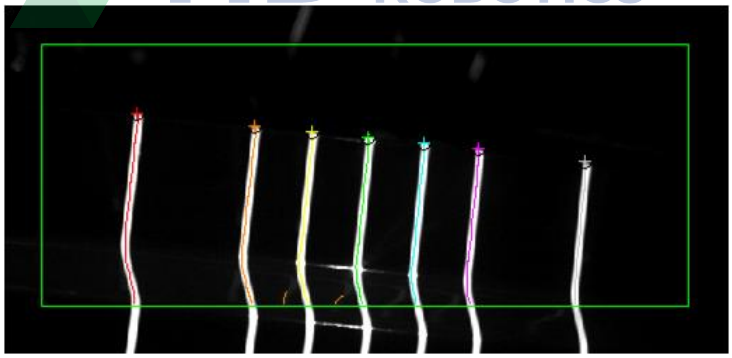
(1) Click the [Cliff Start] or the [Cliff End] button depending on the part to be detected. The starting point or the end point of the line pattern will be indicated by a [+] mark.

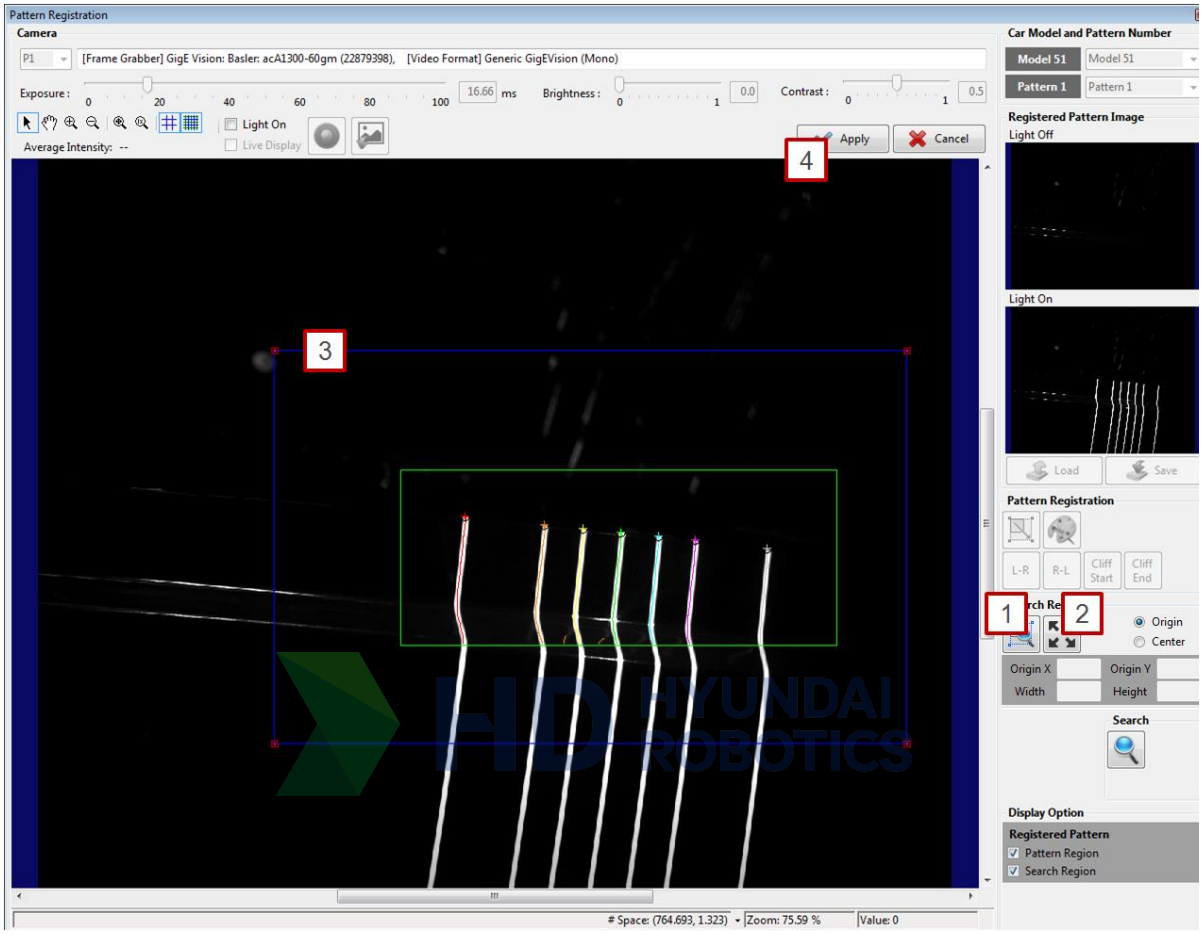
(2) If the location of the starting point or end point is slightly offset because of excessive light exposure or if a problem occurs in which a line pattern remains on the background, raise the [Peak Threshold] value to an adequate level, as shown in the following image. (This is supported only in a specific version or higher.)



(3) If the desired part is not indicated, repeat the above procedure.

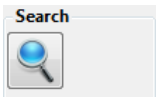
(4) If the starting point or end point is properly detected, click the [Apply] button. The following figure shows an example in which the starting point of a line pattern is detected.





[Step 7]

(1) Set the search area by clicking the [1 Pattern Search Area] button.
(2) Expand the search area to match the image size by clicking the [2 Maximize Area] button.
(3) Considering the movement range of the workpiece, adjust the pattern search area using the mouse so that it is slightly larger than the pattern setting area.
(4) Clicking the [Apply] button will indicate the pattern search area in orange.



[Step 8]

(1) Click the [Search] button to check whether the registered pattern is properly detected.
(2) If the pattern is properly detected, apply the previous procedure to all the remaining cameras.

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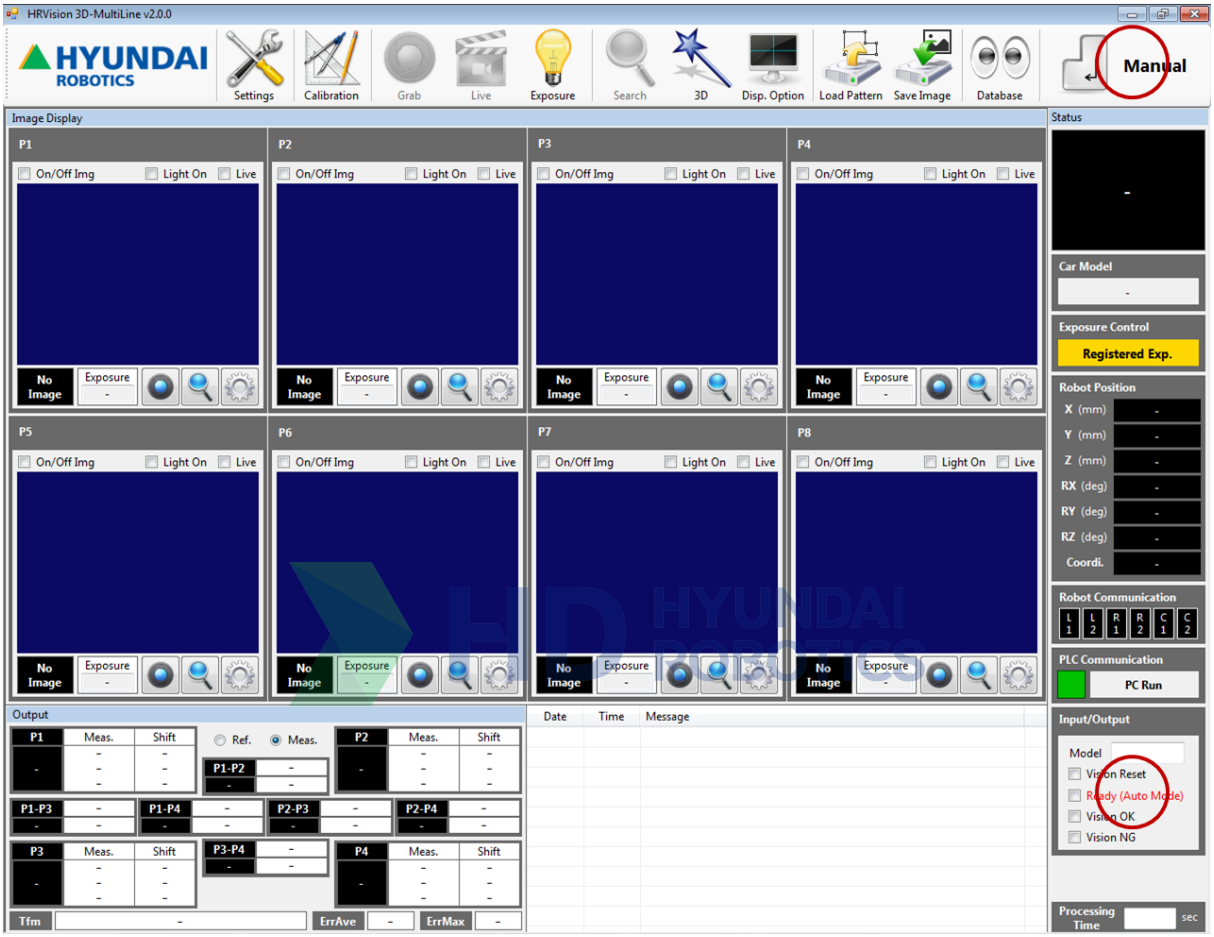
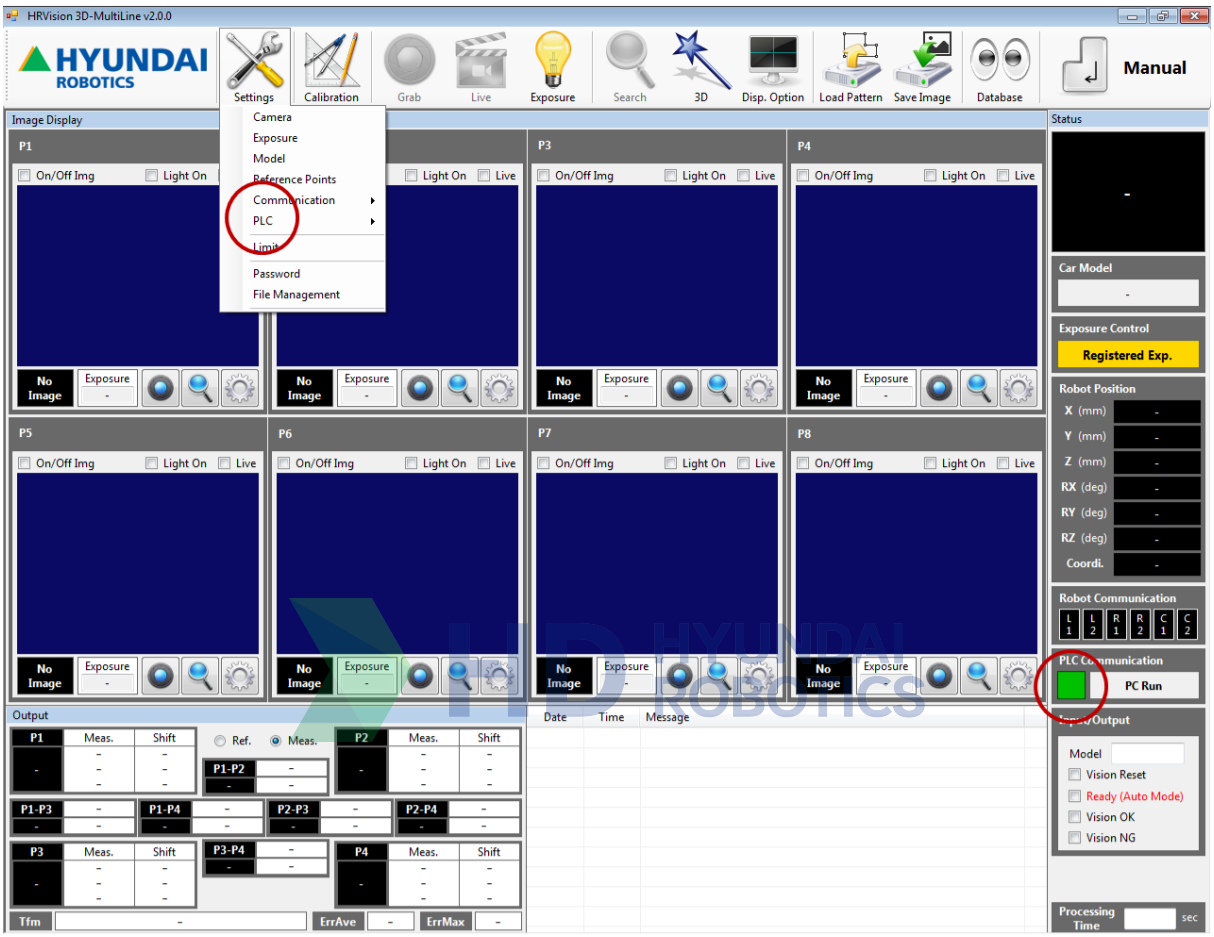
4 Fault Check

4.1. Vision Ready Error



(1) A [Vision Ready Error] will occur if the vision program is not in the [Automatic Mode].
(2) In such cases, the [Ready (Auto Mode)] item will be indicated in red.
(3) Click the [Manual] button, and check whether the mode enters the [Auto] mode.
(4) In the [Auto] mode, the [Ready (Auto Mode)] item will be ticked and indicated in black.

4.2. PLC Communication Error



(1) A [PLC Communication Error] will be issued if a problem occurs in the communication between the vision program and the PLC.
(2) Check whether the [PC Run] (PLC heartbeat) signal turns on and off repeatedly.
(3) If not, check the [Settings 〉 PLC] menu.
(4) If [Non-Use] is ticked, select an adequate PLC type, such as [Mitsubishi] and [Siemens].
(5) If the error persists, check the LAN cable and the network status, including the IP address.

4.3. Vision NG Messages

Message	Model Number Error
Cause	This error will occur if a wrong model number is entered.
Action	Enter the correct model number.

Message	Calibration Error
Cause	This error will occur if the program is not calibrated.
Action	Refer to [2. Calibration] of this manual to calibrate the vision program.

Message	Image Grab Error
Cause	This error will occur if a problem occurs with the camera.
Action	Check the camera and its cables.

Message	Pattern Registration Error
Cause	This error will occur if no pattern is registered.
Action	Refer to [3. Pattern Registration] of this manual to register and save a pattern.

Message	Reference Points Error
Cause	This error will occur if no reference point is registered.
Action	Refer to [1.2. Reference Point Registration] of this manual to register and save reference points.

Message	Moving Distance Limit
Cause	This error will occur if the moving distance of the workpiece exceeds the limit value.
Action	In the [Settings 〉 Limit] menu, adjust the workpiece moving distance limit to an adequate value.

Message	Point Matching Limit
Cause	This error will occur if the matching difference is large between the reference workpiece and the measured workpiece.
Action	In the [Settings 〉 Limit] menu, adjust the point matching limit to an adequate value. (Default value: 1 mm [mean error], 3 mm [maximum error])

Message	Line Detection Failure / Recognition Failure
Cause	These errors will occur if the workpiece is not recognized properly.
Action	Contact a representative of Hyundai Robotics.

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