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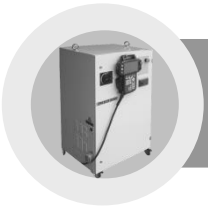
WARNING

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

Hyundai Robot

Hi5aHS210101FMEN1



Hi5a Controller Function Manual

HRSpace3

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1 Introduction

1.1. About HRSpace3

HRSpace3 is a PC based OLP (Off-Line Programming) software for Hyundai Robot and Hyundai Hi5a Controller.

After installing the robot process, teaching the robot and test running the robot, problems unexpected during planning are identified. If these problems are corrected after the installation and teaching process is completed, the timing of mass production will be delayed.

By using HRSpace3, you can configure the robot work in 3-D virtual space and review the problems while simulating the configured work to make any corrections. Because the work prepared in HRSpace3 is saved as work file for Hi5a Controller, this file can be copied to the controller to execute the actual robot work.

HRSpace3 is equipped with a virtual controller that is the same one in actual Hi5a. Thus it estimates the trace and cycle time as precisely as actual Hi5a controller does. Any Hi5a controller users can easily learn how to use this because it supports all HR-BASIC commands and the operation method and functions of Hi5a controller except some functions such as cooperation control or online tracking. It can also be used in user training, how to use Hyundai Robot.

HRSpace3 is the optimal choice for OLP work of Hyundai Robot.

■ **Warning: To HRSpace2 users**

- HRSpace3 doesn't support Hi4a and older controller. It also doesn't support the body of old type robots that are not registered in Hi5a.
- HRSpace3 and HRSpace2 use the same extension (.hrs) for documents but documents from HRSpace3 and HRSpace2 are not perfectly compatible. Please use HRSpace2 to open documents that contain old type robots and controllers.
- There're lots of differences in the operation of HRSpace3 and HRSpace2. Please use HRSpace3 after reviewing manuals or Help fully.

HRSpace3 provides the following convenient functions.

3-D work configuration	You can arrange objects such as robot, jig, work piece and tool on 3-D space. These objects are managed in hierarchy structure.
Open STL file	HRSpace3 can open STL file of 3-D object saved with a CAD program.
Robot simulation	A built-in Hi5a virtual controller in HRSpace3 simulates the actual operations of a robot. It can estimate the correct path of the tool end and the cycle time. It can simulate up to 10 Hyundai robots at the same time and also do traverse axis simulation. It is able to simulate the sequence of I/O signals between a robot and a device and do the whole work cell simulation by linking with scripts.
Save as work file	It can save settings & job files as a format that Hi5a can read. On the contrary to this, it can import the settings & work files from Hi5a controller.
Robot monitoring of Hi5a controller	Real-time monitoring is available with a 3-D screen by receiving the details of a robot's pose controlled by actual Hi5a controls via RS-232C or Ethernet.

1.2. System Requirement

The following system is required to use HRSpace3.

Minimum specification	PC	Pentium 4, 512MB RAM, 300MB HDD space
	OS	Windows 2000 or Windows XP
	Display	General OpenGL accelerated video card Resolution:1024*768 / Color:16M (True Color) / Video RAM:32M
Recommended specification	PC	Core2 Duo, 2GB RAM, 500MB HDD space
	OS	Windows 2000 or Windows XP
	Display	Professional OpenGL accelerated video card Resolution:1920*1200 / Color:16M (True Color) / Video RAM:512M

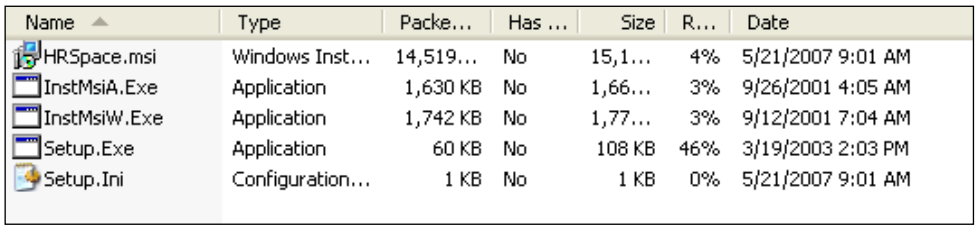
If you work with large scale CAD files, use high performance hardware with sufficient memory capacity and professional video card.

1.3. Software Installation

Close all application software on the system.

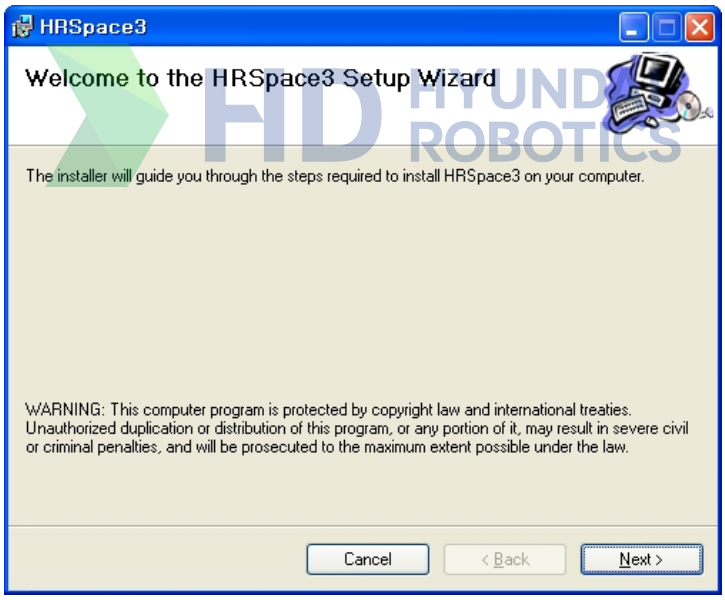
".pdf" is HRSpace Help. Please install Adobe Reader first if it's not installed.

Now, execute 『HRSpace3.msi』, HRSpace3 setup file.

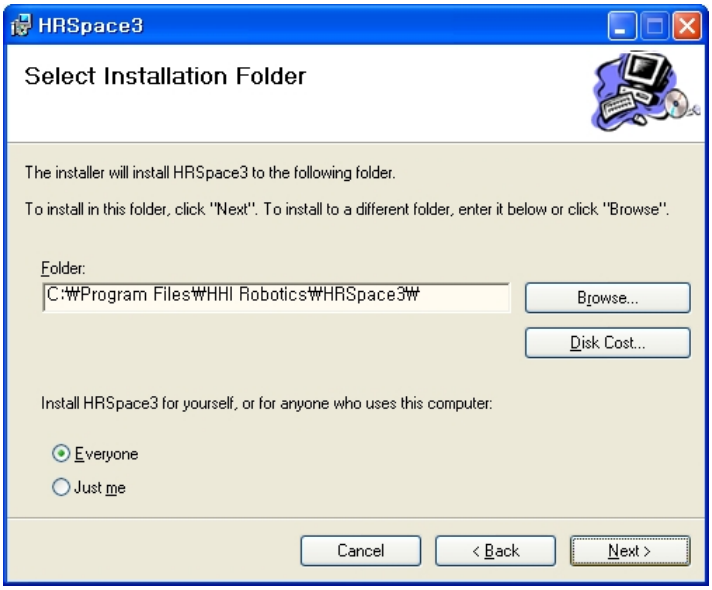


Name	Type	Packe...	Has ...	Size	R...	Date
HRSpace.msi	Windows Inst...	14,519...	No	15,1...	4%	5/21/2007 9:01 AM
InstMsiA.Exe	Application	1,630 KB	No	1,66...	3%	9/26/2001 4:05 AM
InstMsiW.Exe	Application	1,742 KB	No	1,77...	3%	9/12/2001 7:04 AM
Setup.Exe	Application	60 KB	No	108 KB	46%	3/19/2003 2:03 PM
Setup.Ini	Configuration...	1 KB	No	1 KB	0%	5/21/2007 9:01 AM

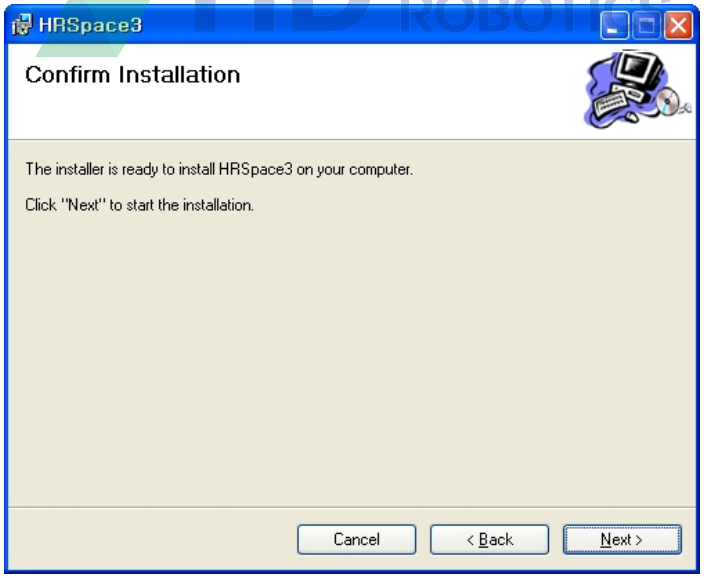
Click the Next button to proceed.



Select the folder to install and decide whether you want to give access to everybody who uses this PC. Then click the Next button to proceed.



Click on the Next button to confirm the installation to start.



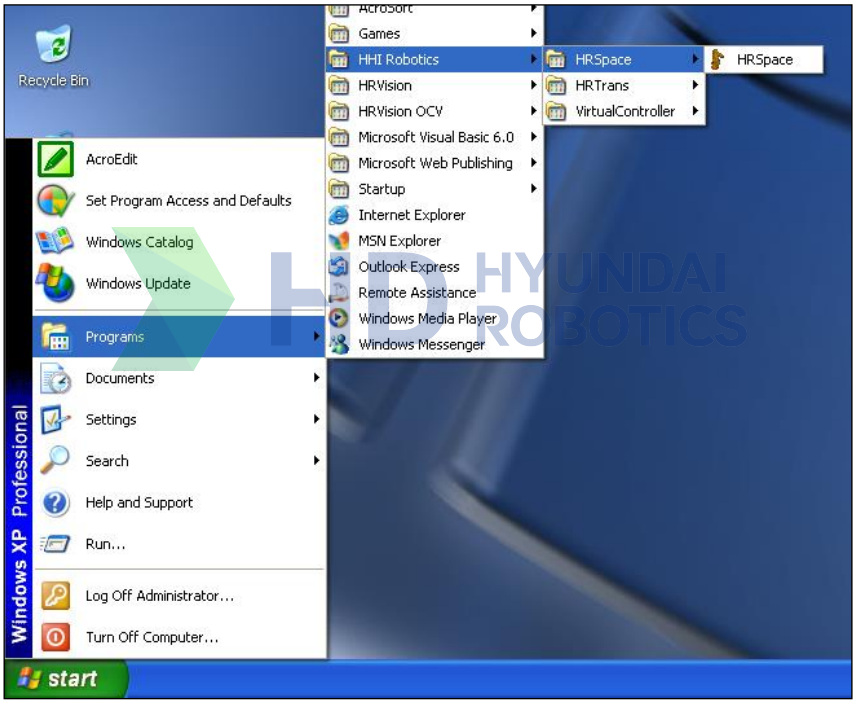
1.4. Software Execution

You must use one of the following methods to execute HRSpace3.

(1) Method 1

① Click on the Start button.

② Select HRSpace3 as follows.



(2) Method 2

Double click on the HRSpace3 icon on the desktop.

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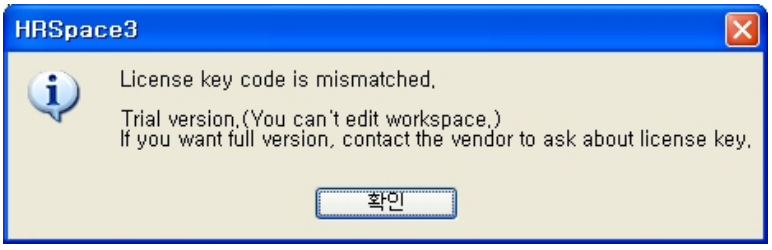
2
License input

2.1. License input

To use the official copy of HRSpace3, you must enter the license key that fits the unique number of the PC where the S/W is installed.

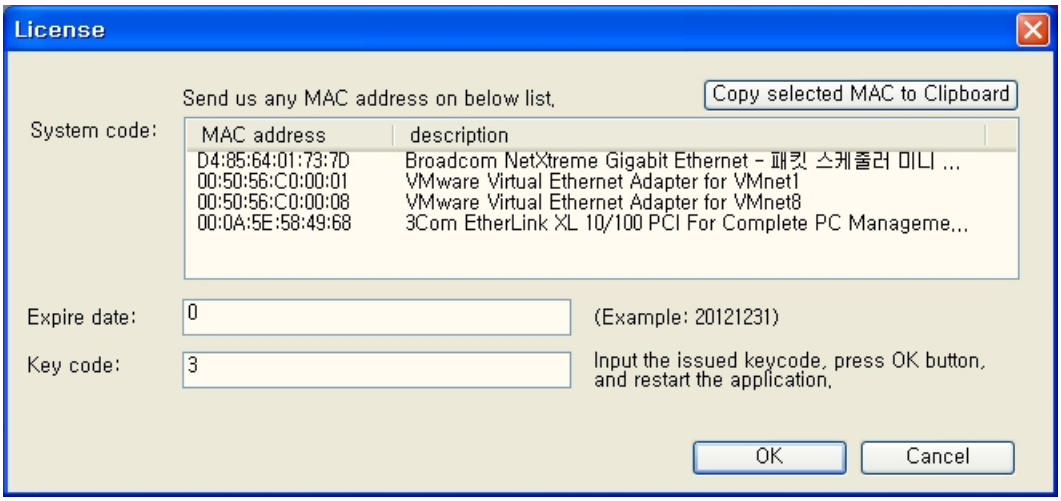
If you run HRSpace3 without entering the license key after installing the application, it will run in trial version. If you see the following message box when executing HRSpace3, it means that it is running in trial version.



In the trial version, you can open the sample document file and run try the simulation but will not be able to open the popup menu by right clicking the mouse. Therefore, it is impossible to create or edit the document.

※ **The following describes how to register the HRSpace3 as the official version.**

① Select 『Tools - License input』 from the main menu. The following message box will be displayed.

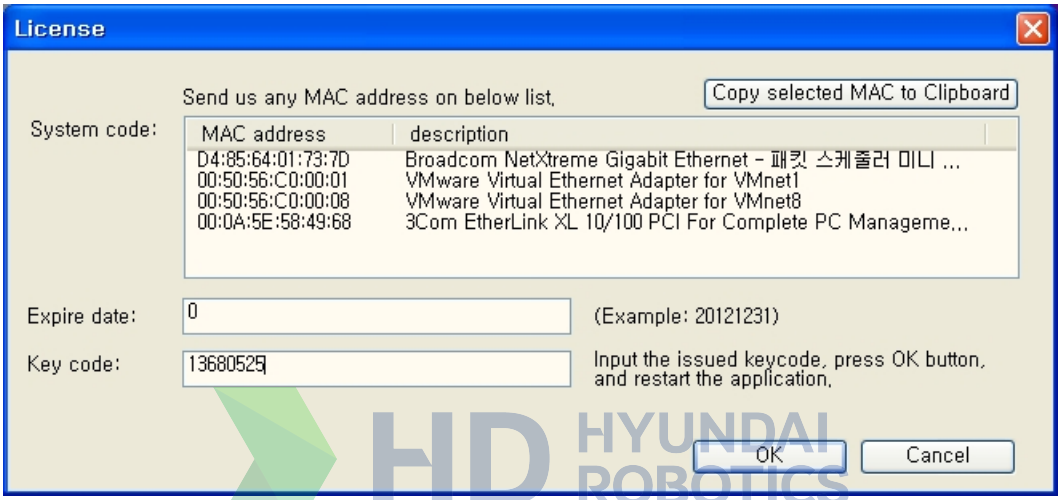


② The 6 byte number on the System code is the unique data of the PC where HRSpace3 is installed.

③ When you purchase the user license from the supplier, provide this number. (This system code is the MAC address of the Ethernet card on the PC. If the PC does not have the Ethernet card installed, you cannot use the official version of HRSpace3.)

④ Due to different uses of the PC including modem and Bluetooth, the PC with HRSpace3 installed may display multiple MAC addresses. Provide the one address that does not change.
(Please note that the MAC address of the modem may be changed every time you boot the computer.)

⑤ The supplier will provide you with the key code based on the provided number. Keep this number securely. After entering this number on the Key code block of the message box, click on the OK button



⑥ Now, close HRSpace3 and then restart the application. If you do not see the message box for the trial version, it means that the license key was successfully entered and is running as official version. In the official version, you can use the pop up menu without any restriction.

Because this key code is stored in Windows registry, you do not need to enter this Key code again when you execute HRSpace3 again or upgrade/reinstall HRSpace3.
But, if you uninstall HRSpace3 from the PC or reinstall the OS or format the hard drive, the Key code information will be deleted. You will need to re-enter this Key code when you reinstall HRSpace3. Therefore please make sure to save this Key code securely.

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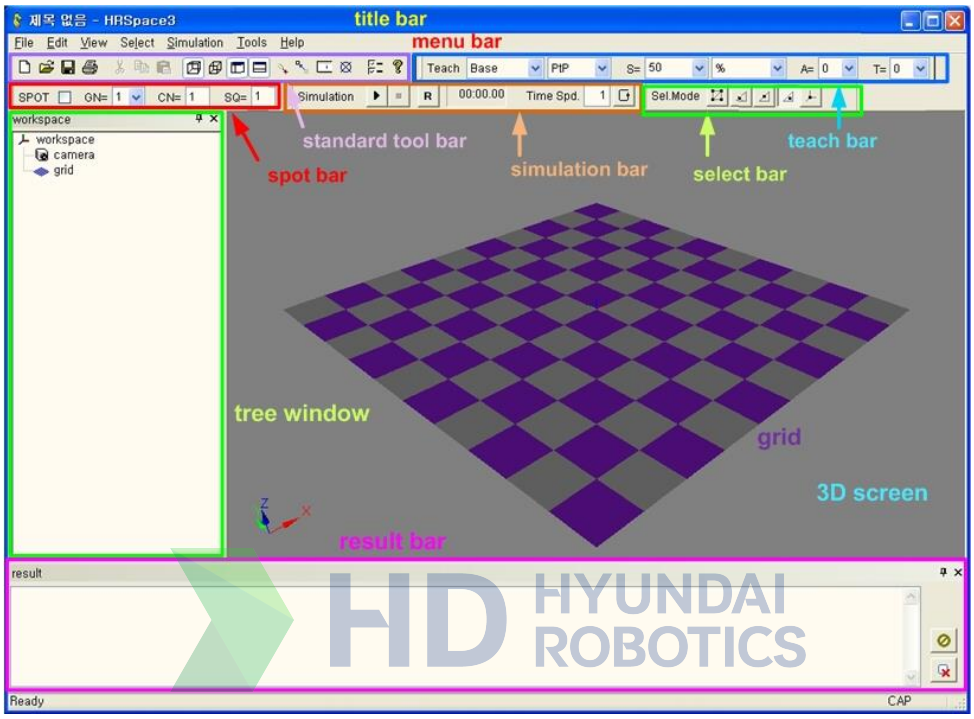
3 Basic Function

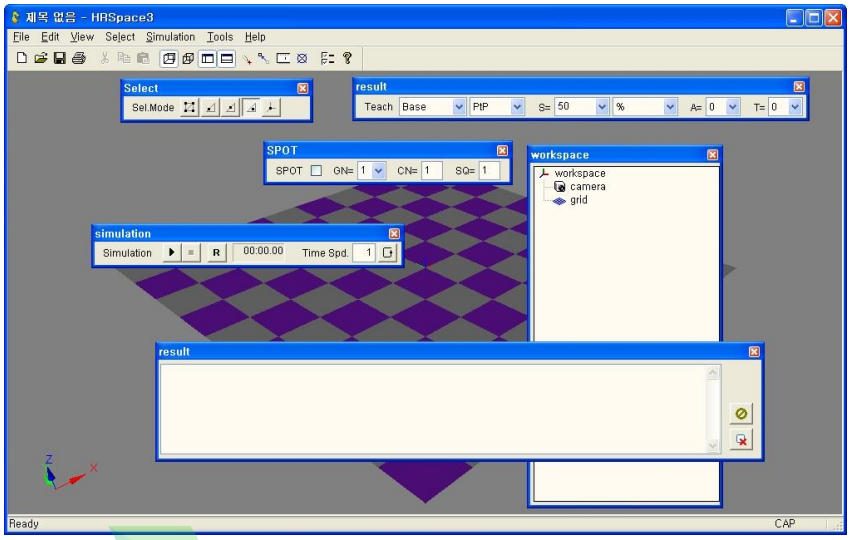
3.1. Screen Configuration

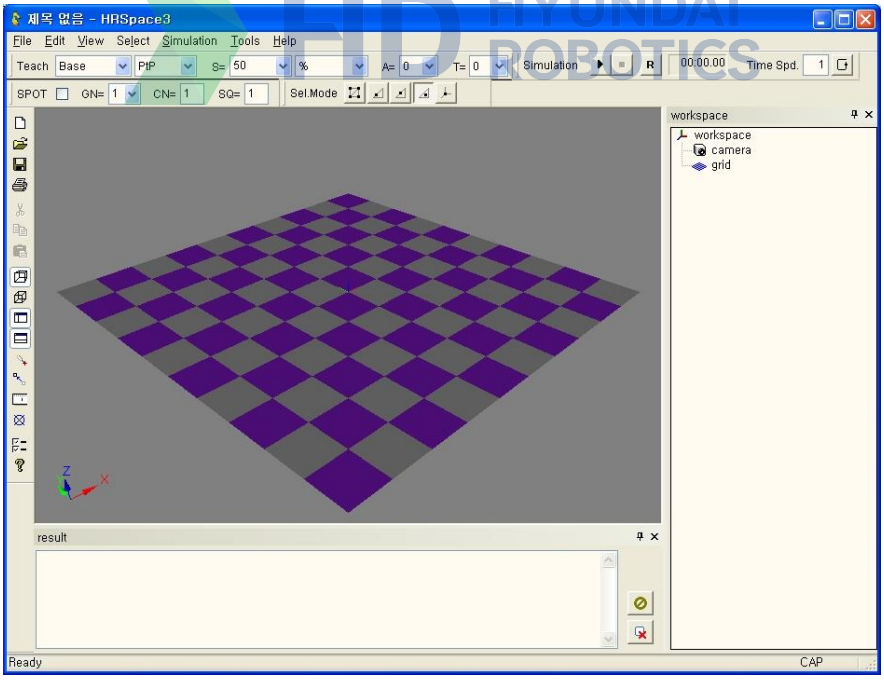
The screen of HRSpace3 is configured as follows.



Title bar	This displays the HRSpace3 title and the name of the currently opened file.
Menu bar	Various functions of HRSpace3 are provided in pull down menu.
Standard tool bar	These are the buttons frequently used for quick operation.
Teach bar	This is to setup the coordinate system and step parameter setting applied when creating the step.
Simulation bar	It provides buttons to play, stop, and reset simulation, a simulation timer to measure the run time, and a speed controller.
Spot bar	This is a convenient function that can enter spot welding command easily.
Tree window	This shows the hierarchy relationship among the models composing the current document and the function to edit the properties of the model and relationships among the models.
3-D screen	This displays the result of layout composed in the work space in 3-D view and lets the user observe the simulation operation of models.
Result bar	Simulation result is recorded in text method.

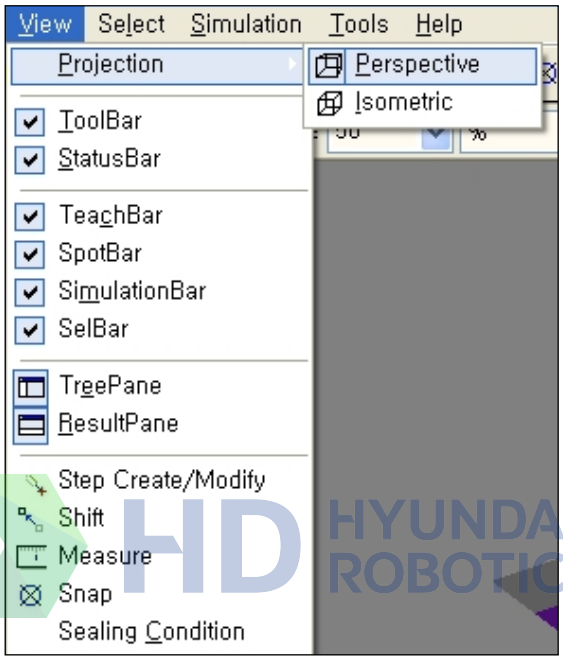
By clicking and dragging the screen elements of HRSpace3 with the left button of your mouse, you can separate them from the frame and rearrange them to the location you want. As rearranged configurations are saved automatically in Windows registry, it will be maintained after you close and execute HRSpace3 again.





3.2. View Menu

The following menus are included in the view menu of the main menu. You can select the item by clicking on the item once and you can click again to unselect the item to toggle back and forth. You can hide or display bars or windows by using these items.



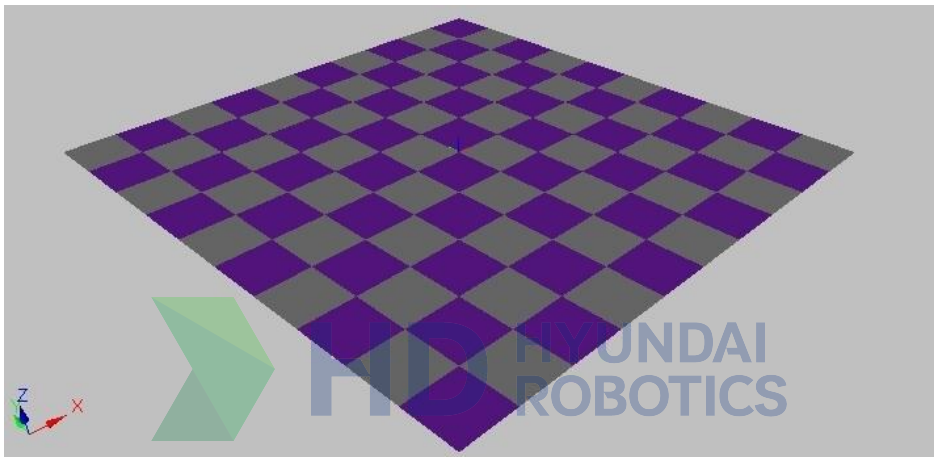
The frequently used view/hide items are arranged in the Standard tool bar.

Projection supports two methods, Perspective projection and Isometric projection.

3.3. Workspace Coordinate system and Grid

In the default condition of HRSpace3, the tree window is shown in the following hierarchy.

In the 3-D screen, one coordinate system and grid will be displayed.



The coordinate named Workspace is the global coordinate system model of the workspace and grid plane named Grid is the grid model.

- **Workspace coordinate system model**

  This refers to the absolute zero point in the 3-D space. The XYZ Cartesian coordinate of this is (0, 0, 0). The location and direction of the workspace coordinate cannot be changed.
  3 coordinate axes are displayed in 3 colors of Red/Green/Blue. Red refers to the + direction of the X axis, Green of the Y axis and Blue of the Z axis.

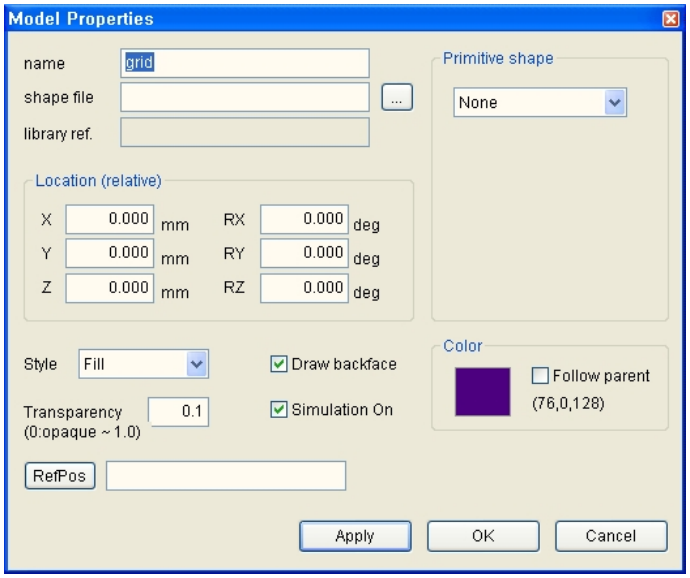
  At the very top of the workspace, there is coordinate system type model called 'Workspace' and all other models are children of the Workspace model.

- **Grid model**

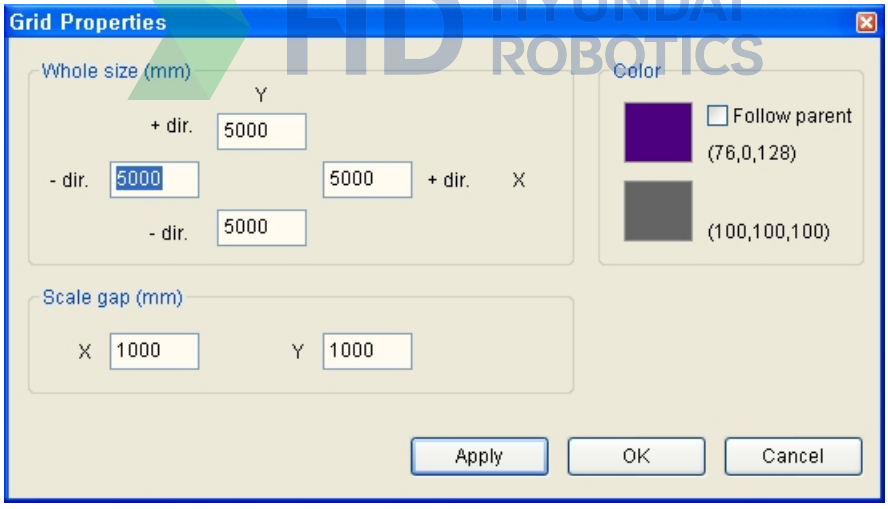
  The grid plane shows a part (Around zero point of workspace coordinate) of the plane of Z=0. In other words, you can think of this as the floor plane of the production line.

  This plane has transparency of 0.1 with violet color as default. But you can change the color and the transparency by editing the model attribute, and also change the location/direction. If required, you can create another plane different from Z=0. Also you can adjust the size and scale of the plane by opening the grid attribute.

When you open the model attribute of the Grid, it will be displayed as follows as default.



When you open the grid attribute of the Grid, it will be displayed as follows.



3.4. Camera Operation

In order to create and edit the work layout on 3-D, you must be able to freely move from the view point of the user.

There is one camera model by default in the tree window, and this is the view point of the user through 3-D screen. In other words, this camera is not displayed on the 3-D screen and you can move the location and direction using your mouse.

Pan

- Move the camera view point horizontally in up/down/left/right direction:
  Right click on your mouse while pressing the [Shift] key on the keyboard to move the mouse.

Zoom in/out

- Screen zoom in (Camera view moves forward) :
  Right click on your mouse while pressing the [Ctrl] key on the keyboard to move the mouse in right or down direction. Or try pulling the wheel on the mouse.

- Screen zoom out (Camera view moves backward) :
  Right click on your mouse while pressing the [Ctrl] key on the keyboard to move the mouse in left or up direction. Or try pushing the wheel on the mouse.

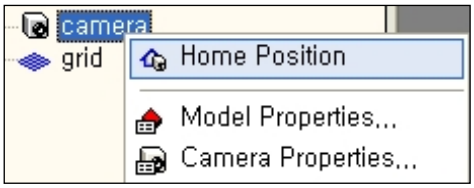
Rotate

- Rotate based on the grid floor point where the center of the screen can be seen :
  Without selecting any model and with the [Ctrl] and [Shift] key of the keyboard pressed, right click and move the mouse.

- Rotate based on the zero point of a specific model :
  After selecting a specific model, right click on the mouse while pressing the [Ctrl] key and [Shift] key on the keyboard to move the mouse.

- Rotate up/down centered at camera itself:
  Push/Pull the wheel of the mouse while pressing the [Ctrl] key and [Shift] key on the keyboard.

■ Home



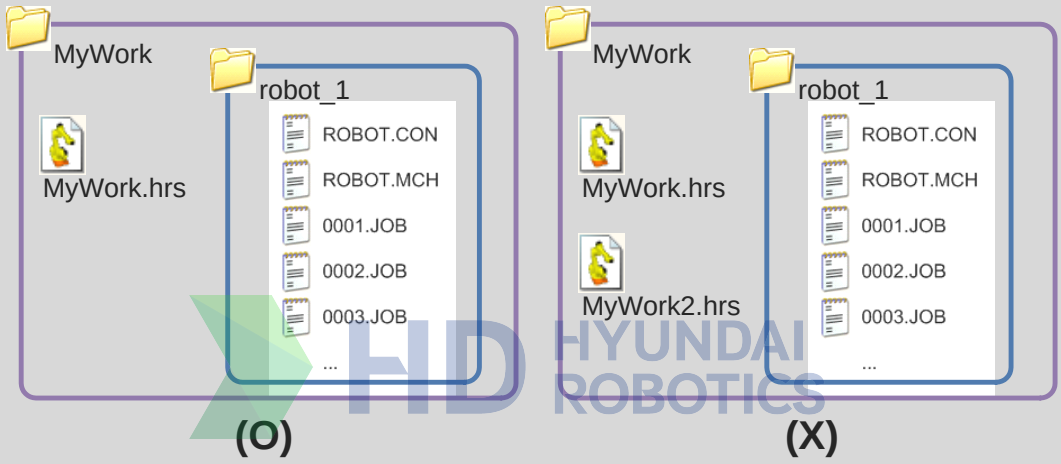
If you select Home after right clicking the mouse on the camera model, the camera view point will return to the default condition.

3.5. New, Save and Open Document

The file type of the document used in HRSpace3 is ".hrs" (HRSpace).

■ **Warning: Save only one .hrs file in one folder!**

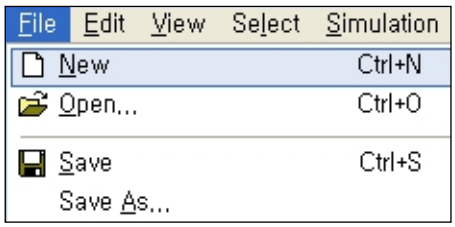
Control files of each robot in project ".hrs" are saved in sub folders. If you save many .hrs files in one folder, be careful because other .hrs file's controller files could be overwritten. (Refer to "6.2 Virtual Controller and controller file.")



The following descriptions are same as the common operating method of Widows applications.
If you are familiar with working on Windows applications, you can skip the following descriptions.

■ New document

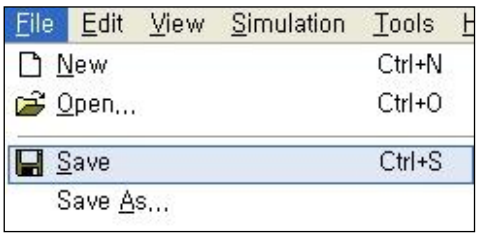
When you select 'File – New File' from the Main Menu, all the work currently in editing mode will disappear and the screen will start in default condition.



Or when you click on new file button in the Standard tool bar or press [Ctrl+N] key, it will return to the initial condition.

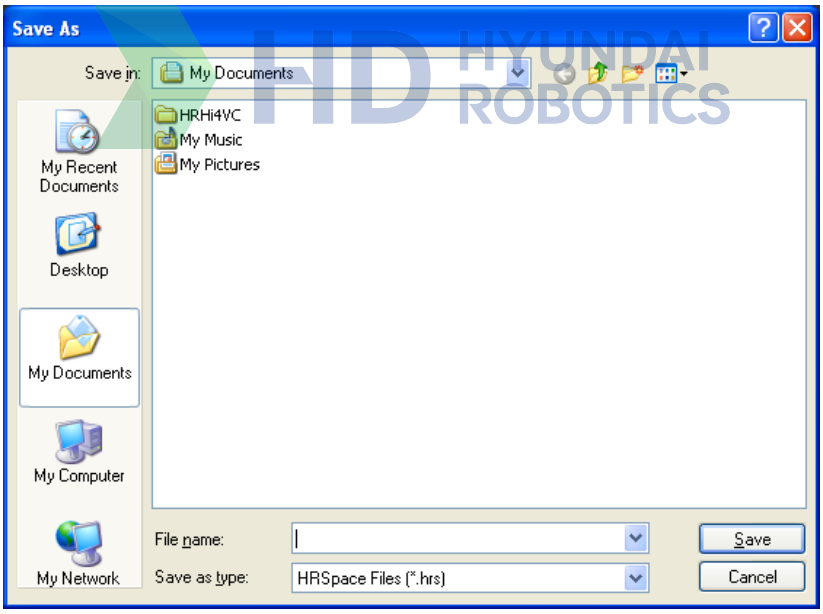
■ Save document

When you select 『File - Save』 from the main menu, the current document will be saved.

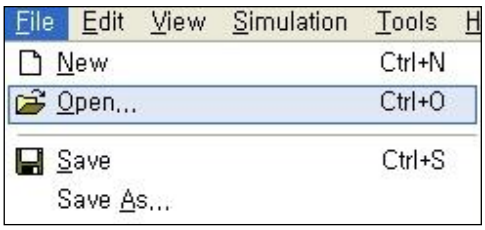


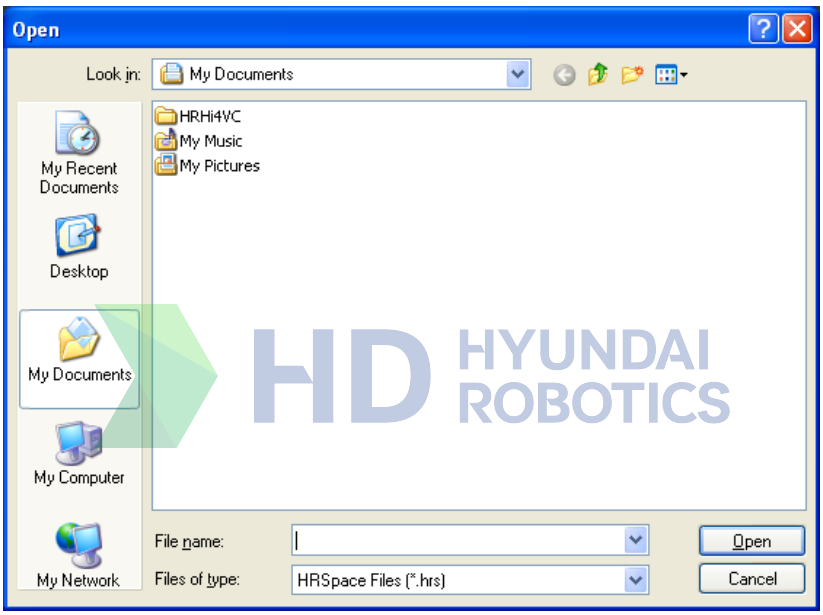
Or when you click the save button on the Standard tool bar or press the Ctrl+S key, it will save the document.

When saving the document for the first time, or when you select 『File – Save as』, the window to select the directory/file name will appear.



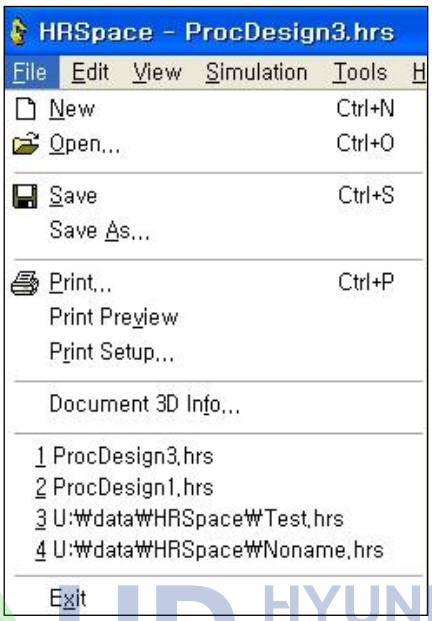
■ Open document
When you select 『File - Open』 from the main menu, the following open document window will be displayed.



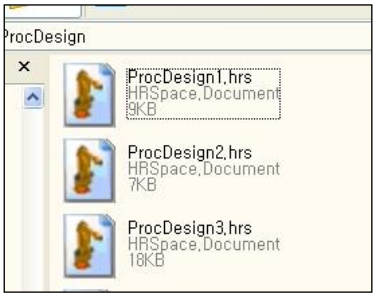


Or when you click on the open button on the Standard tool bar or press the [Ctrl+O] key, the open document window will be displayed.

When you select the document and click on the Open button, the document will be opened. Recently used documents will be shown at the bottom the File Menu of the Main Menu. When you click on any of the recently used documents, the document will be opened directly.

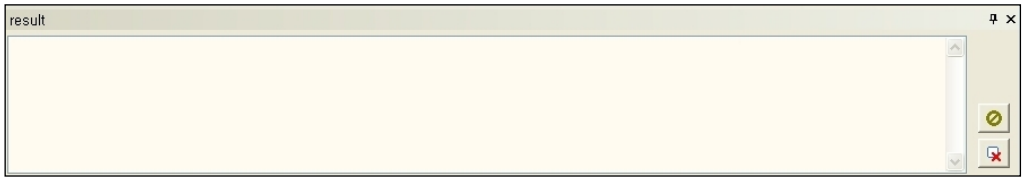


Or you can also open the document by dragging the ".hrs" file from Windows Explorer to HRSpace3 to open the document.
When HRSpace3 application is not running, you can double click on the ".hrs" file from the Windows Explorer to execute HRSpace3 and open the document.



3.6. Result bar

The Result bar displays various information including the simulation results in text format.



The Result bar has the two following buttons.

 (Disable button)	This is a toggle button. When pressed, the results will not be displayed. When the results are displayed continuously quickly, you can use this function to view the results in stopped condition.
 (Delete button)	All the content shown on the Result bar will be deleted.

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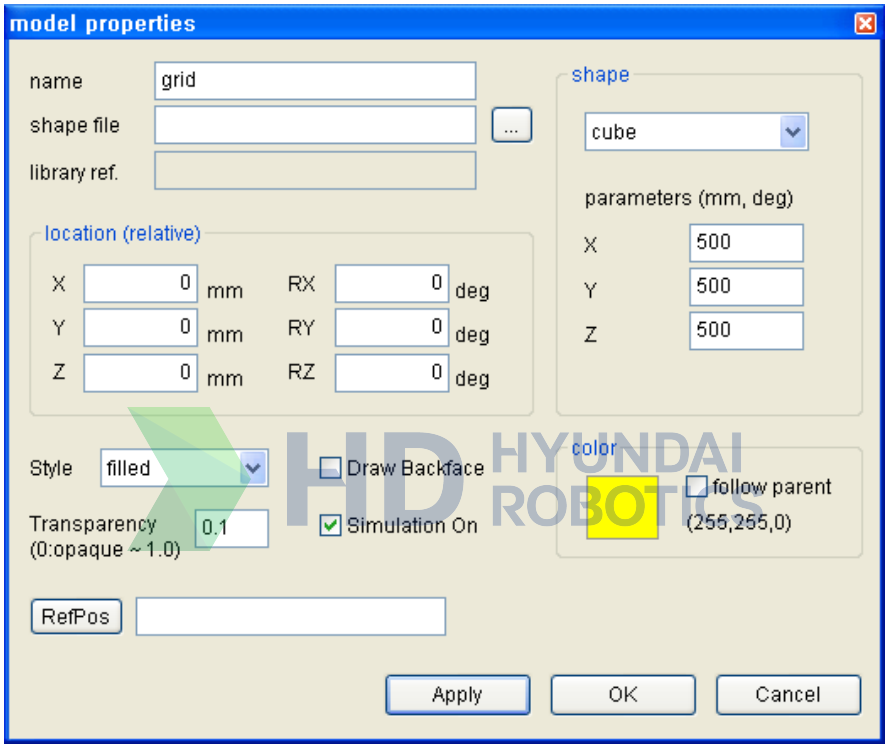
4 Model

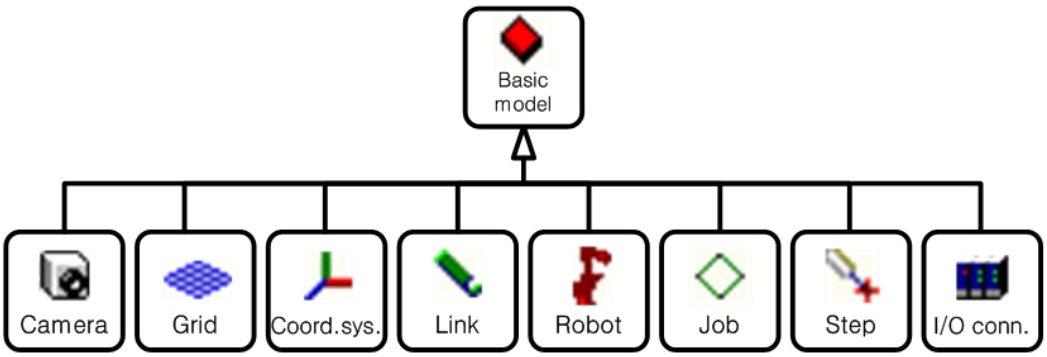
4.1. Concept of Model Hierarchy Structure

All objects inside the workspace are called a 'model' in HRSpace3. Car body, robot, tool, jig or recorded steps or coordinate systems are all types of models.

Each model has its own properties including name, location, shape, color, transparency etc. These properties can be edited by opening the model properties window as follows.

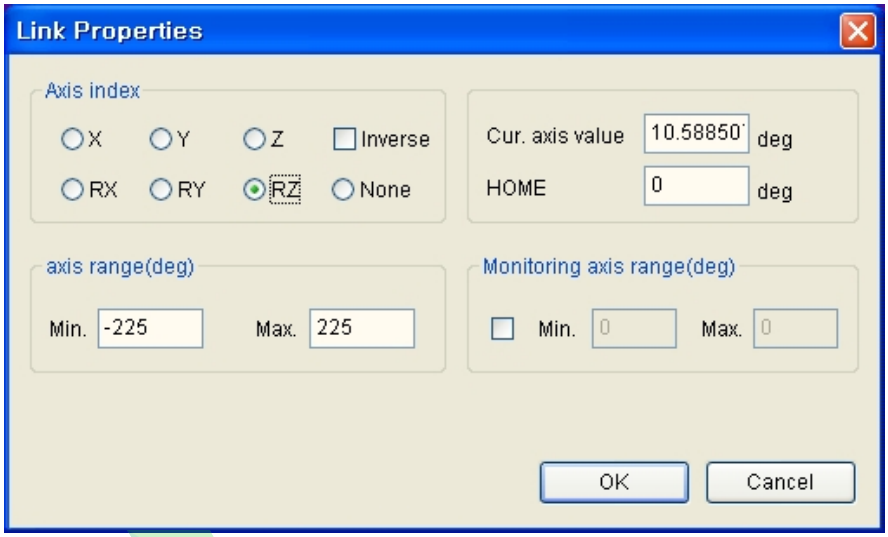


As shown in the following figure, there are models that inherits the properties from the basic model including link, robot, step etc.



Inheriting the properties mean to have the basic model properties and additionally have own unique properties.

For example, the link model has the above model properties and additionally the following link properties.

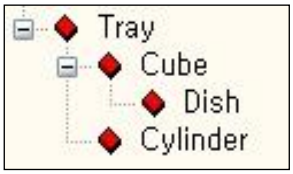


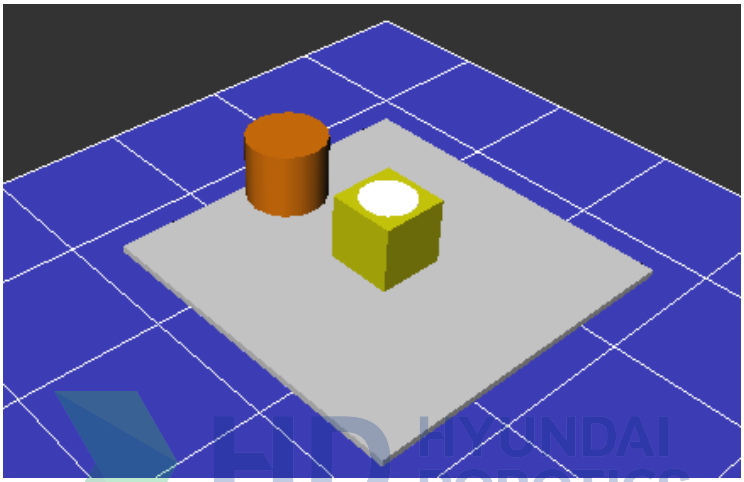
A model form a hierarchical structure and is arranged inside the workspace. (Do not confuse with the above inheritance picture. The following hierarchy structure is a concept of ownership and not inheritance.)

If model B is located under model A, model A is the parent and model B is the child to form a relationship.

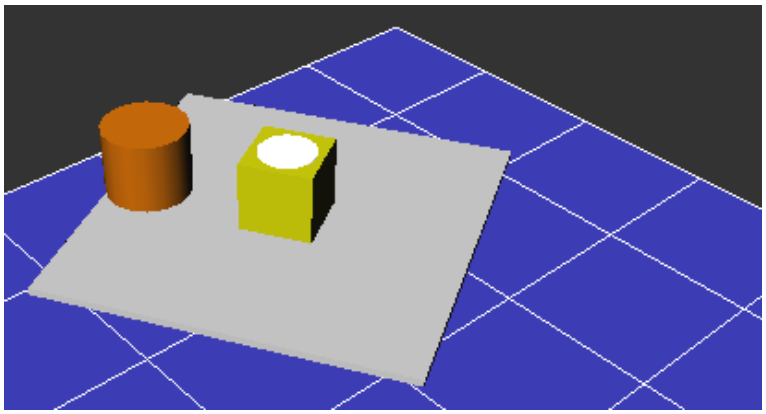
- Because the child model uses the location of the parent model as the origin, when the parent moves all the child models below the parent will move together.
  (But, when setting the RefPos in model properties, the reference position is used as the origin.)
- When you delete the parent model, all the child models will be deleted together.
- When the parent model is copied, all the child models are copied together.
- When the parent model is saved, all the child models are saved together.

If you look at the hierarchy structure in the following picture, the cube is the child model of the tray and the dish is the child model of the cube.

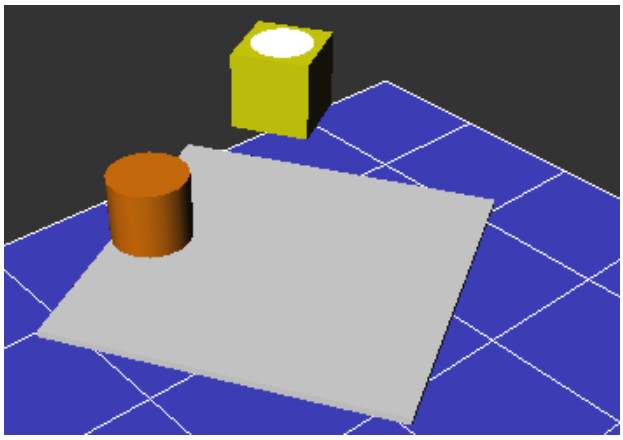




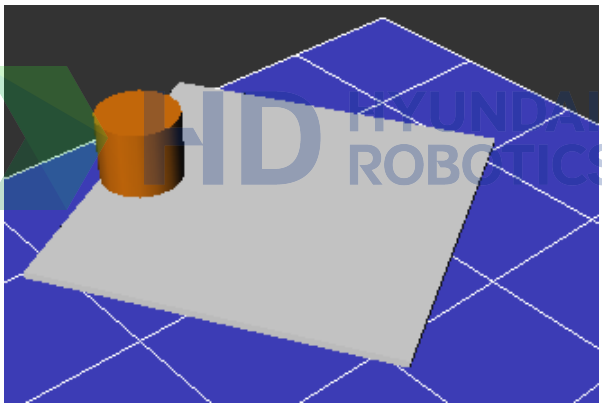
When you move the tray, the parent model, all the child models move as well.



On the other hand, when you move the cube, the dish, which is the child model, will move together but not the tray.



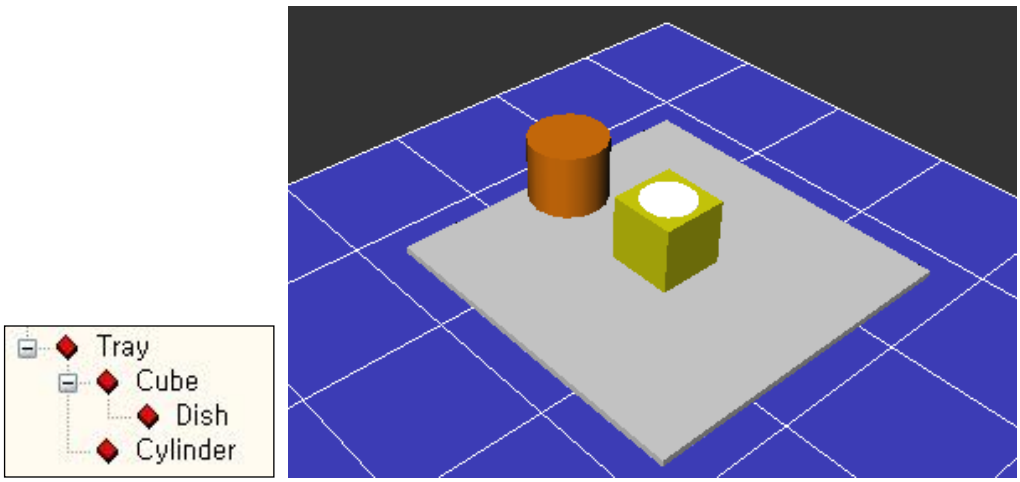
If you delete the cube, the dish, which is the child model, will be deleted as well.



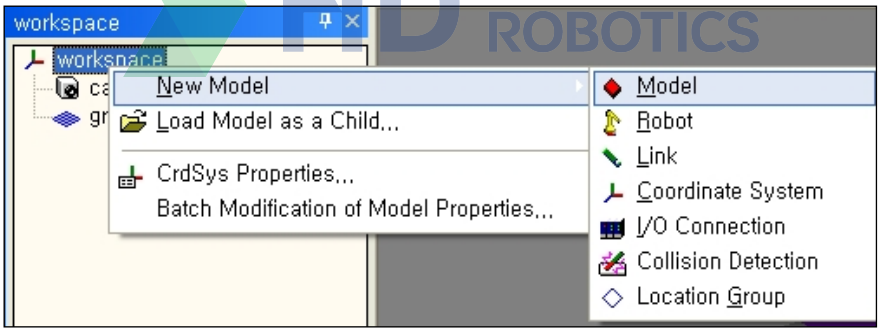
The layout of the automation line to simulate is composed through the relationship among models as shown above, just different in complexity.

4.2. Configure and Edit Model 1

Let's configure the hierarchy structure of the following models.

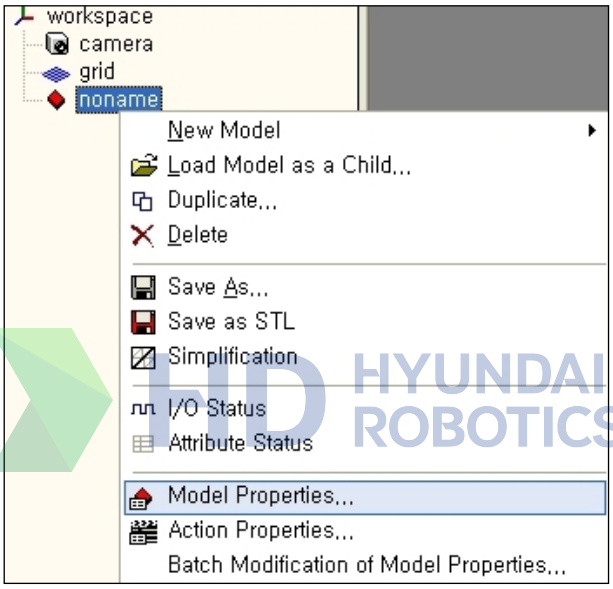


When you right click on the workspace of the tree window, the popup menu will be displayed. When you select new model, the sub menu will be displayed and you can select the 『Model』.



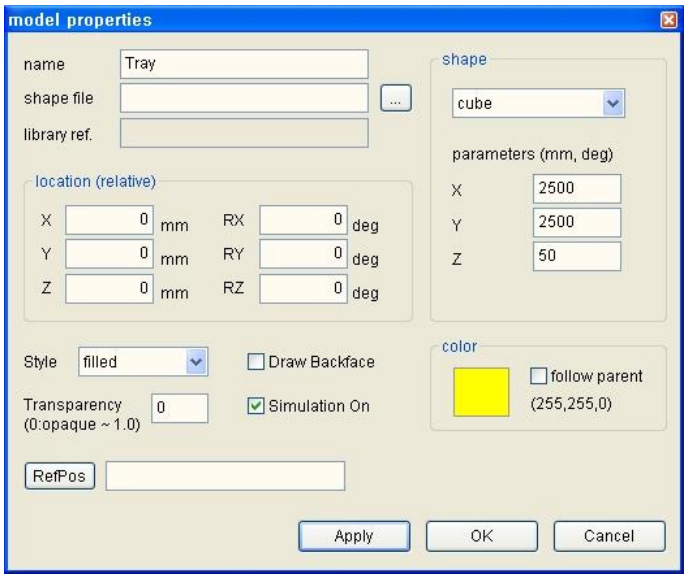
A new model named “no name” is created under the workspace. In the 3-D screen, nothing appears yet. This is because the model shape has not been defined yet.

Now, right click on “noname”, and select the model properties.

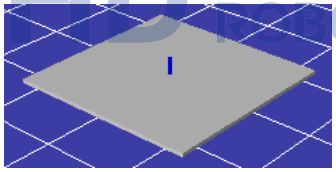


When the model properties window appears, select the drop down list box to select the 3-D rectangular box as shown in the following picture. Leave the other parameters and click OK.

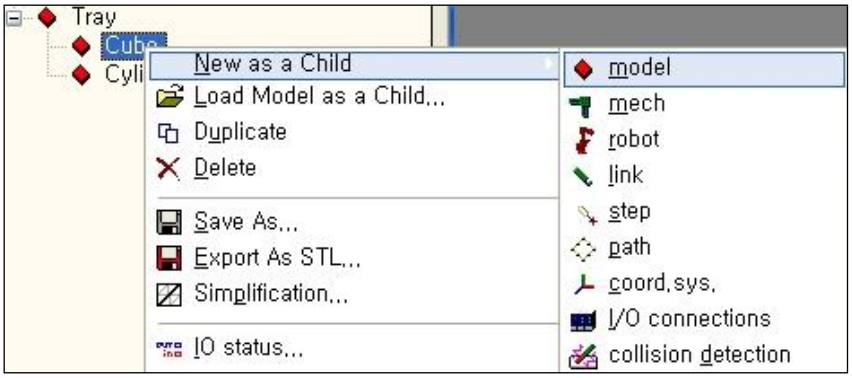
When the properties window appears, edit the name, shape, shape parameter and color as follows. (When editing the color, click on the colored rectangle and set it in the window.)



The tray appears in the 3-D screen as follows.

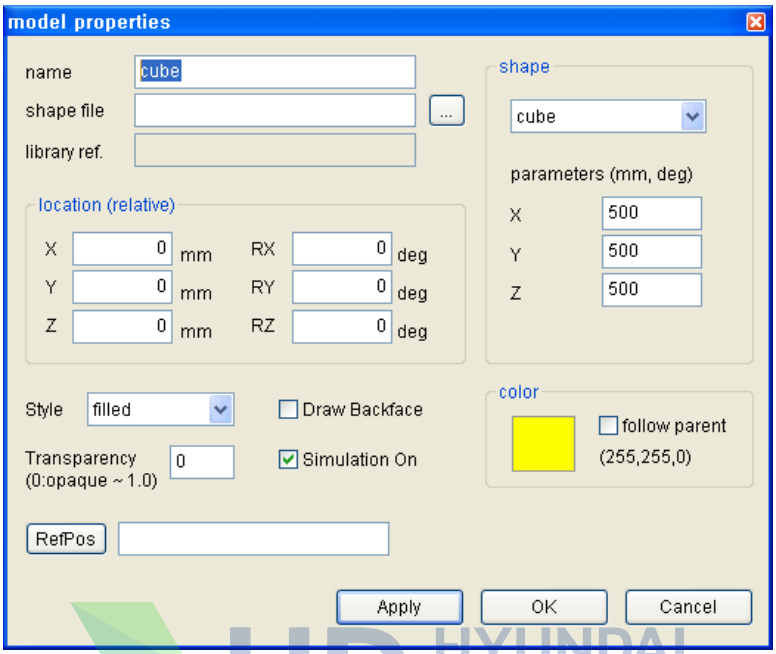


This time, right click on the tray of the tree window and select 『New as a Child - Model』 from the popup menu again.

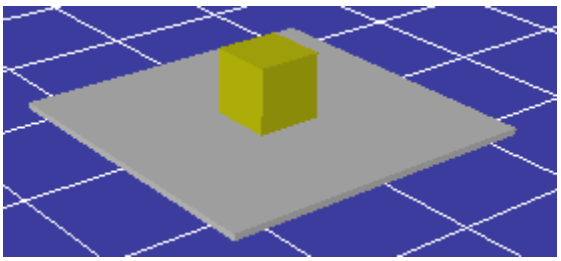


Now the following hierarchy is configured.

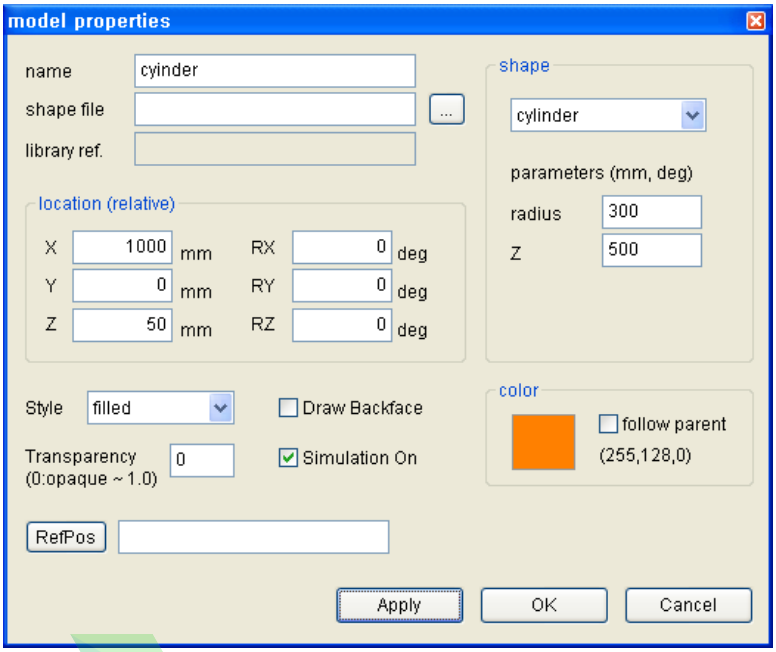
Right click on the noname model under the tray and select model properties. Enter the following information in the model properties window and click on OK.



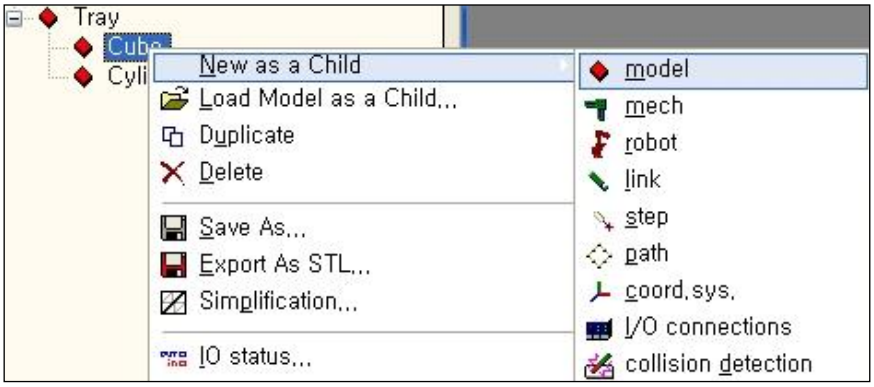
As shown in the following picture, the cube is shown on the tray.



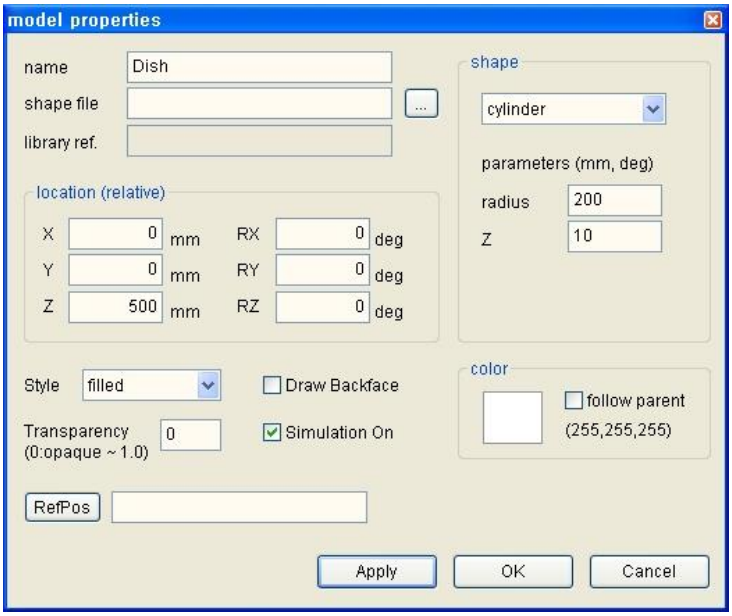
In the same method as the cube, create a cylinder. Set the model properties as follows.



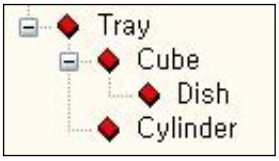
The hierarchy structure of the tree window will now be as follows. Open the popup menu for the cube and select 『New as a Child - Model』.

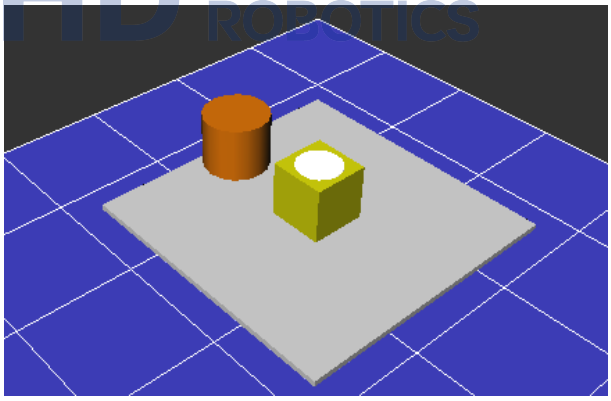


Enter the model properties of the noname under the cube.



You will obtain your planned results.

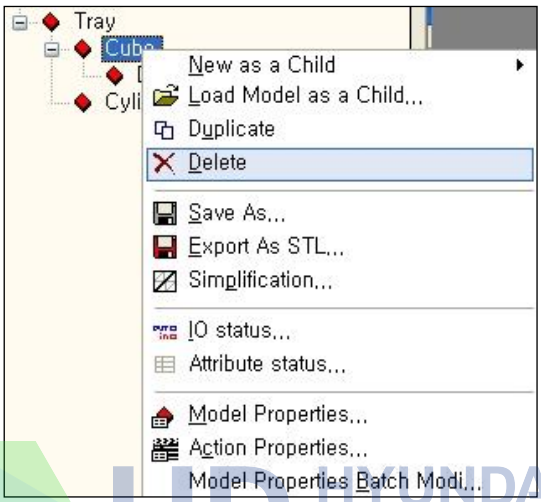




4.3. Configure and Edit Model 2

Let's try to learn a few more ways to work with the model.

- Open popup menu of model
  Right click on the model of the tree window to open the popup menu.

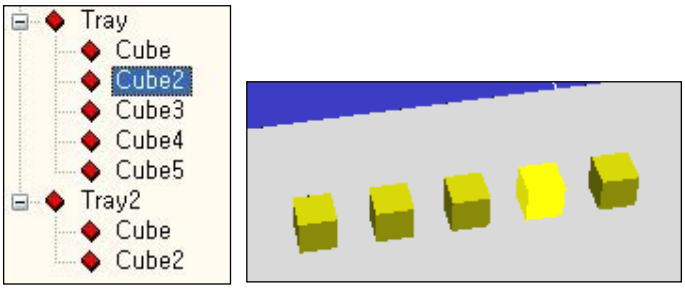


Or you can open the popup menu by right clicking on the model in the 3-D workspace.

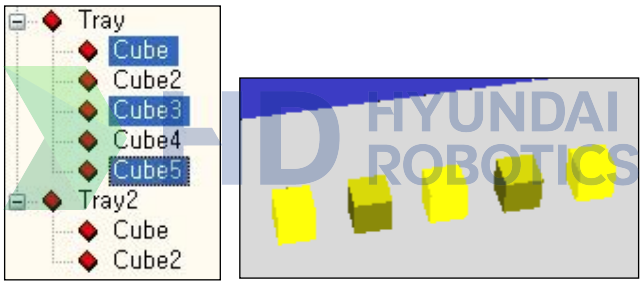
■ Select model

When selecting the model, all models can commonly be selected by clicking the left mouse button on the model.

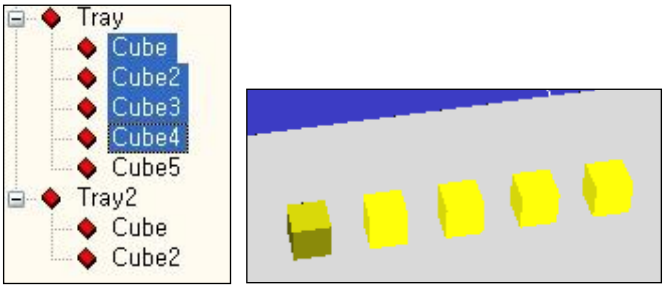
When you click on the model in the tree window, the model will be selected. Or you can click on the model in the 3-D workspace. The selected model will be highlighted in the 3-D workspace.



If you want to select several models, select the models in order with the Ctrl key of the keyboard pressed.



Or you can select all the consecutive models between two models by clicking on the two models with the Shift key pressed.



But, you can only select the models with the same parent model. For example, you cannot select cube 2 under the tray and cube 2 under the tray 2 cannot be selected together.

■ Edit model name

You can edit the name of the model from the model properties window but there is a simpler method.

With the model of the tree window selected, left click again on the name.

Or with the model of the tree window selected, press F2 on the keyboard.

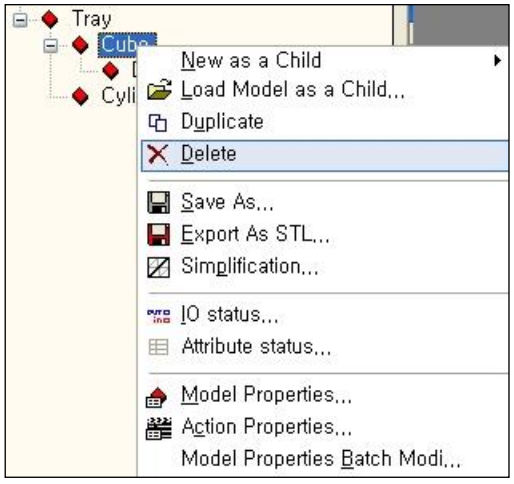
It switches to the condition where you can edit the name of the model.

Type the new name with the keyboard.

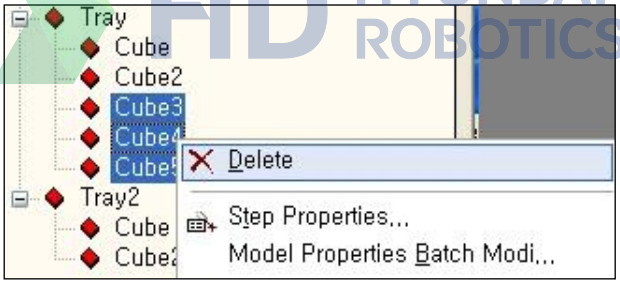
Press the Enter key on the keyboard or click on another model with the mouse to reflect the entry.

■ Delete model

To delete the model, you can open the pop up menu from the model to delete and select Delete. When you delete the model, all child models of the model will be deleted.

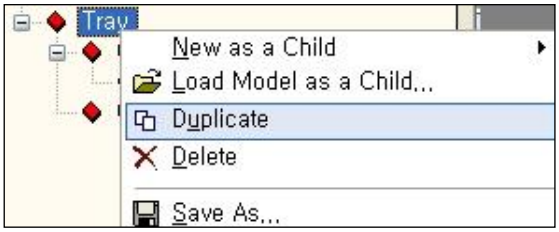


You can also delete multiple models at the same time by selecting multiple models and using the same method.

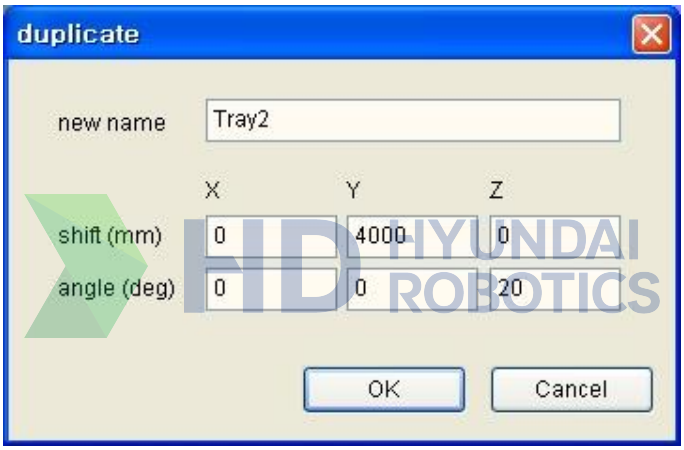


■ Duplicate model

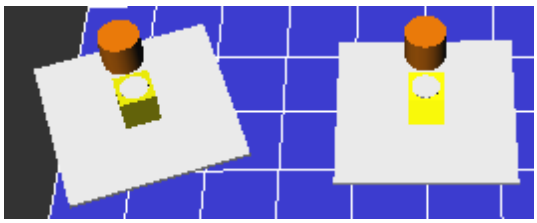
To duplicate the model, you can open the pop up menu from the model to copy and select Duplicate.



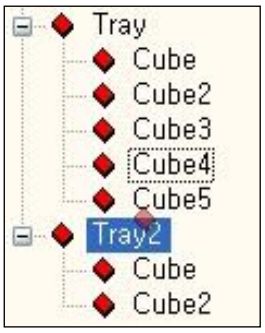
When the duplicate window appears, set the name of the new model and how much to move/rotate the duplicated model as shown below and click on OK.



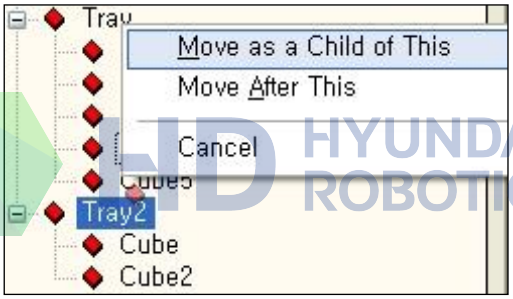
All child models are duplicated together as shown below.



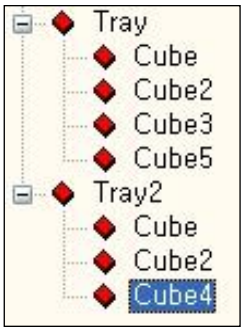
■ Move model in hierarchy structure – Move as a Child of This
You can move the model under the existing parent to a different parent.
For example, let's try moving the cube 4 under the tray to the parent of tray 2. As shown below, drag cube 4 with the right click and drop it on the tray 2.



The following pop-up menu will be shown. Select 『Move as a Child of This』.

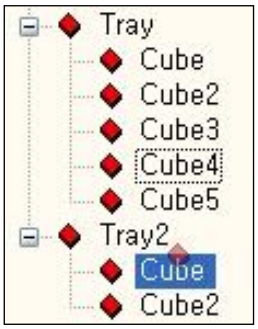


It moved as follows. You can see that the cube 4 moved to the tray 2 in the 3-D workspace.

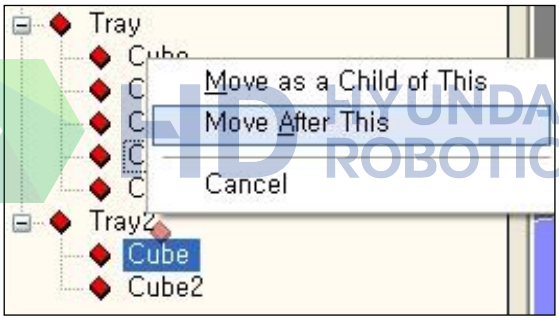


When you drag and drop with your left mouse button, the popup menu will not appear and execute 『Move as a Child of This』.

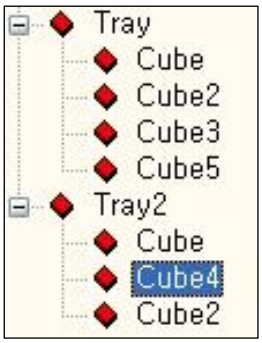
■ Move model in hierarchy structure – Move After This
You can move the model under the existing parent to the next location of a different model. For example, let's try moving the cube 4 under the tray to the next location of the cube under the tray 2. As shown below, drag cube 4 with the right click and drop it on the cube under the tray 2.



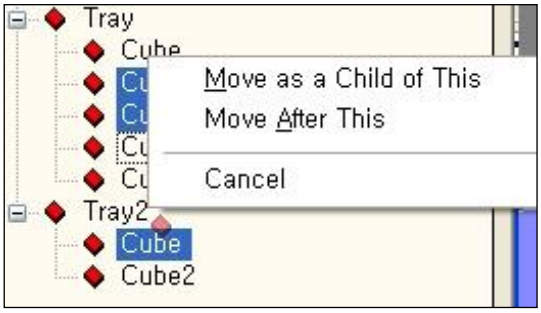
The following pop-up menu will be shown. Select 『Move After This』.



It moved as follows. You can see that the cube 4 moved to the tray 2 in the 3-D workspace.



■ Move model in hierarchy structure – Move multiple models at once
After selecting multiple models as shown below, you can drag and drop in the same method to move all the models.

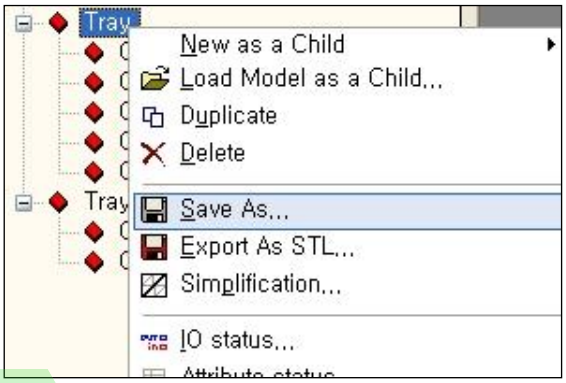


4.4. Save and Open Model

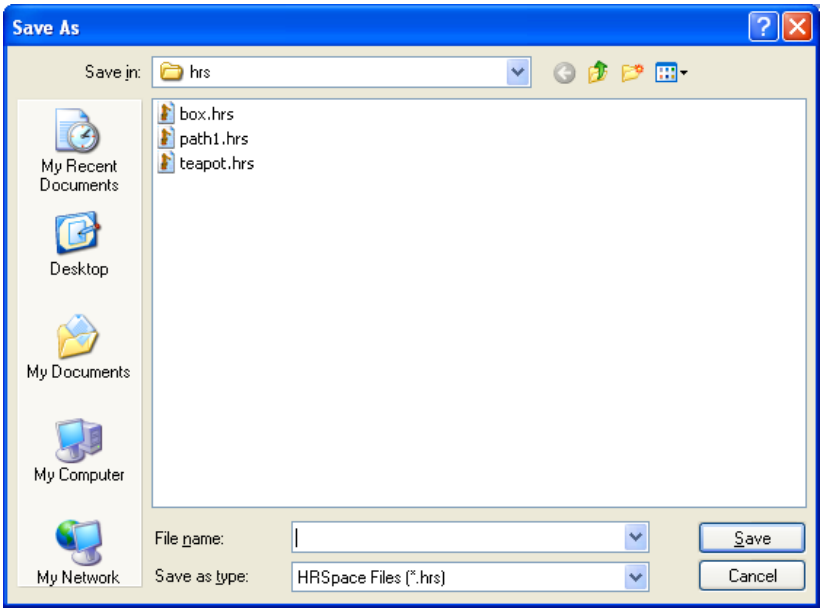
You can save and open the hierarchy structure of a specific model and the related child models as an hrs document.

- Save model

① Open the popup menu of the model to save and select Save as.



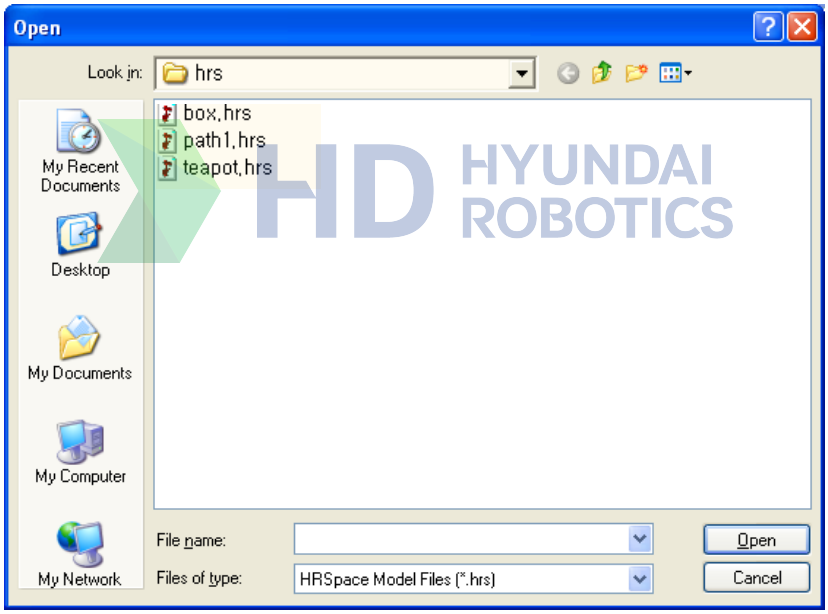
② The following window appears. The file name is set as the model name by default but can be changed.



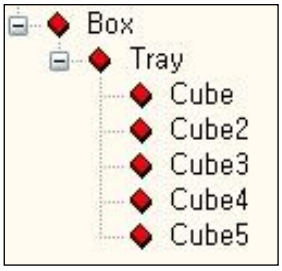
■ Load Model as a Child

① Open the popup menu of the model to become the parent and select “Load Model as a Child”.

② The following window appears. Select the file and click on Open.



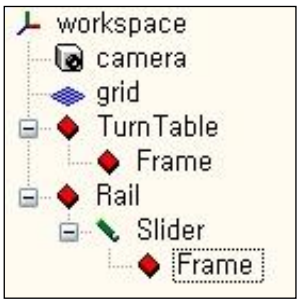
③ The model is opened as the child model as shown below.



4.5. T Path

T path refers to the type of string that refers to a specific model within the hierarchy structure of the tree window. (This is a unique terminology used in HRSpace3.)

For example, when you look at the following hierarchy structure, it has two models with the name 'Frame'.



When you are entering one of the two frames in the window, it would be difficult for HRSpace3 to distinguish which model it is.

Therefore, HRSpace3 uses an expression method of T path. T path expression lists the name of parents in front of the model delimited by the symbol '/'.

The prior example of the two frames would be expressed as follows.

- /TurnTable/Frame
- /Rail/Slider/Frame

The highest level model, name of workspace, is not entered. The first '/' located at the first T path refers to the workspace.

Generally, there is a button for T path designation in front of the edit box where T path needs to be entered as shown below.

When you press this button and move the cursor to the tree window, the cursor shape changes to  shape. When you click on the model in this condition, the T path of the model will automatically be entered to the edit box. (You can also directly type the T path in the edit box without using this method.)

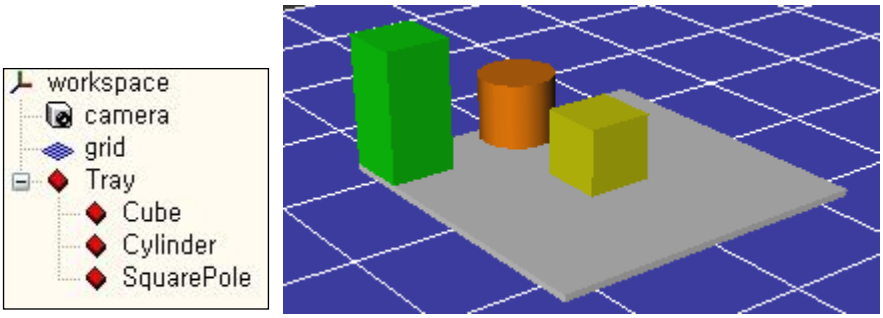
Generally, there is a limitation in the type of model that can be entered in the edit box. For example, you will not be able to enter the basic model or step model with the  cursor for the edit box that only allows the link model to be entered,

To cancel T path selection mode, press the Esc key on the keyboard.

4.6. Shift message box

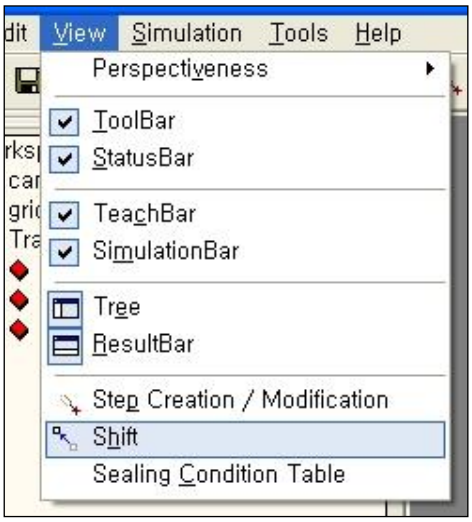
By using the shift message box, you can move or rotate 1 or more models.

For example, let's assume there is a model with the following hierarchy structure and try to shift the cylinder and rectangular pillar simultaneously in +Z direction.

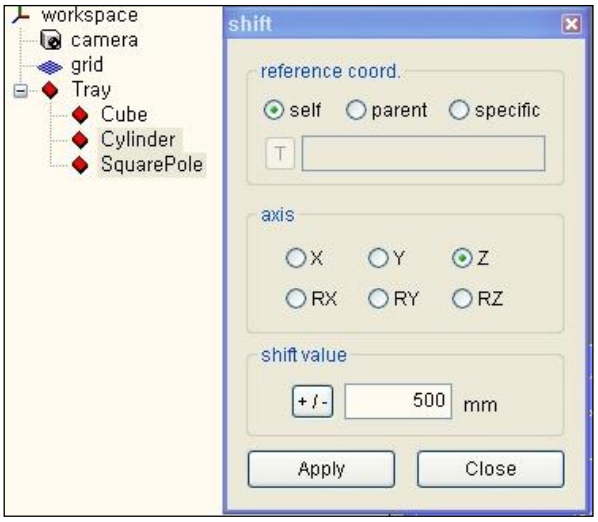


Click on the shift message box button from the Standard tool bar.

Or you can select, 『View - Shift』 from the main menu.



The following shift message box appears.

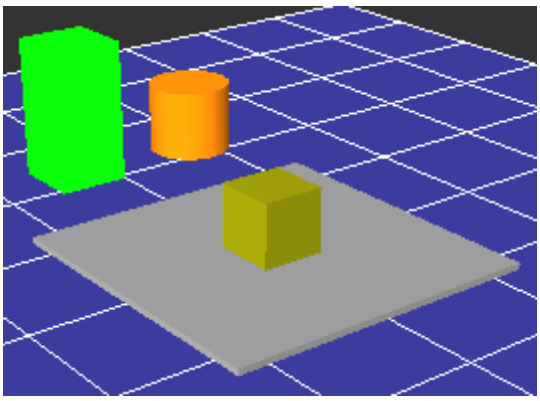


Refer to the following table to set the reference coordinate, axis and shift.

Reference coordinate	To shift based on the coordinate of the object itself, set the reference coordinate as 'Self'. To shift based on the parent coordinate, set the reference coordinate as 'Parent'. To shift based on a specific coordinate other than the above, set the reference coordinate as 'specific' and press the T button to click on the model to set as reference from the tree window, and enter the T path.
Axis	When you select X, Y or Z axis, it shifts in the direction of that axis. When you select RX, RY or RZ axis, it rotates based on this axis.
Shift	Enter the shift distance (or rotation angle). You can change the sign of the entered value by pressing the +/- button.

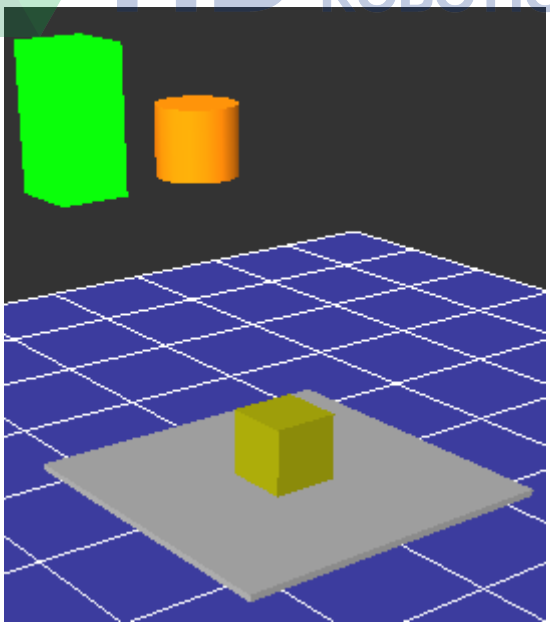
Select the model to shift in the tree window or 3-D screen. (To select multiple number of models, click on the models with the [Ctrl] or [Shift] key pressed.)

Now when you click on the apply button of the shift message box, you can see the selected model shifted in the 3-D screen. That is, the location properties among the model properties of the selected model have changed.



When you continuously click on the apply button, it will shift for every click.

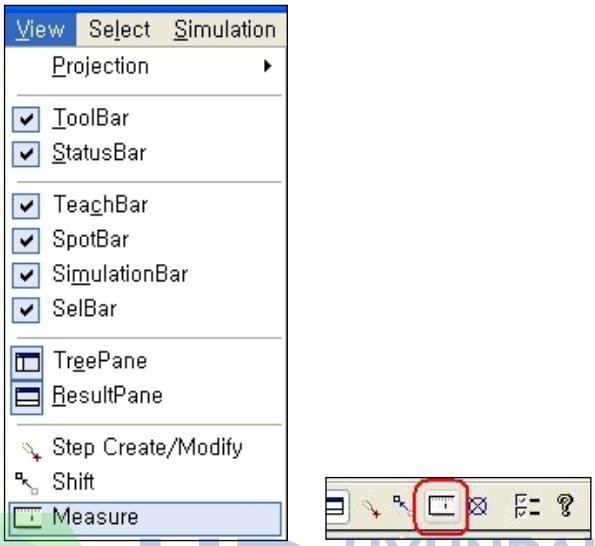
The following picture is the result of clicking the apply button 3 times.



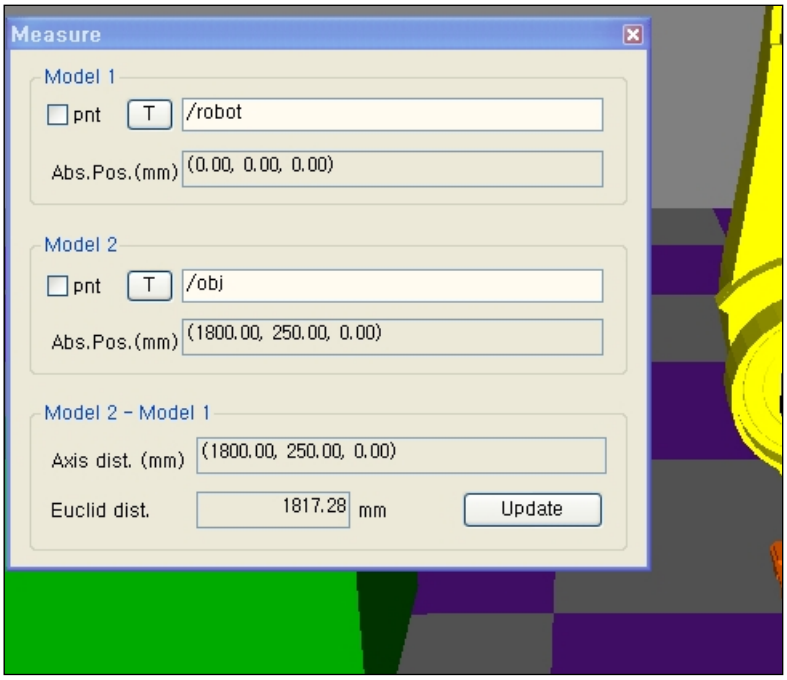
Click on the close button to close the shift message box.

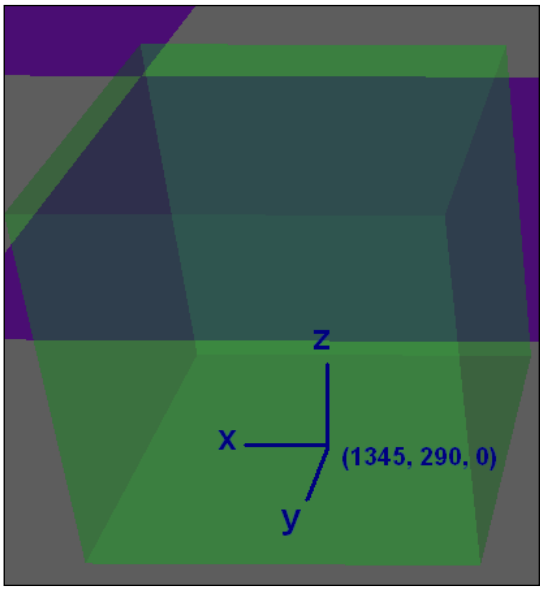
4.7. Measure dialog box

You can use measure function if you want to know the distance between models. Measure dialog box is appeared when you select Measure from View menu or press Measure button on tool bar.



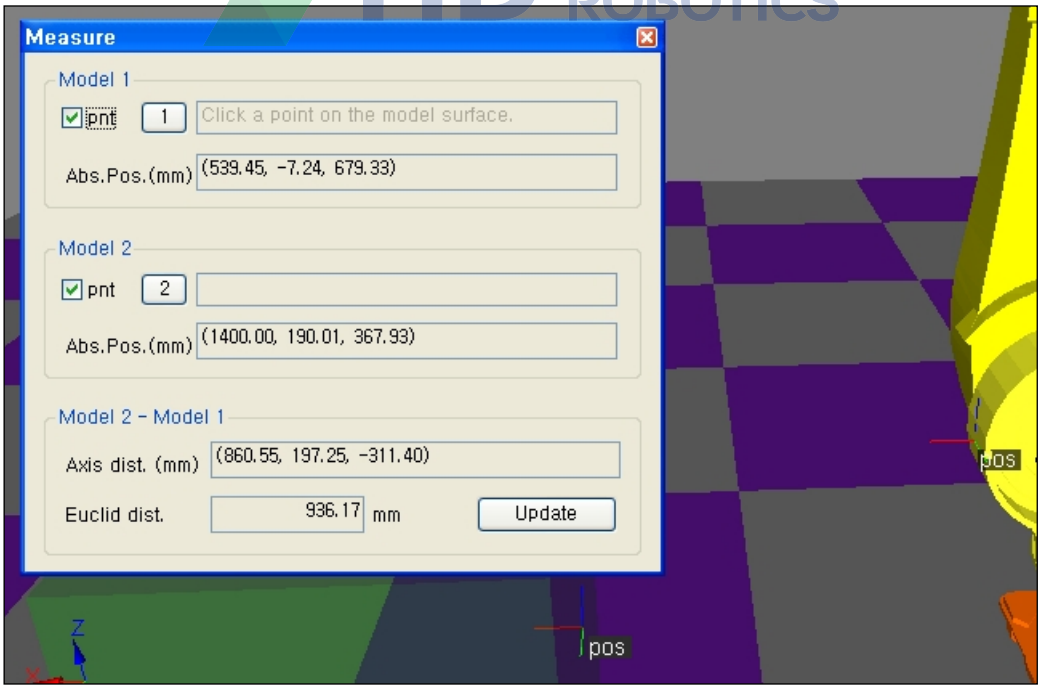
Let's measure the distance between model 1(robot) and model 2(cube). There're two ways in specifying targets, T path method and point method. Press T button, click a model to specify T path as below. Then the base location of the model is used.





The location of model 2 when T path is used

On the other hand, if you check “pnt” check box and click specific surface of a model, then the location that is clicked is used.



In this case, the location that you can click is restricted by the settings of Sel. Mode tool bar (or Select menu).

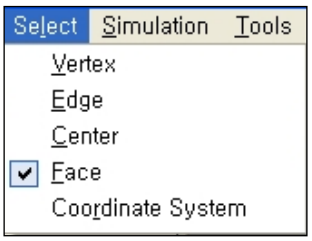
 : Select a vertex

 : Select a point on an edge

 : Select a center of an edge

 : Select a point on a face

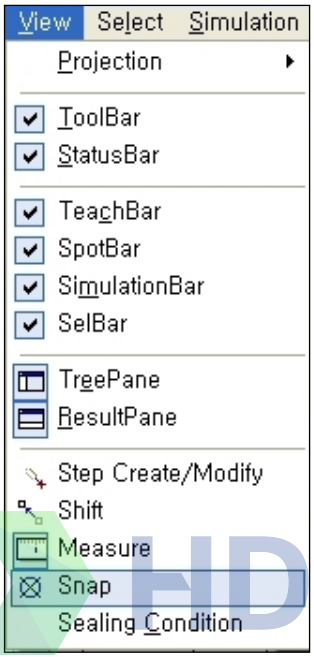
 : Select Coordinate System



(This selection mode function is utilized in Snap and Step Create/Modify function that is explained in later sections.)

4.8. Snap dialog box

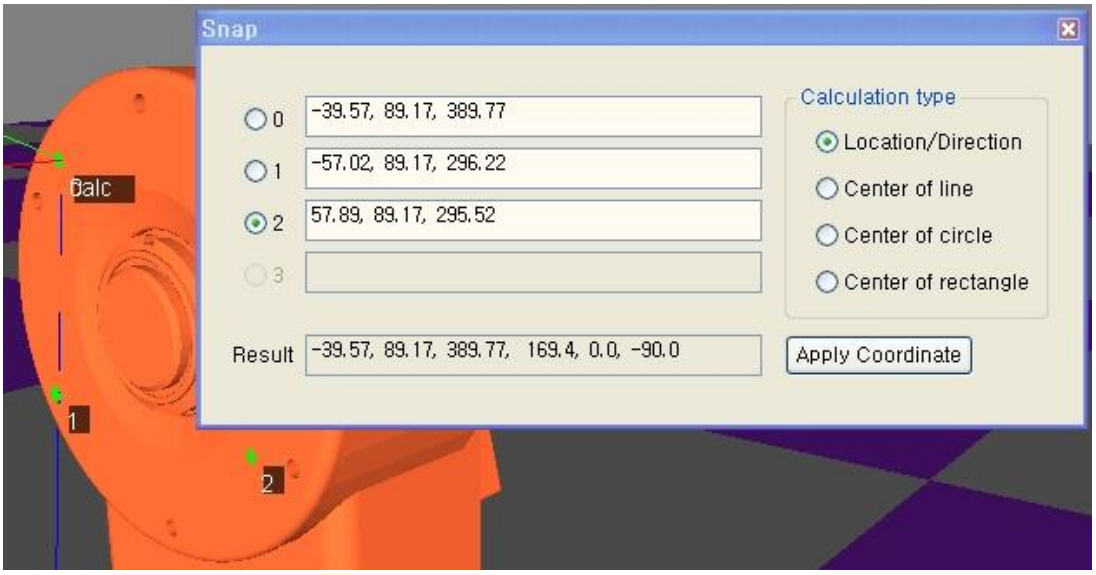
Snap dialog box helps you to select the correct location/direction on the surface of a model. Select Snap from View menu or press Snap button on the tool bar.



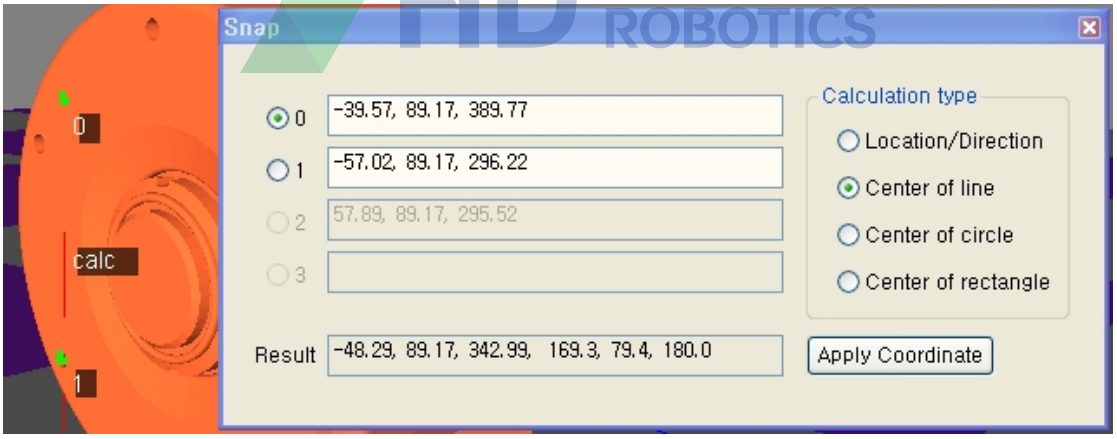
Four methods are provided for snap calculation. The total number of inputs (locations) depends on the method.
Calculated result is displayed on the 3-D screen as a coordinate system called calc and the location and direction are displayed in the result field in numbers (X, Y, Z, RX, RY, RZ ; unit: mm, deg).

Use Sel. Mode bar appropriately when you click locations to select.

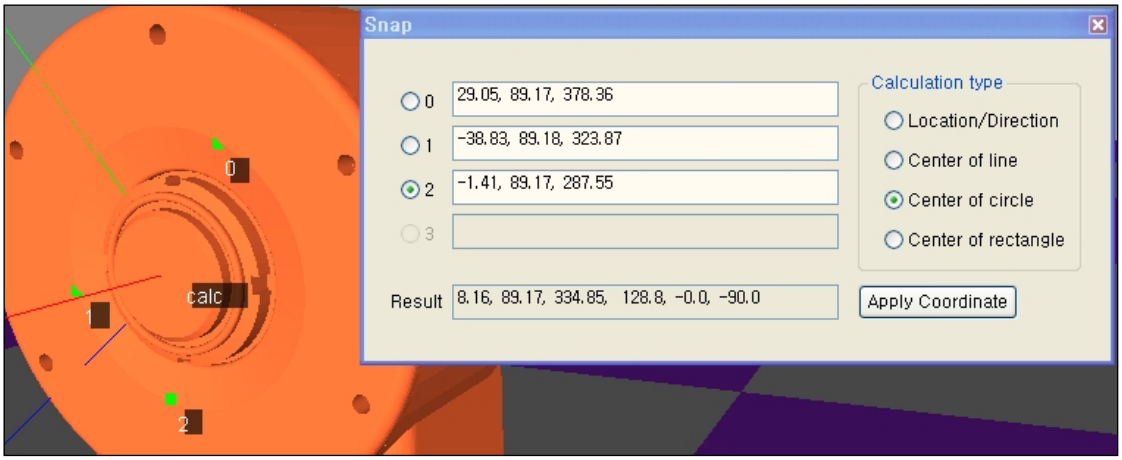
1) Location/Direction: Choose 0 as the origin, 1 as Z direction, and 2 as YZ plane.



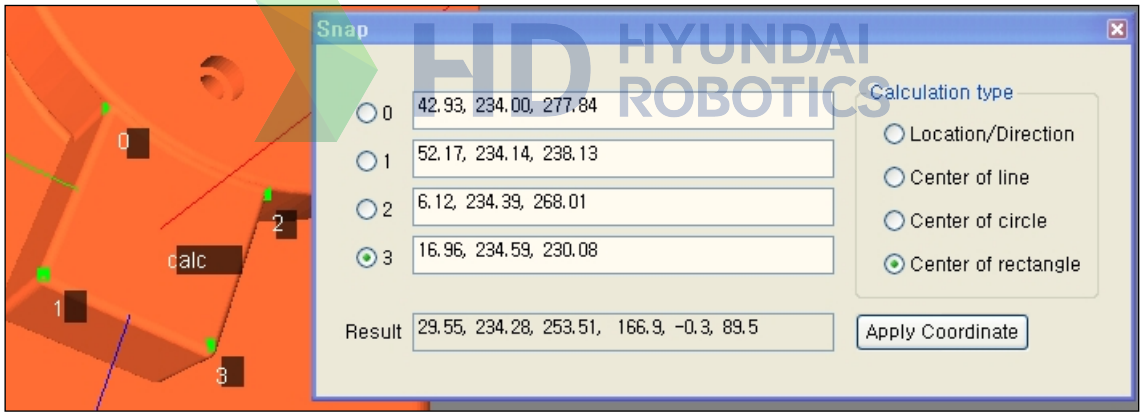
2) Center of line: Choose the middle of 0 and 1 as the origin and 1 as X direction.



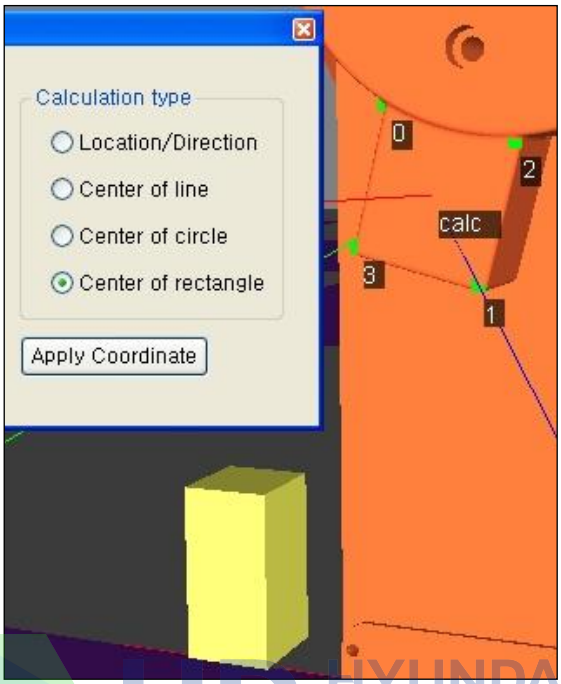
3) Center of circle: Calculate a circle whose circumference includes 0, 1, and 2. Choose the center of the circle as the origin and the plane of the circle as YZ plane



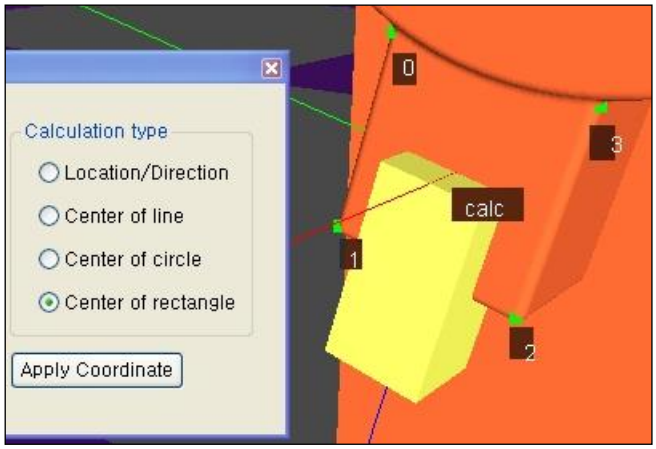
4) Center of rectangle: Choose the middle of 0, 1, 2, and 3 as the origin and the plane of the rectangle as YZ plane



5) Click Apply Coordinate button if you want to apply the calculated coordinates to a specific model



6) If you click an object with a cursor whose shape is changed to , the object is located on the calculated location and direction.

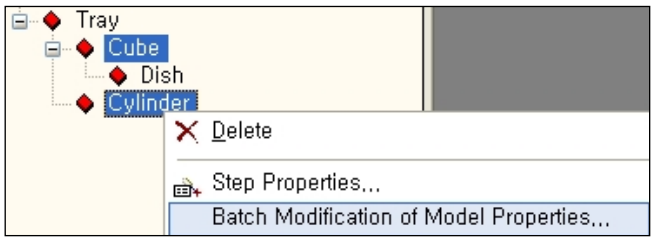


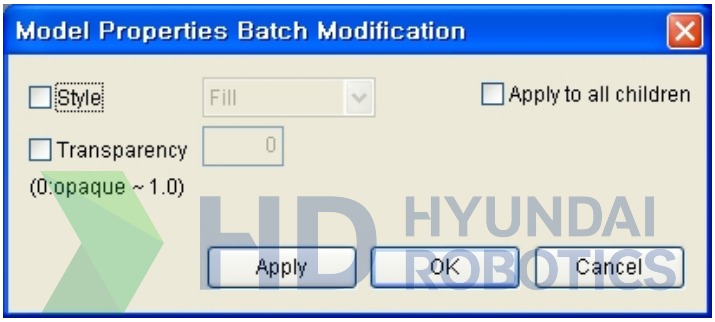
(Rotate the object 90 degrees by 90 degrees with Shift dialog box if you want to change the direction of the object.)

4.9. Model Properties Batch Modification

The same model properties can be applied to many models.

A dialog box as below is displayed when you select several models that belong to the same hierarchy. Open popup menu and select 'Batch Modification of Model Properties.... '





Check the check box of each item that you want to modify and select values. It applies the modifications down to all the children models of the selected model when you check 'Apply to all children' check box.

HYUNDAI ROBOTICS

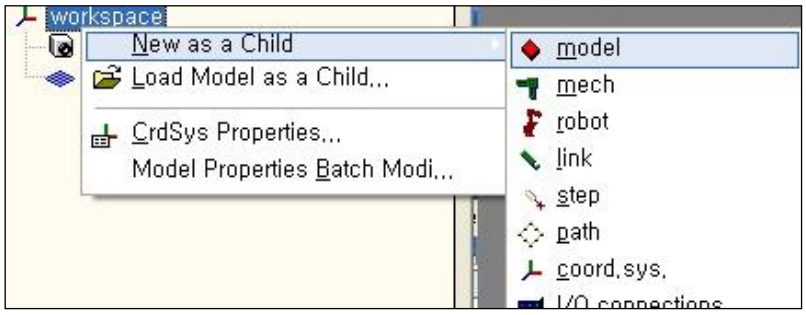
5 CAD File

5.1. Open STL File

When the shape of the model is prepared in STL file type, it can be read as follows.

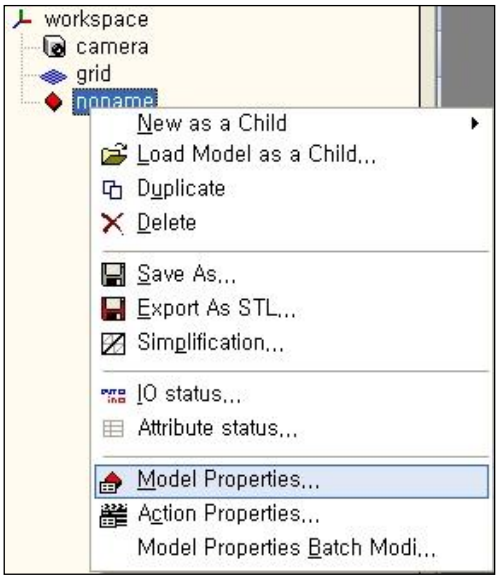
Both the ASCII type STL file and binary type STL files can be read, and the unit of measure is mm.

Right click on the workspace model (or another parent model), open the popup menu and select new model to see the sub menu. Select 'Model' from here.



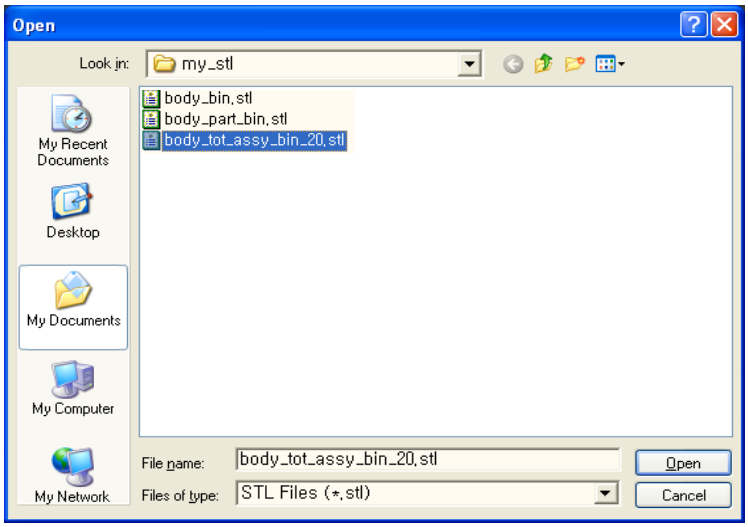
A new model is created under the workspace, named "noname". Nothing is displayed in the 3-D screen yet. This is because the shape of the model has not been defined yet.

Now, right click on “noname” and select model properties.

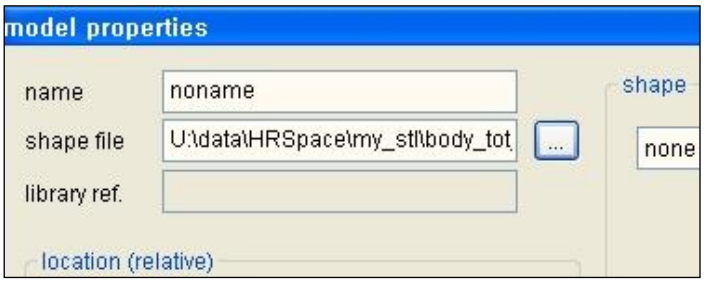


When the model properties window appears, click on the  button located on the right side of the shape file edit box.

Select the STL file to read from the open file window and click on Open.



You can see that the file path of the STL file is entered in the shape file edit box as shown below. (You can directly enter in the shape file edit box without using the ... button.)



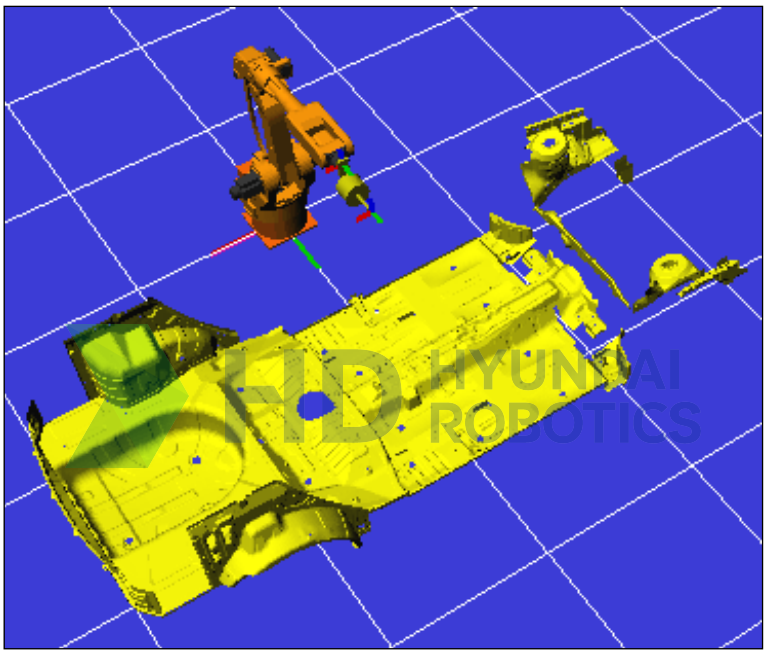
When the path of the file selected with ... includes a path designated in option library, that part will be replaced with {LIBRARY}.
Example) {LIBRARY}₩Tool₩Hanger₩Hand₩HAND2.STL

When the path of the file includes the path of the current document file, that part will be replaced with {DOC}.
Example) {DOC}₩STL₩GLASS.STL

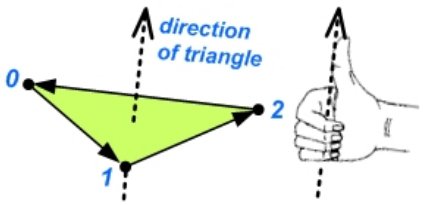
When the path of the file includes the folder path of the library file referred to, that part will be replaced with {LIBREF}.

If you want to see both sides of the model, check the “Draw Backface” option from the model properties window so that both sides can be viewed. The performance of 3-D process is a little bit degenerated if you check this option. You don’t need to check this option if all the directions[1] of triangles in the closed surface object toward outside because the back side won’t be shown.

If there are other properties required, set up the properties. Now click on OK in the model properties window and the shape of the STL file will be displayed in the 3-D screen.



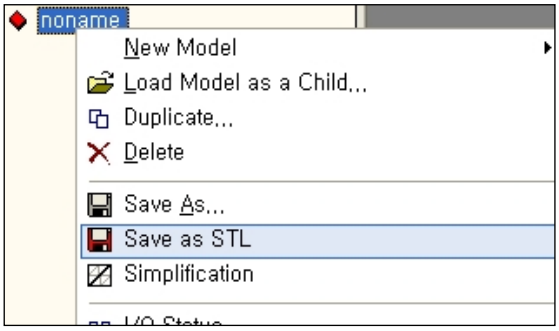
[1] In 3-D graphics, the direction of a triangle depends on the order that the three vertexes are saved in memory.



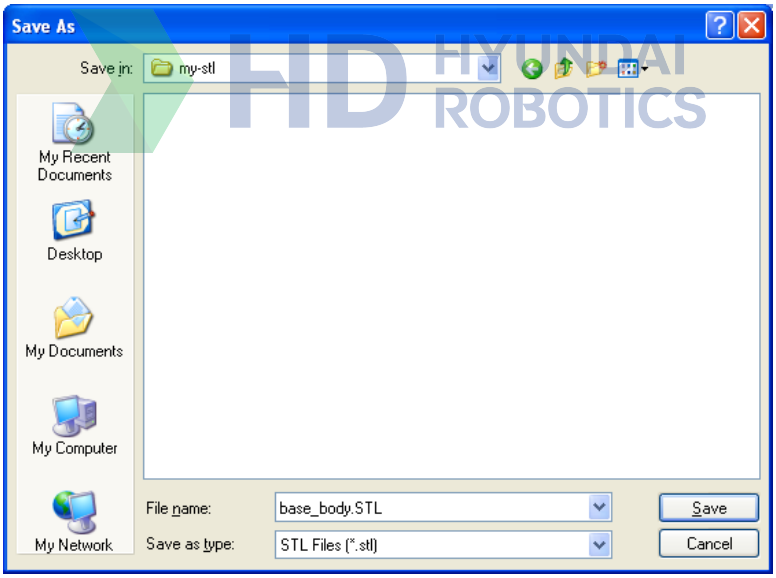
5.2. Save STL File

Use the following method when saving the opened STL file in a different format (ASCII or binary) or when saving after simplifying.

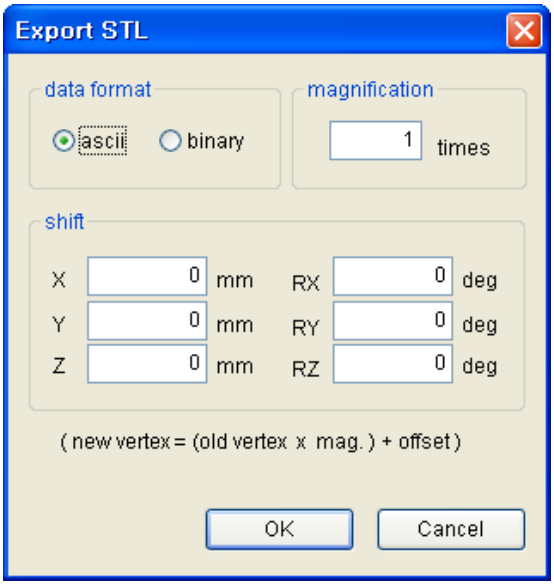
Right click on the model of STL shape and open the popup menu. Select "Save as STL".



When the following window appears, designate the folder and file name to save and click on Save.



The following window appears.



For the data type, you can select either the ASCII or binary type.

Designate the multiplier, how much you are going to multiply on the apex coordinate of each triangle. Generally, default value of 1 is applied but when you want to change the unit from m to mm, you can set this to 1000. To convert in the opposite direction, set as 0.001.

Shift is the shift value to apply on the apex coordinate of each triangle. First the location information of the model properties is shown here as default. (Note that the multiplier is first applied and then the shift is applied.)

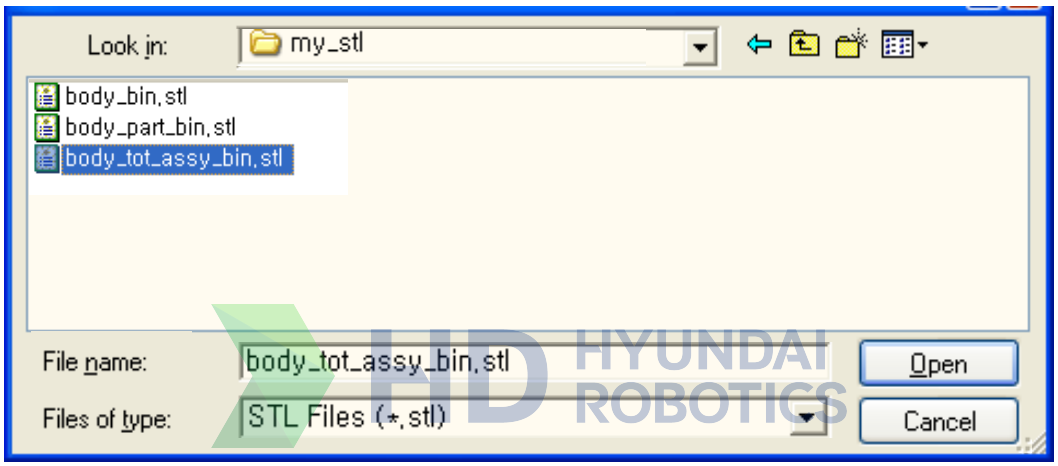
Click OK to save the information.

5.3. Simplification

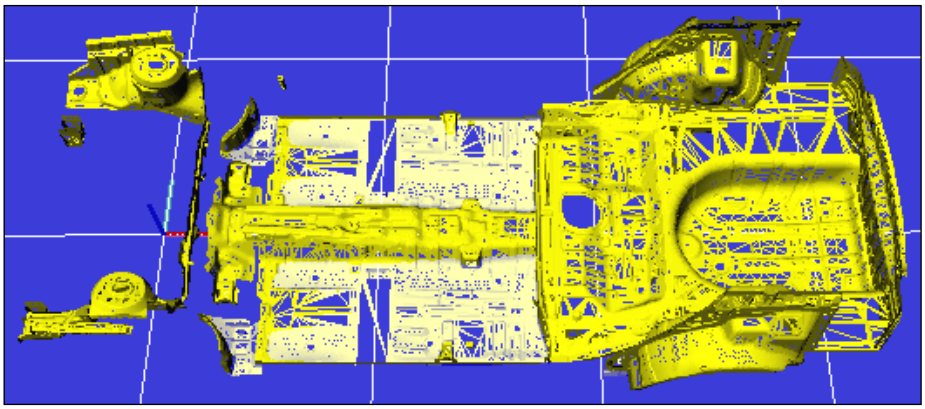
When you open a STL file with very complex shape composed of hundreds of thousands triangles, even the higher performance hardware will have severely reduced processing speed.

To resolve this issue, you can use the Simplification function for saving the file. Simplification function uses the method of appropriately joining the detail triangles that contact each other. Due to this process, the precision will be sacrificed but the number of triangles will be reduced.

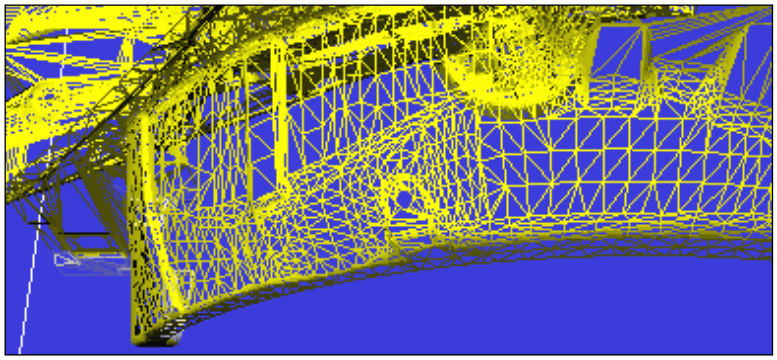
For example, let's assume that the following is a case when a chassis of a car floor shape is opened.

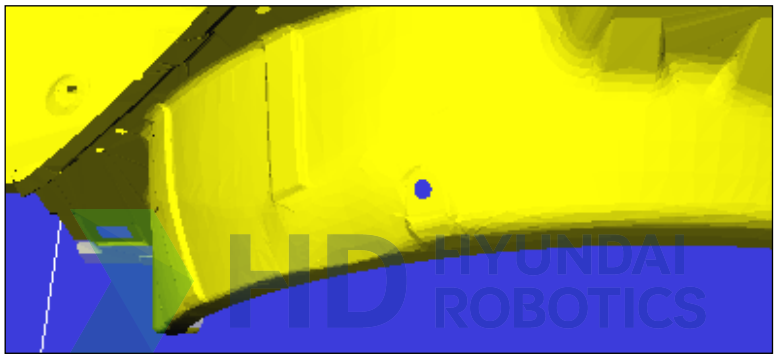


This model is composed of about 200 thousand triangles and the file size is about 10MByte.



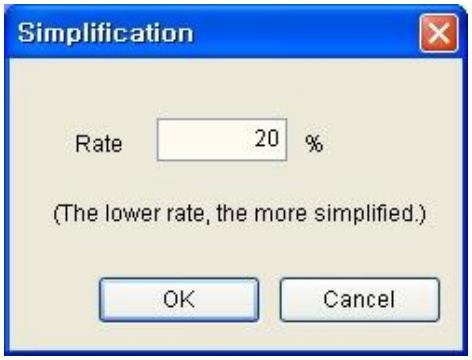
When you zoom in a part, you will notice that it is composed of detail structure. When you assume the current condition as 100%, let's try to simplify to the 20% condition.





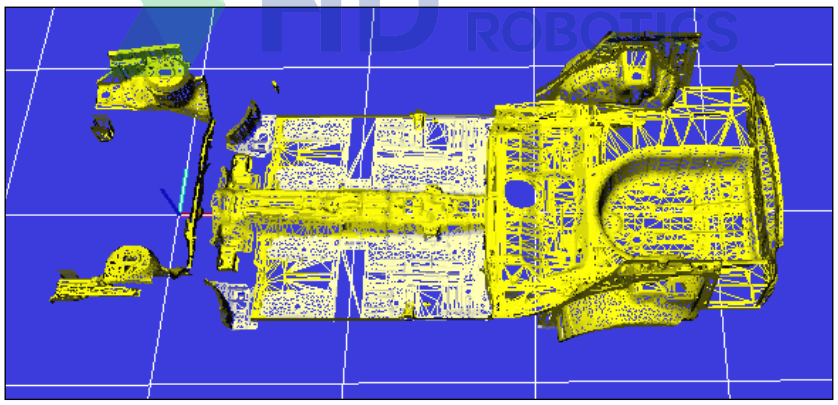
Open the popup menu for the model and select 『Simplification』.

When you see the Simplification window as shown below, enter 20 in the rate, and then click on OK.

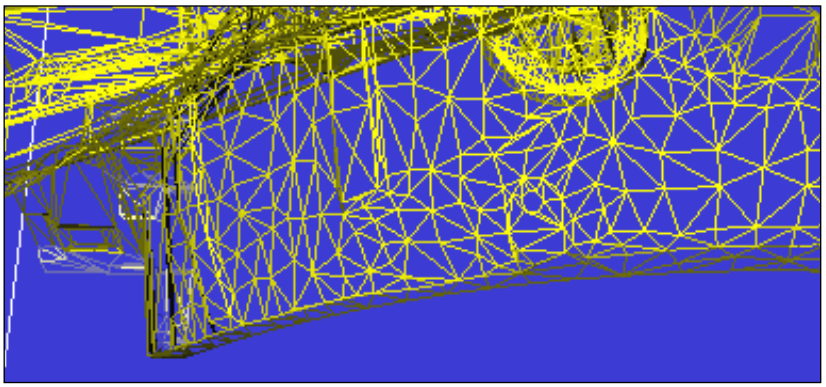


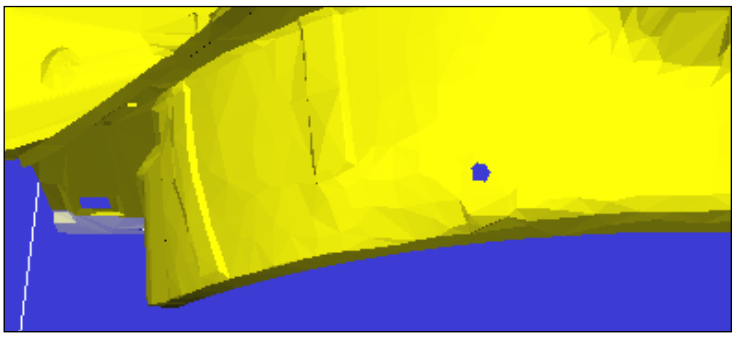
The shape is simplified as follows.

Warning: There're cases that incorrect shapes are produced when you do the simplification too much from the beginning (for example, less than 10%). In this case, restore it to the original shape and try the simplification process (about 50 to 60%) several times.

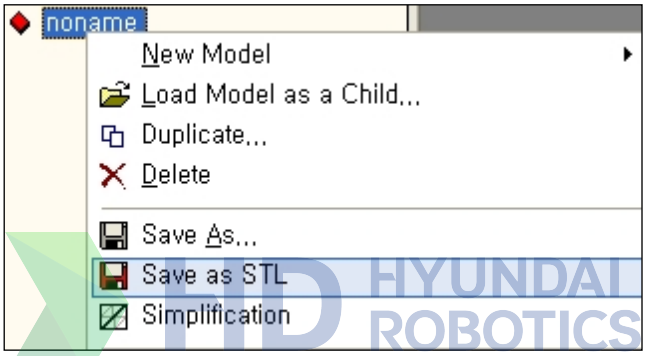


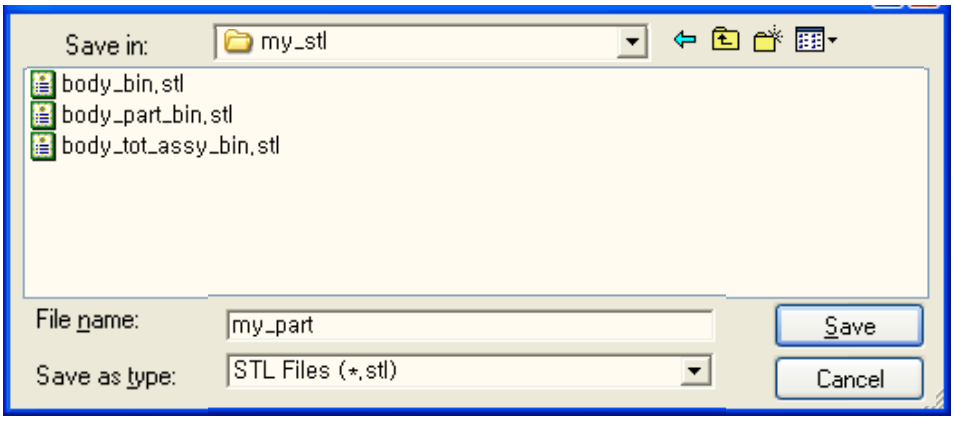
If you zoom in the parts as before, you can see that it is not as precise as before.





The simplified condition is only reflected in the memory. You must save in STL file format to continuously utilize the file. Maintain the original STL file if possible and save the STL as a different name.





The saved STL file is composed of about 40 thousand triangles and the file size is about 2MByte.

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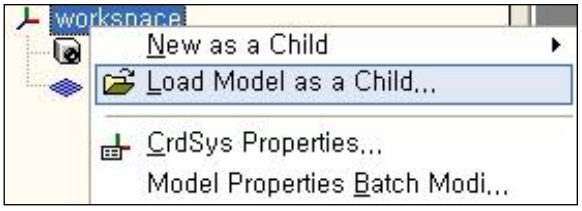
6

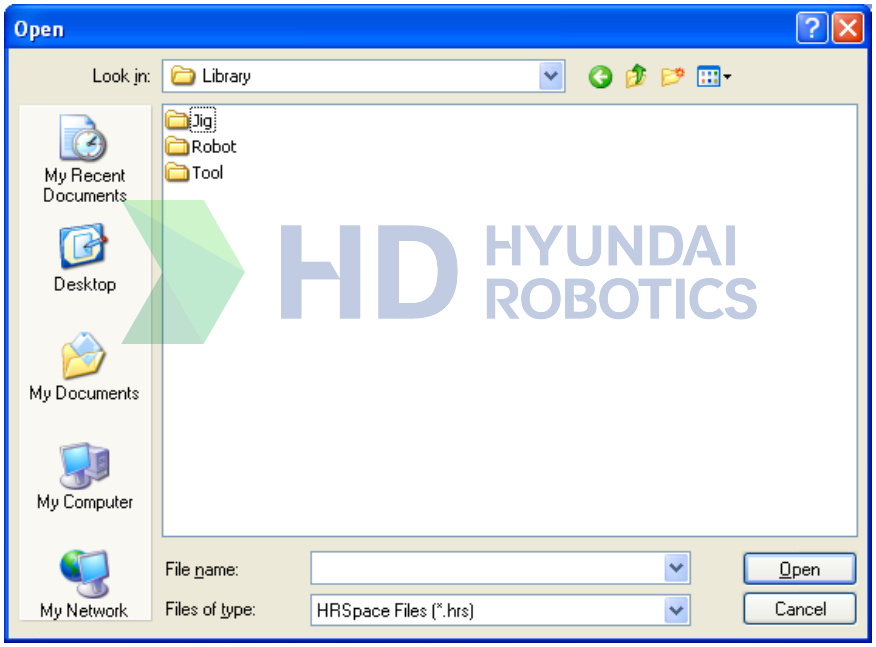
Load Robot and Tool

6.1. Load Robot

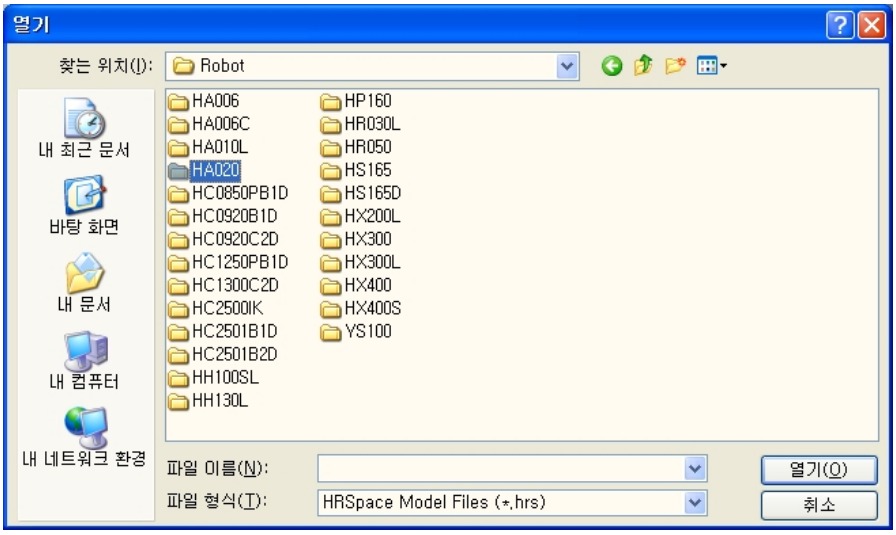
Right click on the workspace of the tree window and select 『Load Model as a Child…』 from the popup menu.

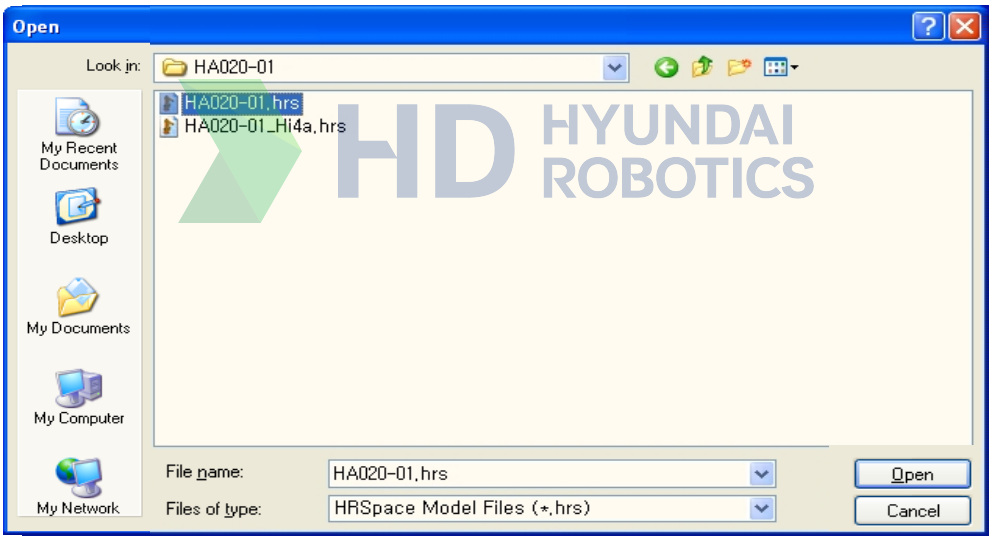


The open window appears for the Library folder.

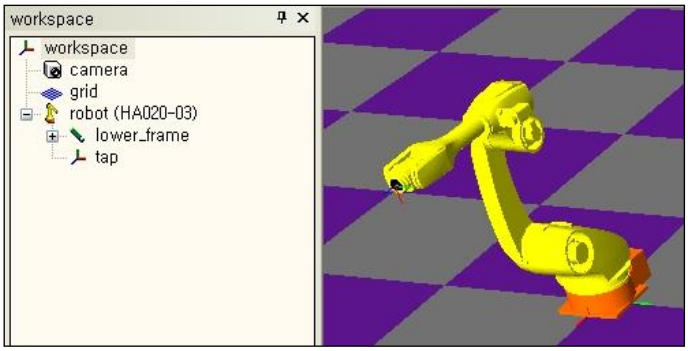


Open the Robot folder under the Library folder, and open the HA020 folder to select the hrs file.





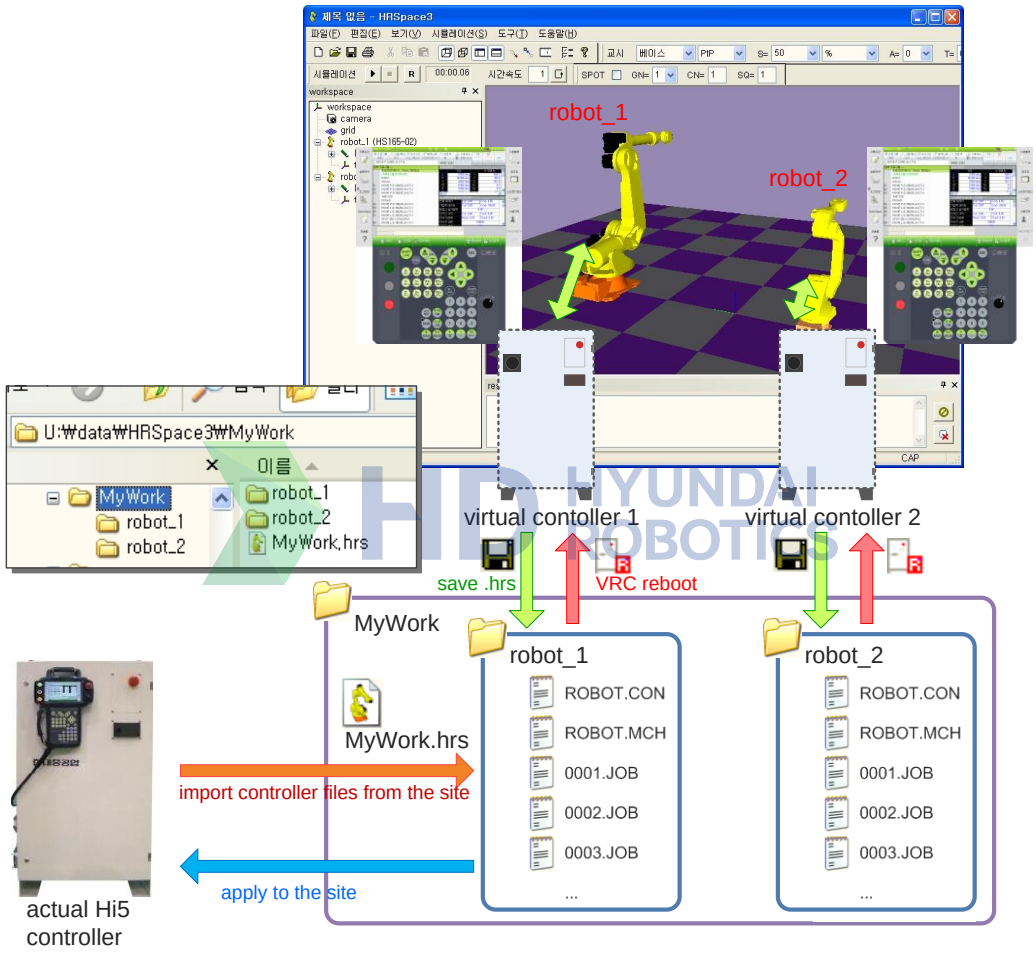
A new robot named “noname” has been created under the workspace of the tree window as shown below. The robot shape is shown also in the 3-D screen.



6.2. Virtual controller and controller files

One virtual controller is connected to one robot in work space. When a robot comes in work space, first the virtual controller is initialized and then is set to the type of the robot without any additional axes.

You can use 10 robots at the most.

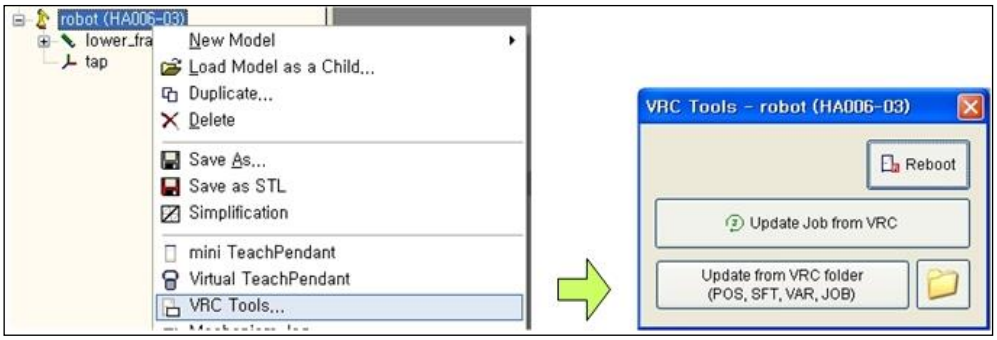


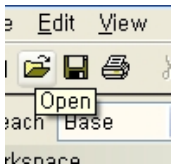
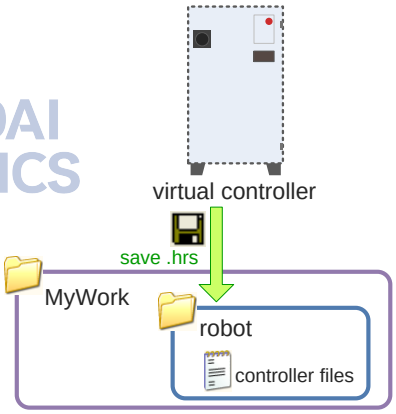
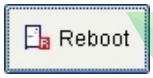
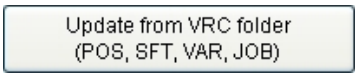
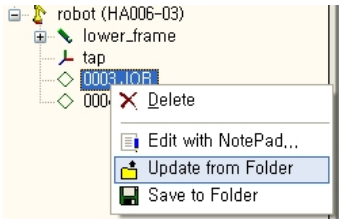
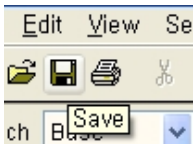
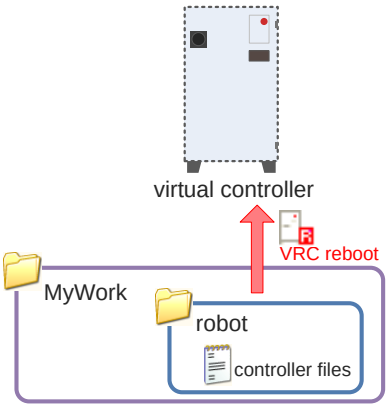
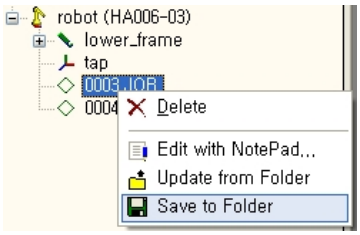
In an actual Hi5a controller, when job files are created, they are saved as .JOB files and when system settings are done, they are saved as .CON, .MCH, or other various setting files. This is the same in a virtual controller. These text files are not included in .hrs document files and saved in separate folders.

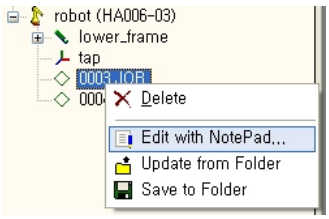
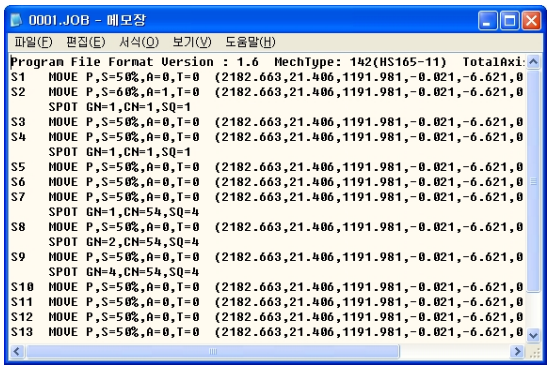
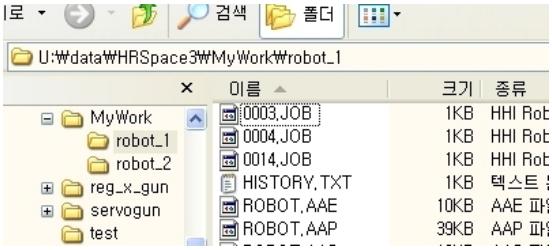
■ **Warning: Save only one .hrs file in one folder!**

Control files of each robot in project ".hrs" are saved in sub folders. If you save many .hrs files in one folder, be careful because other .hrs file's controller files could be overwritten.

VRC Tools dialog box is open when you select VRC Tools from popup menu to the robot model.



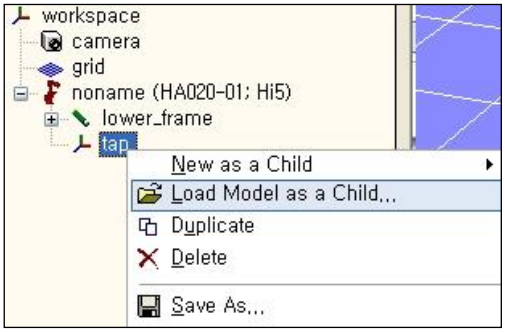
	Virtual controllers to all robot models import controller text files and are booted when you open .hrs document.	
	Virtual controllers import all controller text files and are rebooted when you click [Reboot] button in VRC Tools dialog box.	
	It imports only all variable files and JOB files without rebooting when you click [Update from VRC folder] in VRC Tools Dialog box.	
	It only updates selected JOBs by using text files when you click [Update from folder] in VRC Tools Dialog box to JOB model.	
	All controller files to robot models are saved as text files when you save the whole .hrs documents.	
	Only selected JOBs are saved as text files when you select [Save to Folder] in popup menu to JOB model.	

	You can edit selected JOBs with NotePad when you select [Edit with NotePad...] in popup menu to JOB model. The changes are applied to virtual controllers when you run [Update from Folder] after editing.	
	You can open VRC folder with Explorer when you click [Folder] button in VRC Tools dialog box.	

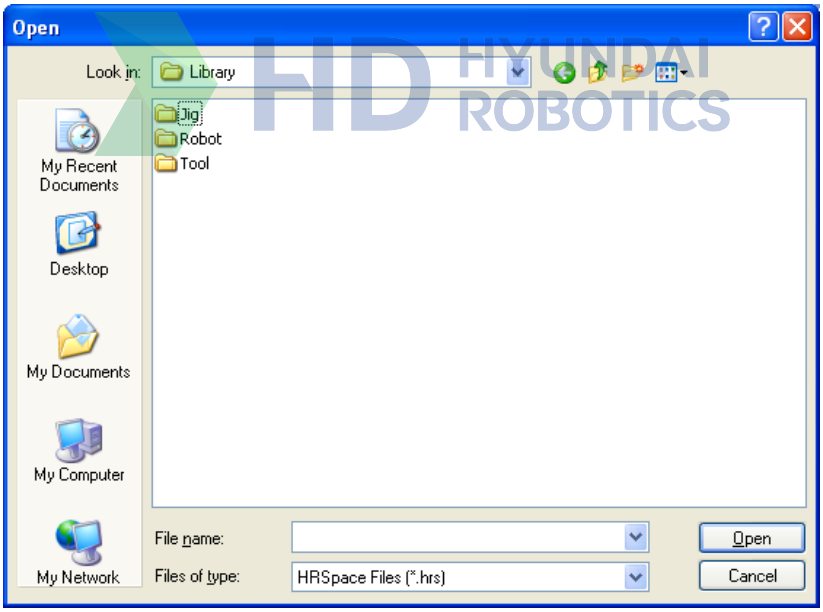
6.3. Load Tool and Mount on Robot

In tree window, you can see tap (Tool Attachment Point) is attached to a Robot. Tools should be loaded as children models of tap.

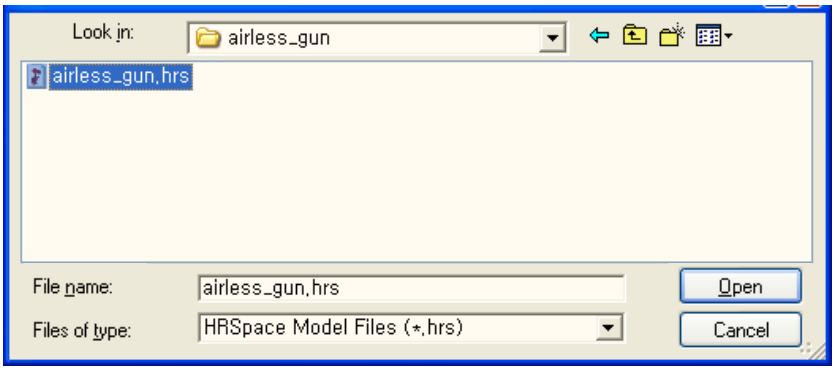
Right click on the tap as shown below and open the popup menu to select open all models.



The open window for the Library folder appears.



Open the Tool folder under the Library folder.
For example, open sealing/airless_gun folder under Tool folder, select airless_gun.hrs, and click [OK] button if you want to add a sample, airless gun tool.

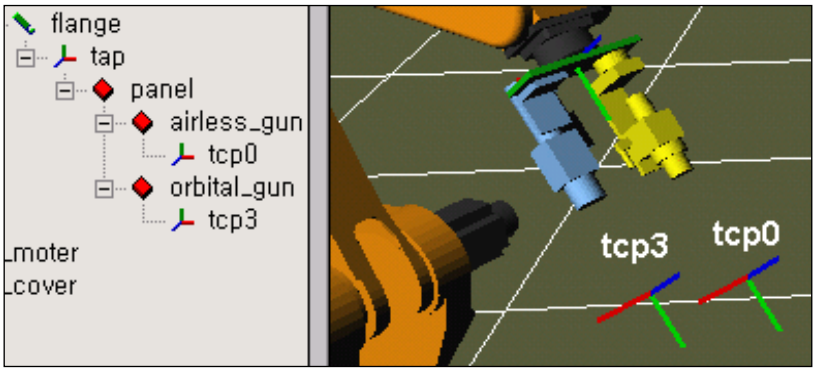


A model called airless_gun is created under the robot of tree window as shown below. You can see that the tool is attached on the robot also in the 3-D screen.

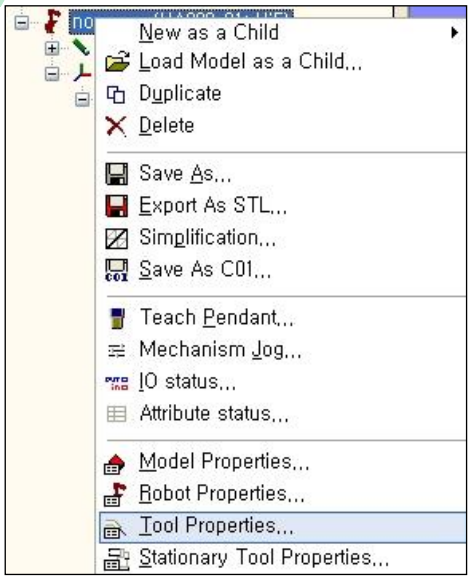
6.4. TCP and tool number

As the child model of airless_gun, there will be a coordinate system model called tcp (Tool Center Point). The relative location/direction data of tcp based on the tap is used as the location/direction data of tool no. 0 (T0) when recording the step or running the simulation. Hi5a controller supports a total of 16 tools (T0~T15), and the coordinate models are tcp0~tcp15.

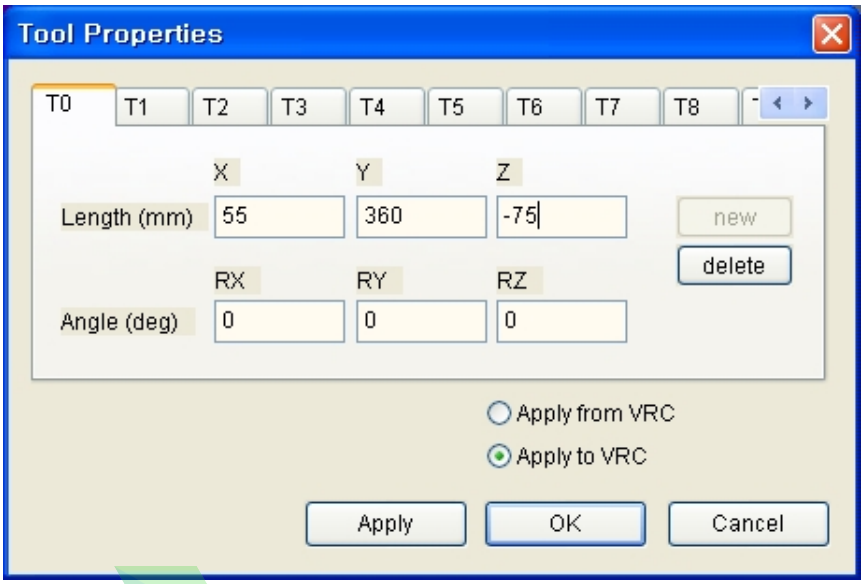
For example, let's assume that 2 tools are attached as follows and names set to tcp0 and tcp3.



If you want to directly edit the tool data, right click on the robot and open the pop up menu to select tool properties.



The tool properties window appears as follows. For example, if you want to edit the data of tcp3, click on the T3 tab and enter the accurate length and angle of the tool. Then click on OK. The entry method is the same as the setting screen of the tool parameter for the actual Hi5a controller.



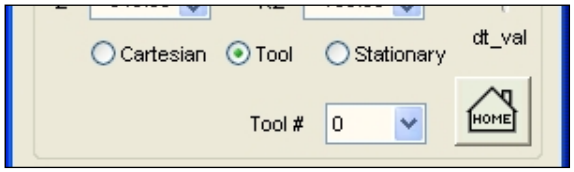
(You can adjust the relative value of model properties of tcp or adjust the tool data by using the shift function.)

Choose one from options as below to select how to connect with a virtual controller.

Apply from VRC	Changes in Tool data on a virtual controller is immediately applied to the virtual controller. This is useful when you observe a 3D screen by importing onsite robot control files or utilize virtual Teach Pendant to practice the operation.
Apply to VRC	Changes in Tools data on HRSPace3 is immediately applied to the virtual controller. This is useful when you create robot control files by designing work cells on a 3D screen.

The set tool data can be utilized as follows.

(1) When you are jogging the tool coordinate using the mechanism jog window, it is based on the currently selected tool coordinate.



(2) When recording the step with the record button of T/P, you can create the step on the location of the currently selected tool coordinate.

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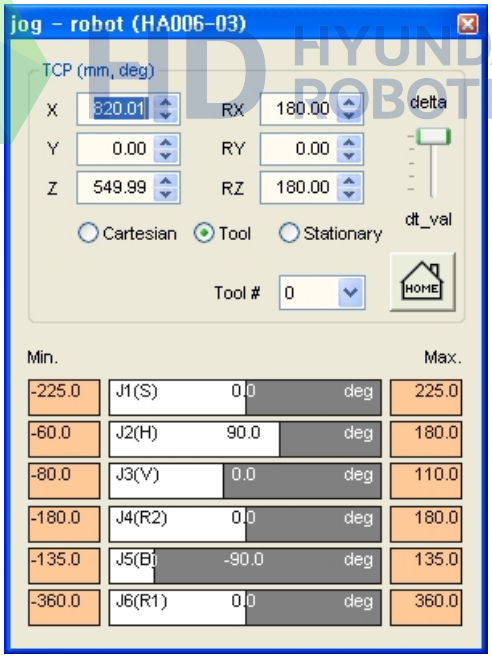
7

Create Job

7.1. Robot jog

You can move the robot with the jog window.
Right click on the robot of the tree window and open the popup menu.

When you select the mechanism jog, the following jog window appears.



■ **Scroll bar**

There're 6 scroll bars for 6 axes in a robot and additional scroll bars whose number is the same as the total number of additional axes if there're any. The degree of each axis is displayed in the center of the scroll bar. It also displays the minimum and maximum values that each axis can move.

By operating the scroll bar, you can move each axis of the robot independently. For a parallel robot, the maximum/minimum value of V axis is dependent on the H axis.

When you press [ENTER] key, it displays a dialog box that you can edit the value of selected axes. Type numeric values by using a keyboard and press [ENTER] key to complete the editing.

You can also edit Softlimit if you double click the minimum and maximum values of each axis.

■ **TCP**

The location and direction of the TCP(Tool Center Point; Robot tool end) is shown on the right side of the TCP window. You can move the TCP in grid coordinate method by pressing the spin button of each item of X, Y, Z, RX, RY and RZ. Or you can move the up/down cursor key on the keyboard or rotate the mouse wheel up/down after left clicking the edit box of each item.

(It is increased by the value that is specified in delta slider.)

Also you can directly enter the value of each axis with the keyboard and hit Enter or select other edit box to reflect the value.

■ **HOME button**

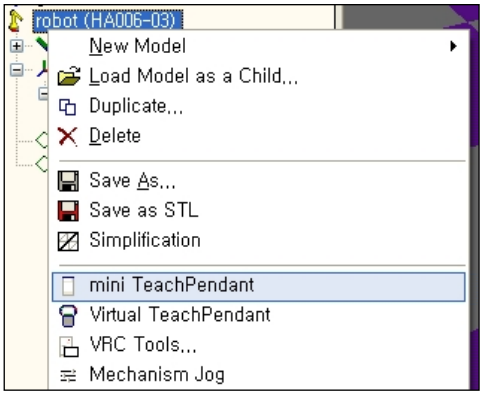
By clicking the HOME button, the robot will be positioned in HOME location (Default position).

■ **Cartesian / Tool / Stationary**

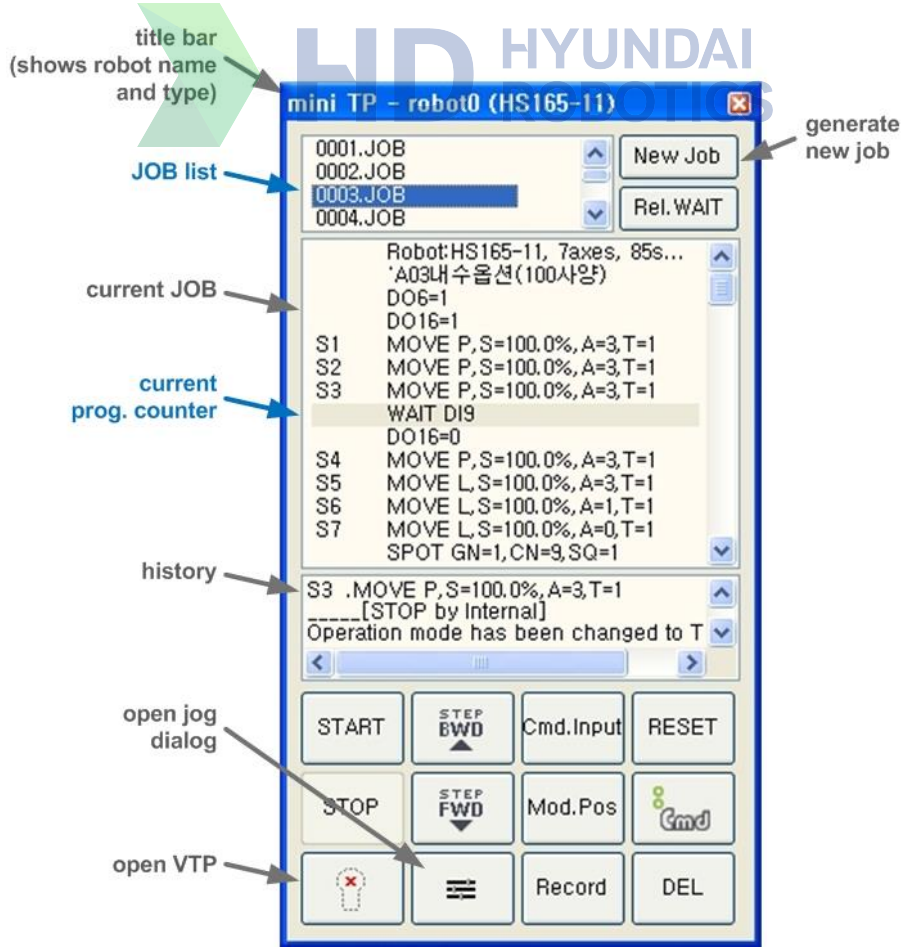
① When operating each axis of X, Y, Z, RX, RY and RZ of TCP, you can select which coordinate to be based on.
Select the "Cartesian" and operate the TCP to shift the tool end based on the robot coordinate.
② When you select the "Tool" and operate the TCP, the tool end will shift based on the coordinate of the currently selected tool.
③ When you select the "Stationary" and operate the TCP, the work piece held by the robot will shift based on the coordinate of the currently selected stationary tool.

7.2. mini TeachPendant

Open popup menu to a robot in tree window.

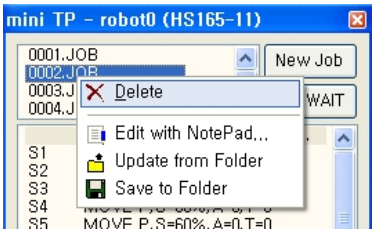


Select mini TeachPendant. TeachPendant is a dialog box with key functions that are needed to teach and playback robots.

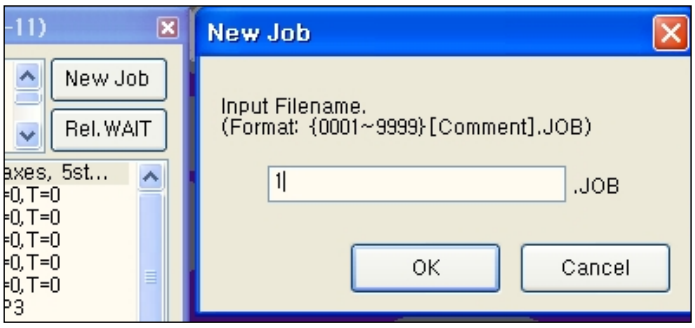


A picture above explains the structure and function of mini T/P. Names and functions of the most buttons

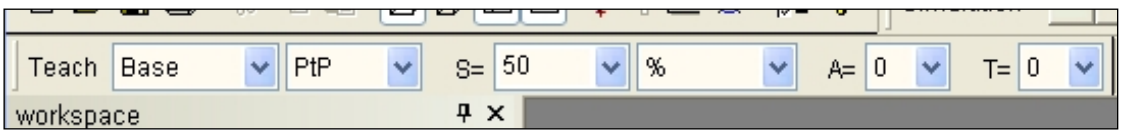
are the same as those of an actual Hi5a Teachpandant.

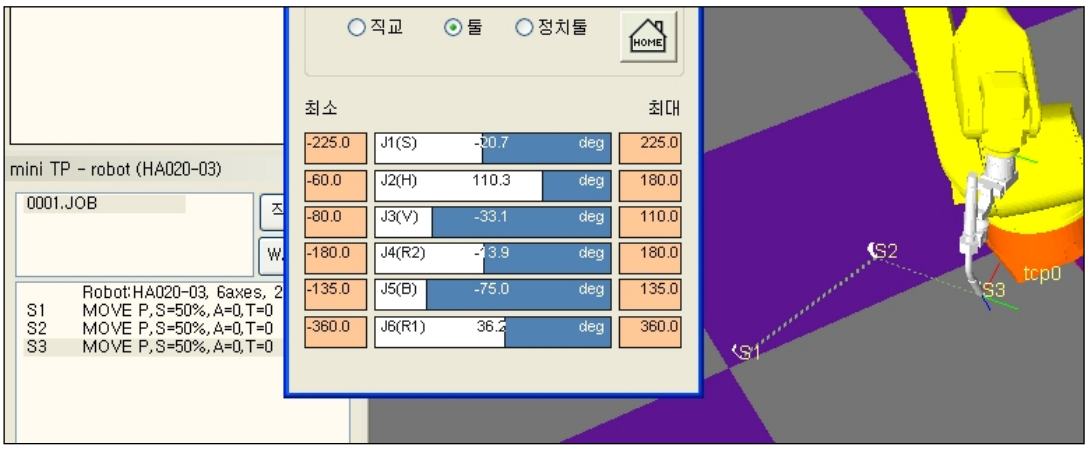
JOBList 	It displays the list of all work files that are saved in the controller and displays current work as selected during play. If you click one of the work programs while teaching, the work program is selected as the current program and the contents of the program are displayed at the bottom. It displays popup menu that lets you delete or save work when you click the work with the right mouse button.
Current job program	It displays the contents of the current program and the current program counter. You can move the program counter by clicking a certain command and edit relevant commands by double clicking the commands.
History	This is an area where the history of Hi5a controller is displayed. In other words, it displays commands that were executed or error messages.
Open JOG dialog box 	This is a button that lets you to open JOG dialog box promptly.
Open virtual T/P 	This is a button that lets you open virtual TeachPendant promptly. TeachPendant is explained in the next section.

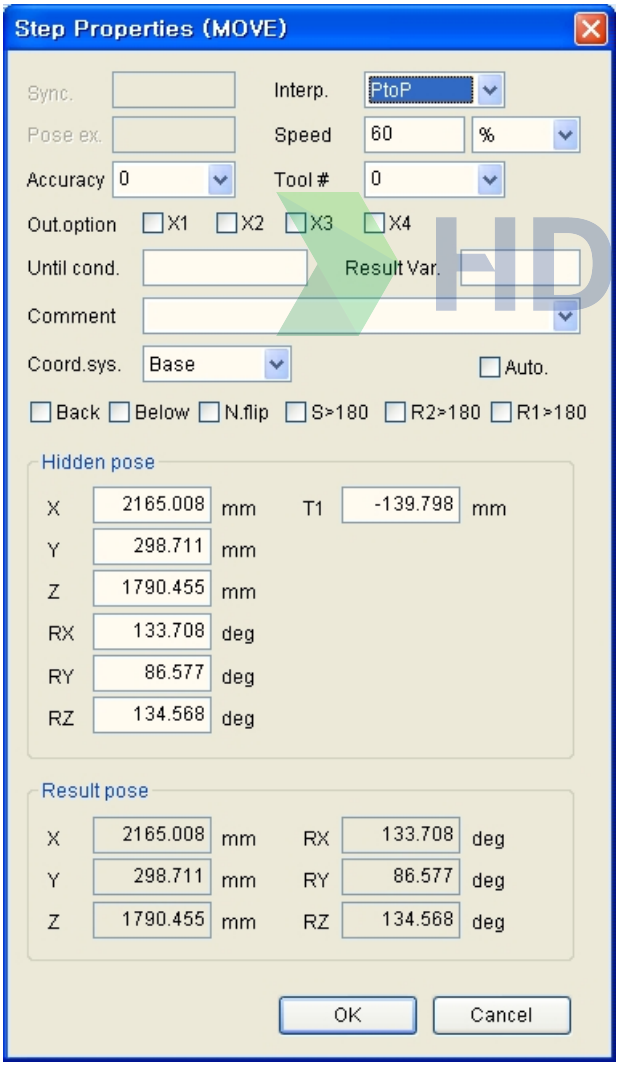
Click New Job button, enter JOB number, and press 'OK' button to create JOB.



Now you can create steps by pressing 'Record' button while you move a robot with JOG dialog box. In this case, record coordinate system and step parameter depend on the settings in teach bar.





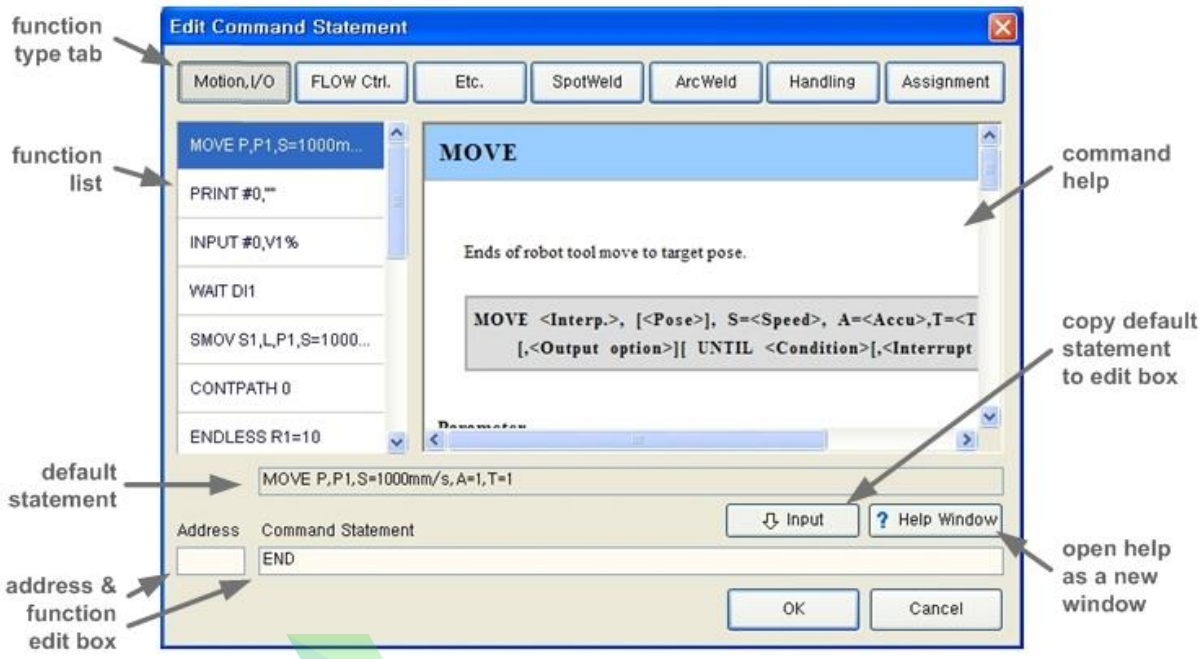


Open Step Properties dialog box by double clicking a step if you want to edit the step parameters. You can edit it freely with values, variables/expressions and others.

Also you can edit the value of a hidden pose and when you select other coordinate system, the coordinate system transformation is automatically done on the pose value. (This is similar to the function of Quick Open Screen in Hi5a TeachPendant.)

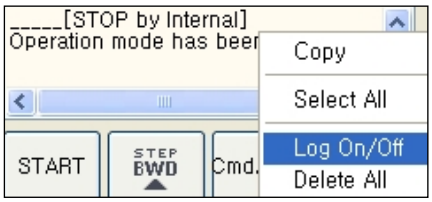
For a hidden pose of an encoder type, axis degrees, pose expression, or hidden pose + shift variables, the cartesian coordinate's value to this can be identified in Result pose.

Edit Command Statement dialog box is displayed when you click Command Input button.



When you select a function type with a tab on the top, relevant commands are displayed on the left list. Help and a default statement are displayed when you select one command. Copy a default statement to the edit box by clicking 'Input' button, edit Command Statement by referring to Help, and click "OK' button.
(You may type commands directly into the Command Statement edit box from the beginning.)

Open this dialog box by double clicking commands in mini TeachPendant if you want to modify functions that are entered or steps without hidden poses.

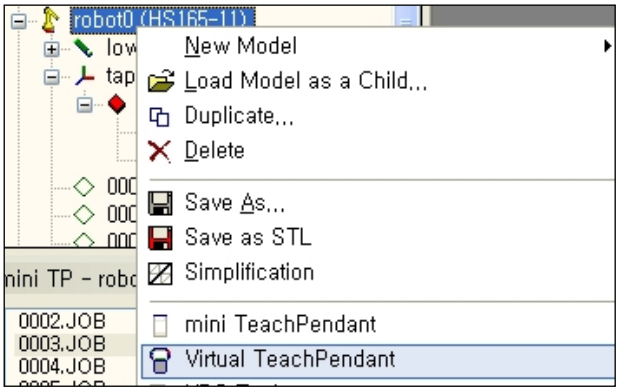


Popup menu is displayed when you click the right mouse button on History. Logs can be deleted or turned on/off when there're too many contents to be displayed.

7.3. VTP (Virtual Teach Pendant)

Open popup menu to a robot model in tree window to execute Virtual TeachPendant.

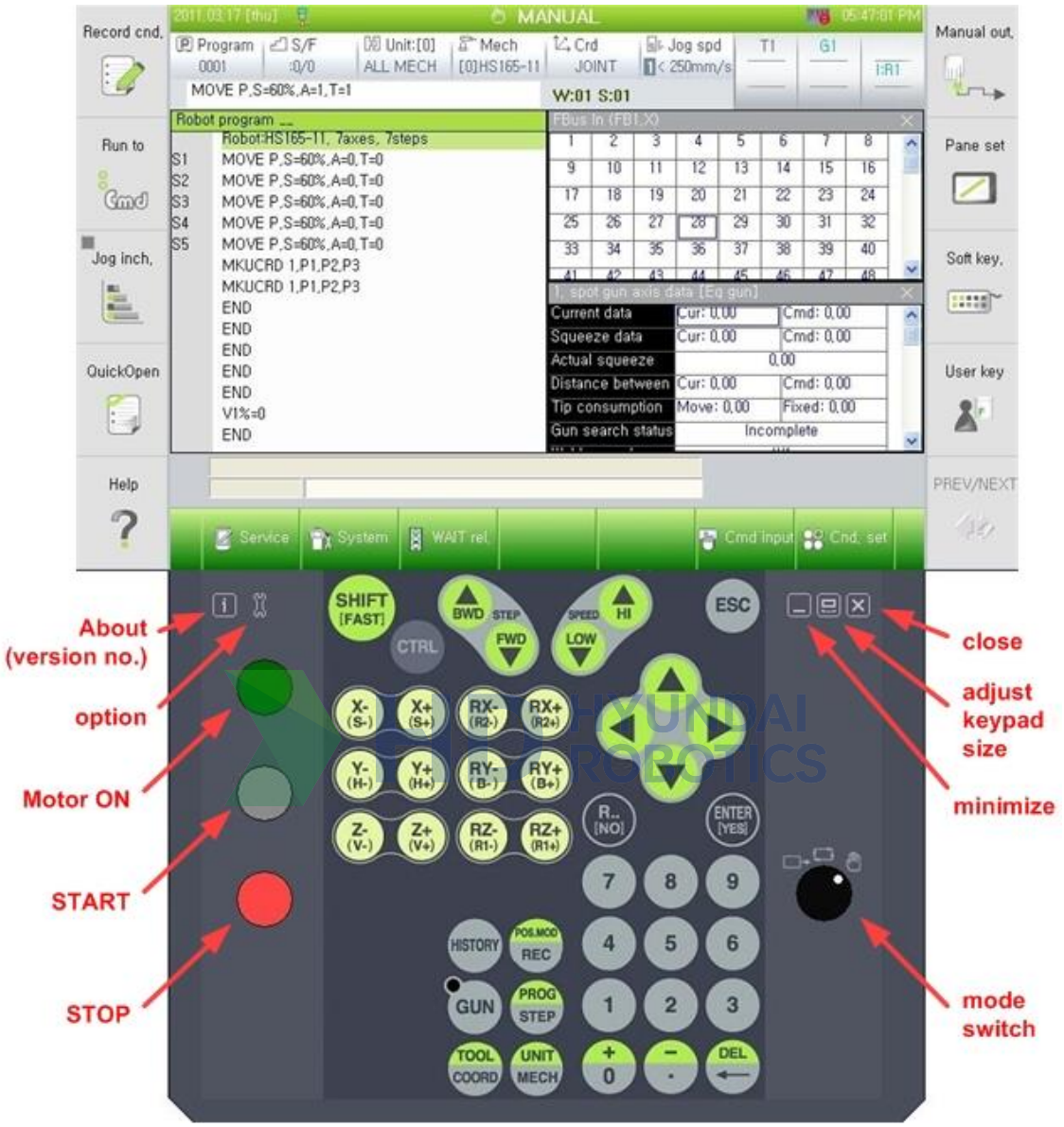
(Or press  button on mini TeachPendant.)



You can run the basic operation with mini TeachPendant mentioned in the previous section but you need Virtual TeachPendant to do a detailed system setting or monitoring.
The structure and operation functions of Virtual TeachPendant are almost the same as the ones in actual Hi5a TeachPendant. However unlike the actual one, Motor ON/OFF, Start, and Stop buttons and mode switch are located on both sides of a keypad to utilize space more efficiently. Click the [adjust keypad size] button if the width of TeachPendant is too big to be fit on a screen due to the low resolution of a monitor.
(Vertical resolution of the monitor should be at least 730 pixels. If you use a monitor that is smaller than this, you may not run it even though you reduce the size of the keypad.)

Drag dark borders on the left, right, or bottom of a keypad if you want to move the window.

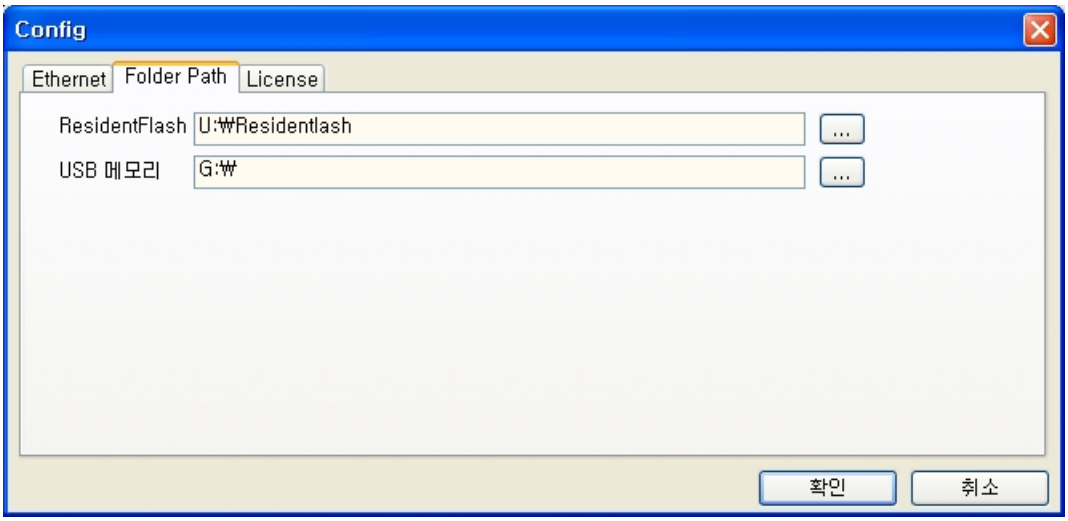
Keypad that is reduced with [adjust keypad size] button



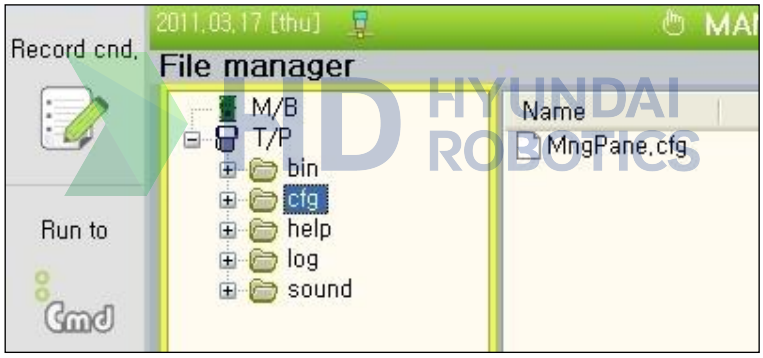
Operations of Virtual TeachPendant and actual Hi5a's TeachPendant are the same.

> Sometimes, buttons on TeachPendant don't work after you operate other windows. If it happens, click TeachPendant screen and retry the buttons.

There're 3 tabs in 'Config' dialog box, 'Ethernet', "Folder Path', and 'License.' Use the default settings in Ethernet and License tab. (You don't need a separate license for Virtual TeachPendant if you use it with legal HRSpace3.)



Folder Path is the location of various setting files that is managed internally when virtual T/P is operated. And when the File Manager of VTP is executed, in tree structure, TP and USB are mapped to this path.

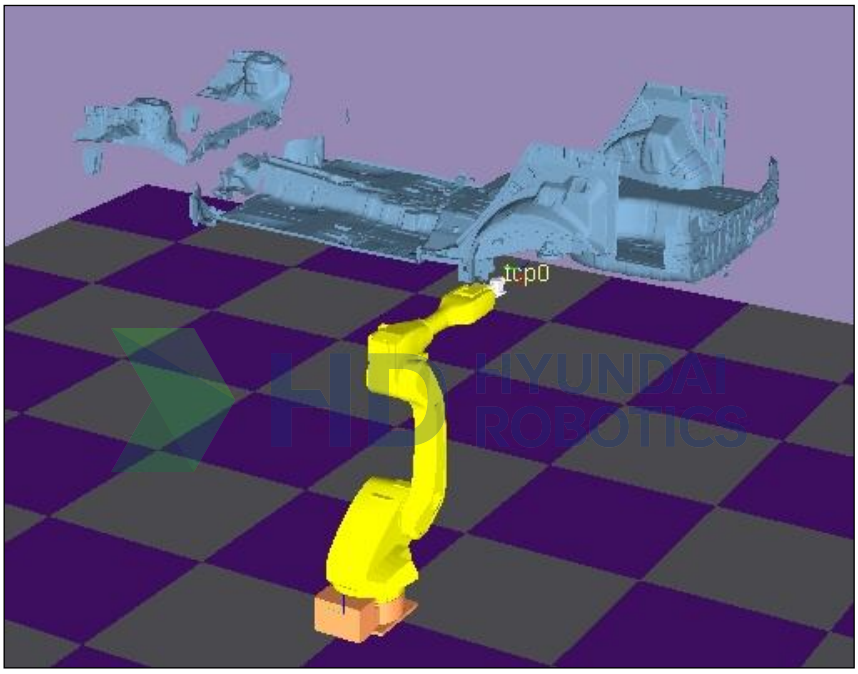


7.4. Step creation / modification dialog box

When you utilize the step creation/modification dialog box, you can generate accurate steps on the surface of the model quickly.

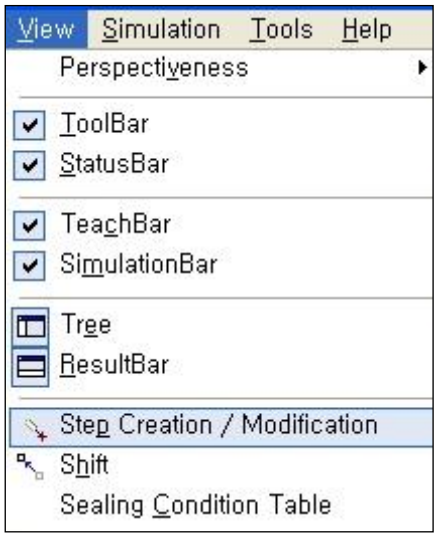
7.4.1. The basic way to create steps

Let's assume that there is data for the following robot and chassis floor, and create some steps at a part of edge.

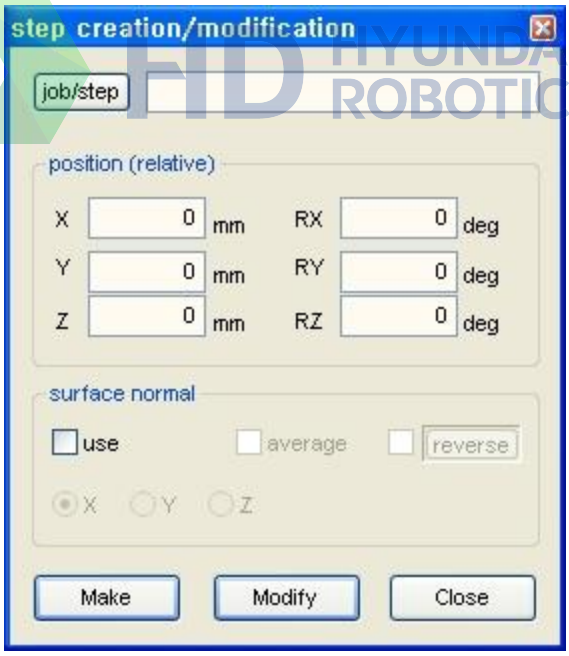


Click on 『Step Creation/ Modification』 button on the Standard tool bar.

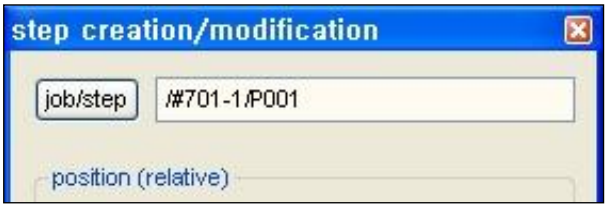
Or you can select 『View – Step Creation/ Modification』 from the main menu.



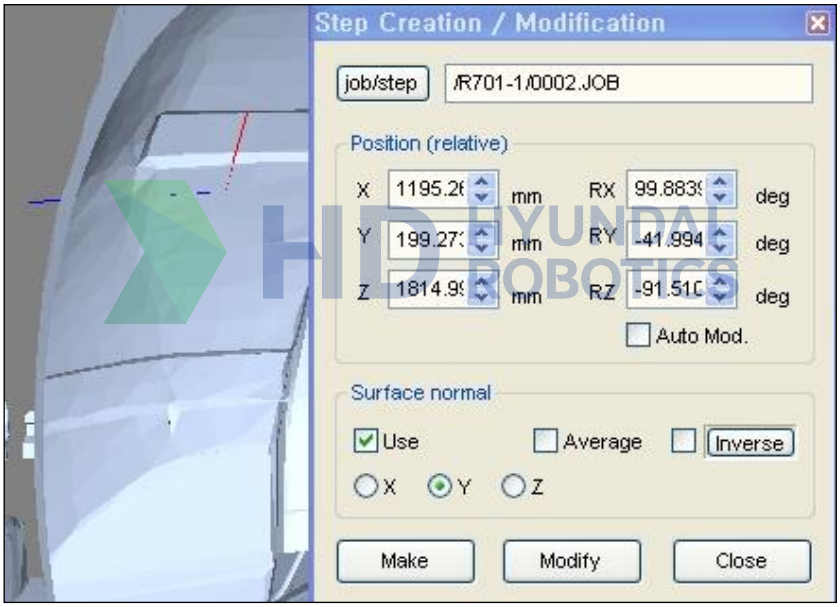
The following “step creation/ modification” dialog box appears.



You must set at which job you want to create the step through the edit window on the right side of the “jop/step” button. You can either directly enter the T path through the keyboard or press the “jop/step” button and click on the job from the tree window.



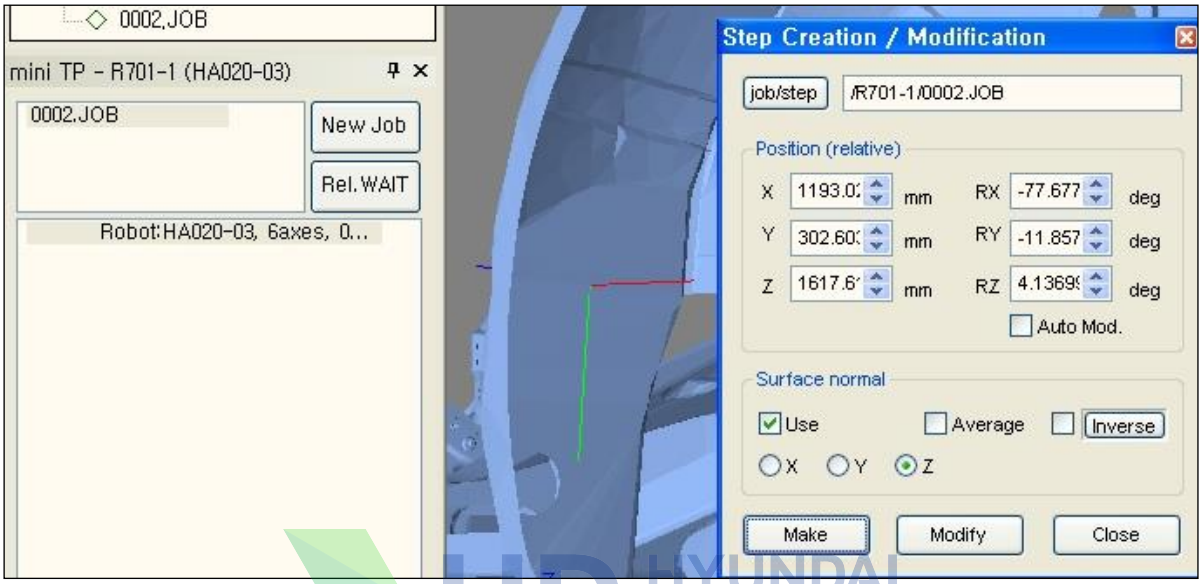
Click on the surface location of the chassis floor data to create the step. When the job is set in the “Step Creation/ Modification” window, the coordinate appears on the clicked surface. This coordinate is only to show the location and it has not created the step yet.



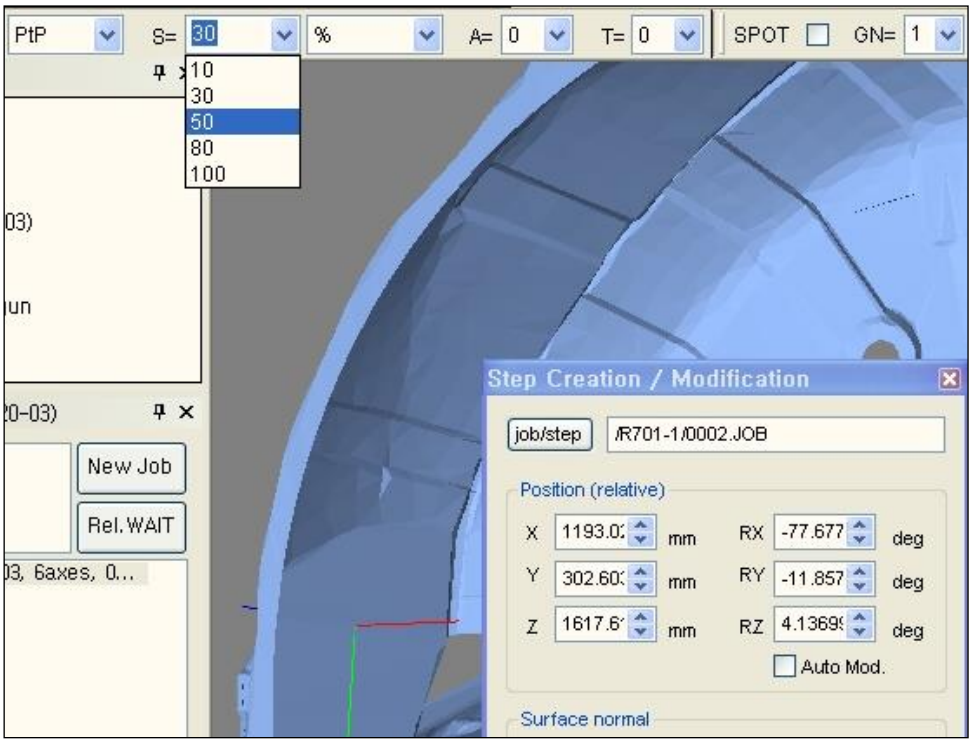
When the location is incorrect, click again and to adjust the direction, enter the rotation angle in the edit window of RX, RY and RZ.
(When you turn the mouse wheel after clicking on the wanted edit window, it increases/decreases by 10 degrees.)
(Location value, that is the value of X, Y and Z in the edit window can be directly edited with the keyboard or mouse wheel.)

If you want to create a step so that the specific axis is vertical to the surface automatically, select the use check box of surface normal and select X, Y or Z.

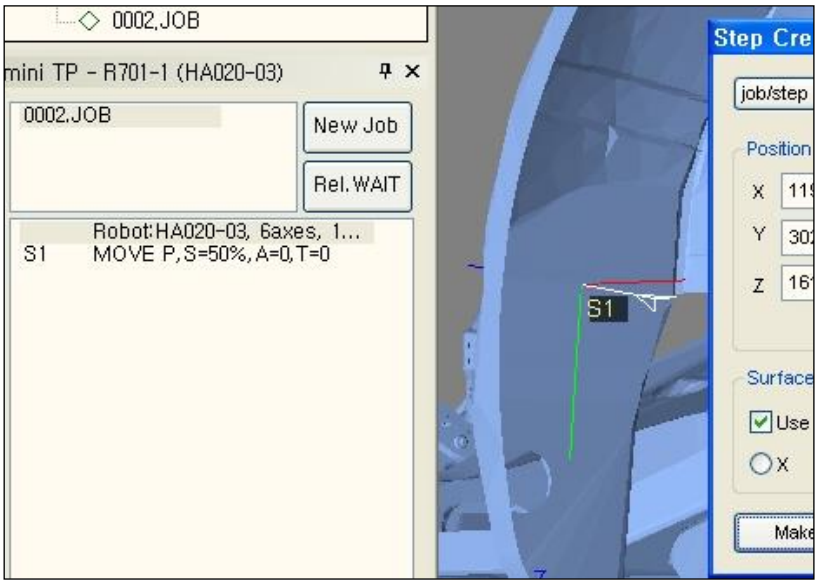
When you click on the surface in this condition, you can see the step indicated with the selected axis vertical to the surface.
If you want to change the direction of the vertical axis by 180 degrees, press the Inverse button.
(If you want to continuously apply the inverse direction, check the Inverse check box.)



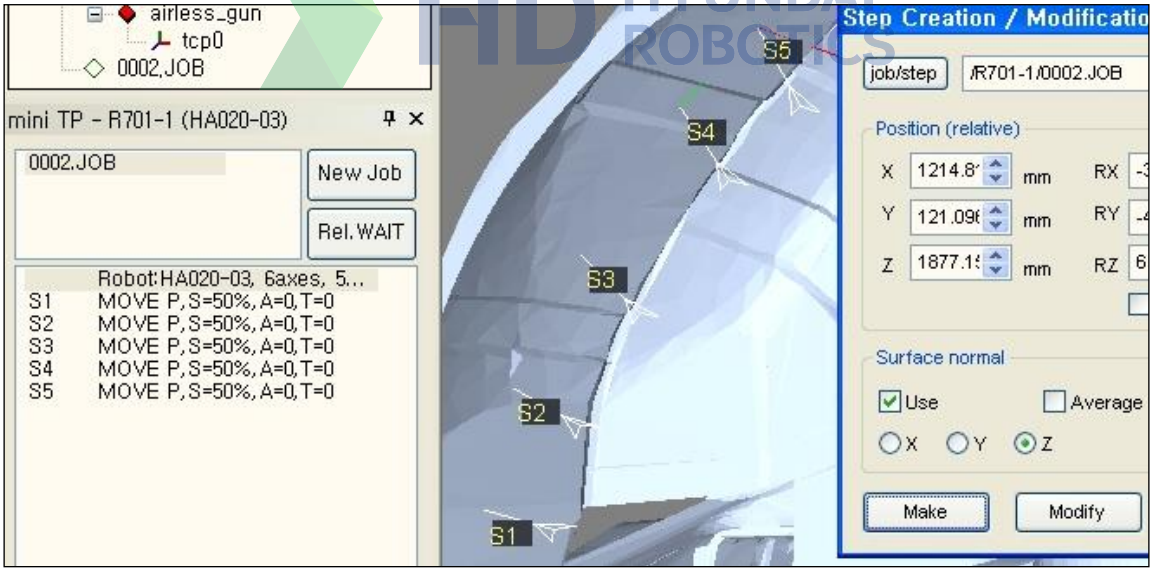
Set the parameter of the step to create in the teach bar.



Now, click on the create button to create a new step at the end of the designated job.



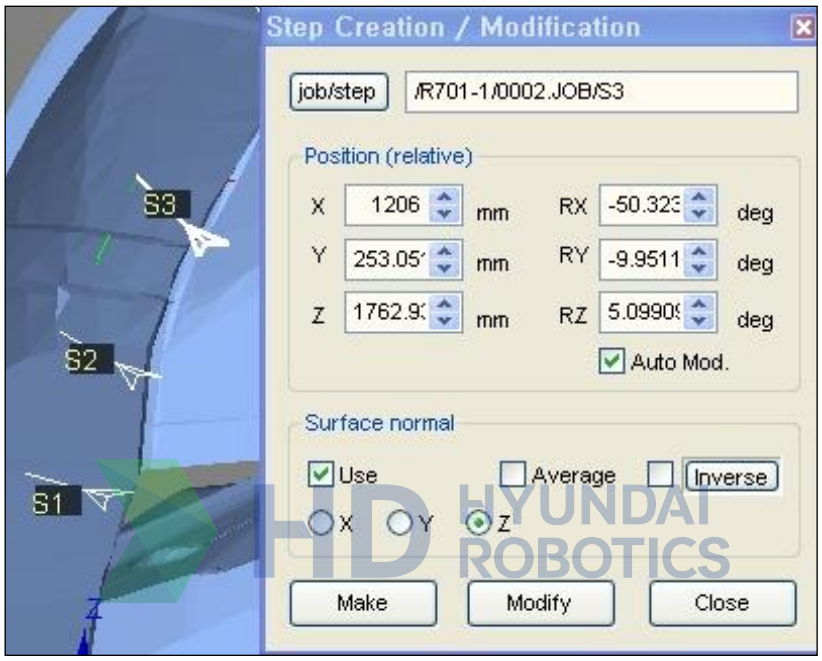
Try creating other steps on the surface of the chassis floor with the same method.



Steps that are displayed in red mean the robot can't do this pose. In order to modify this, press iob/step button, click the steps in red on 3-D space, to enter T path in the dialog box.
(Or you can directly enter with the keyboard.)

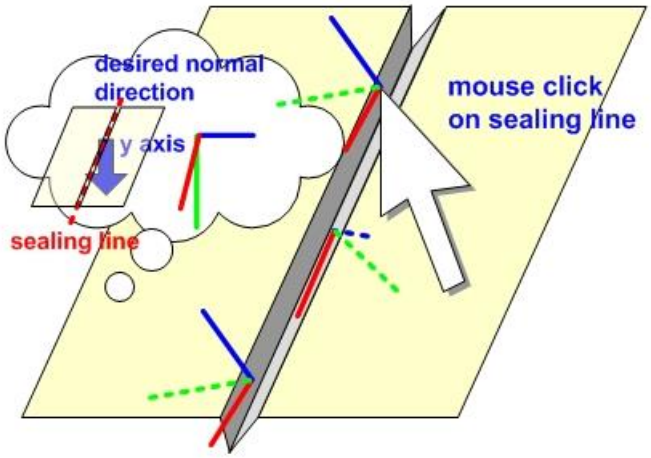
Now, click on a new location and click Modify button. Or if you adjust the spin control of a location edit box (it's convenient if you use a wheel on a mouse) after checking Auto Mod. check box, then you can easily find the location that is changed to white because the step location is immediately changed.

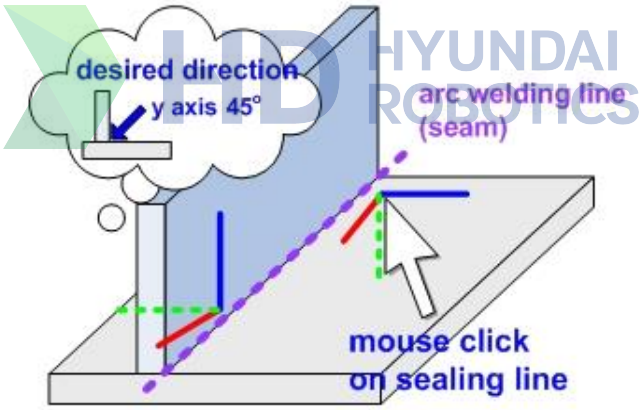
(The edit only affects location/direction. The set parameter value of the current step of the teach bar is not applied.)



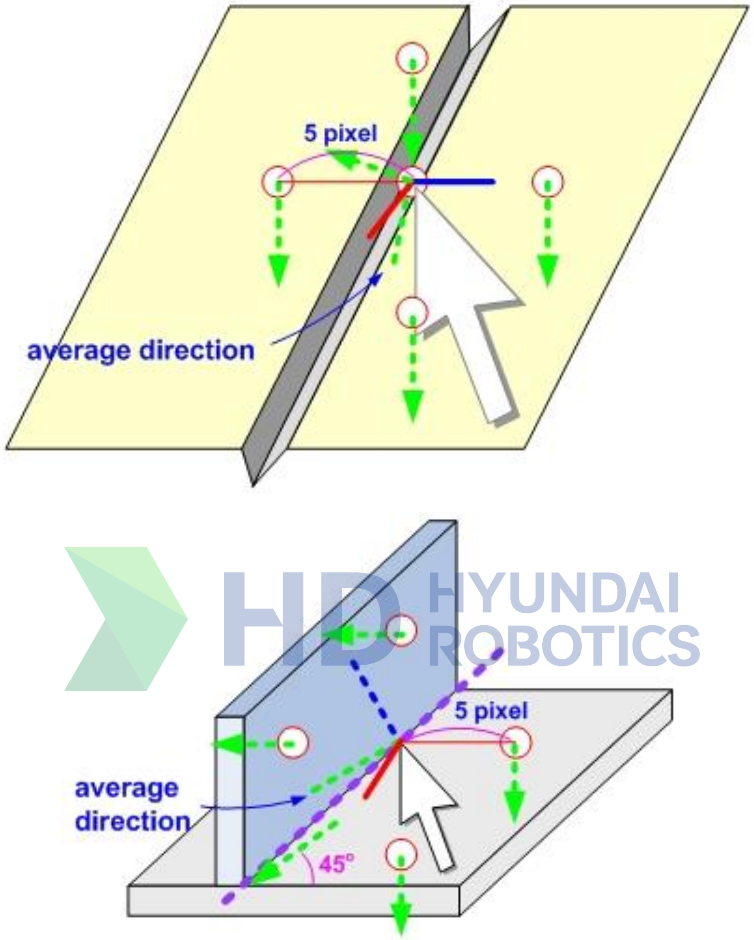
7.4.2. Average function

For sealing or arc welding, it is common to create steps on V type seam not the flat surface. When you use the surface vertical function, the direction of the step may be improper as shown below.





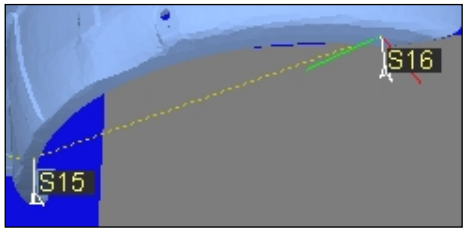
Select the average checkbox and click on surface, it will get the surface vertical directions of the clicked location and the locations apart, and make average direction of step with these 5 directions. (When you use the average function, the response to the surface click becomes slower.)



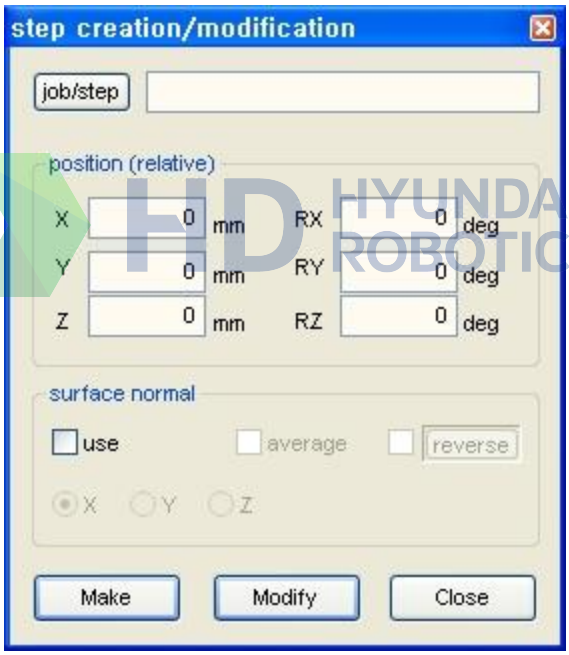
Sometimes when the direction is inappropriate even by using the average function, manually modify it.

7.4.3. How to Insert another Step in Between Steps

For example, let's assume that you need to insert several steps between two steps S15 and S16 as shown below.



First open the "Step Creation/ Modification" dialog box as shown below and click on job/step button. Then click on S15 from the tree window to enter the T path in the edit box.



Now, click on the desired chassis as you did before and click on the create button. You can see that a new step named S16 is created/inserted after S15. The existing step S16 now became S17.

Another thing to note is that the T path in edit box is automatically converted from S15 to S16. That is, it prepares for S17 to be inserted next.

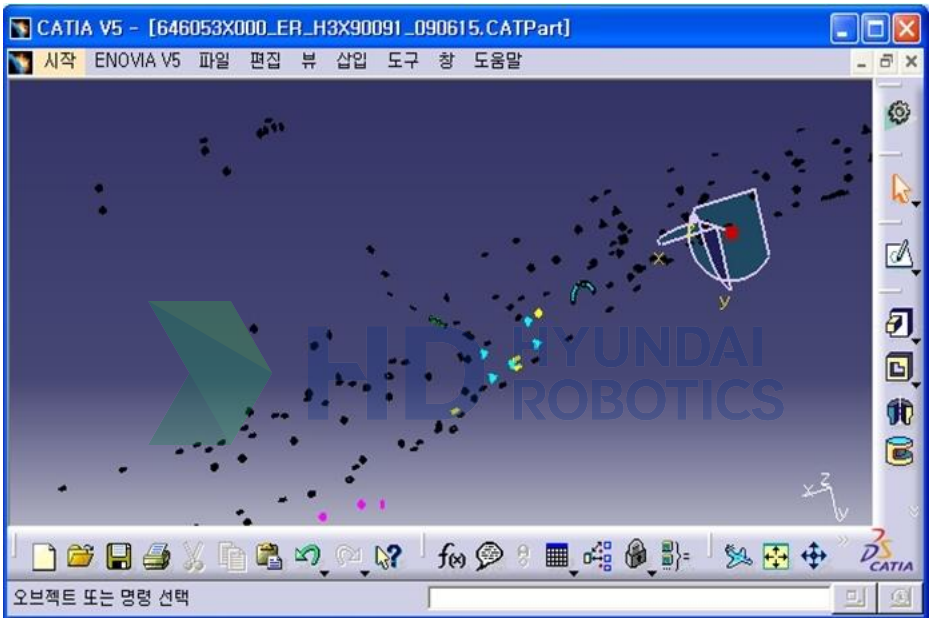
Now create 3 more steps in the same method. Insert the steps in the following order. The T path of the edit box now points to S19.

7.5. Import teach point and location group

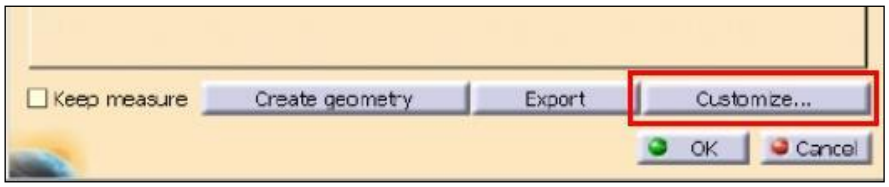
You can set up the direction to be vertical to the surface of an object by importing mass teach location data from CAD data. (It's only available for data exported from CATIA V5.)
And steps also can be distributed properly by using a mouse when the work should be done by several robots.

First, below is how to extract welding points in CATIA V5.

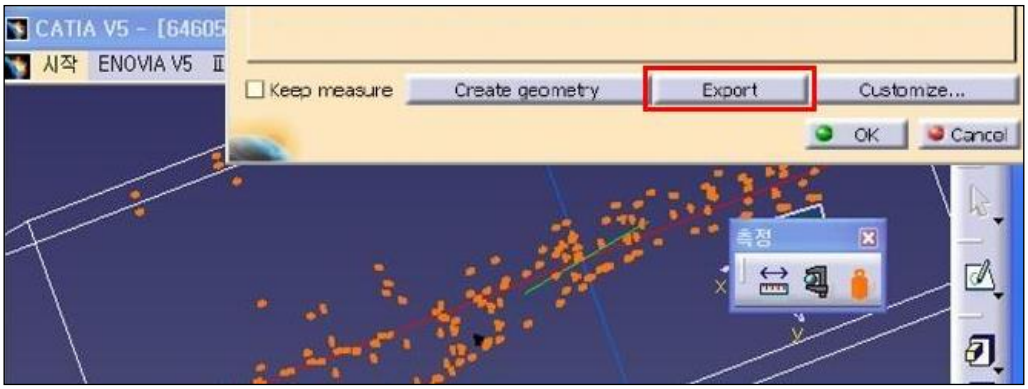
Hide parts except welding points.



Select Measure Inertia/Customize...



Drag the whole welding point area, click Export button, and select a file name.



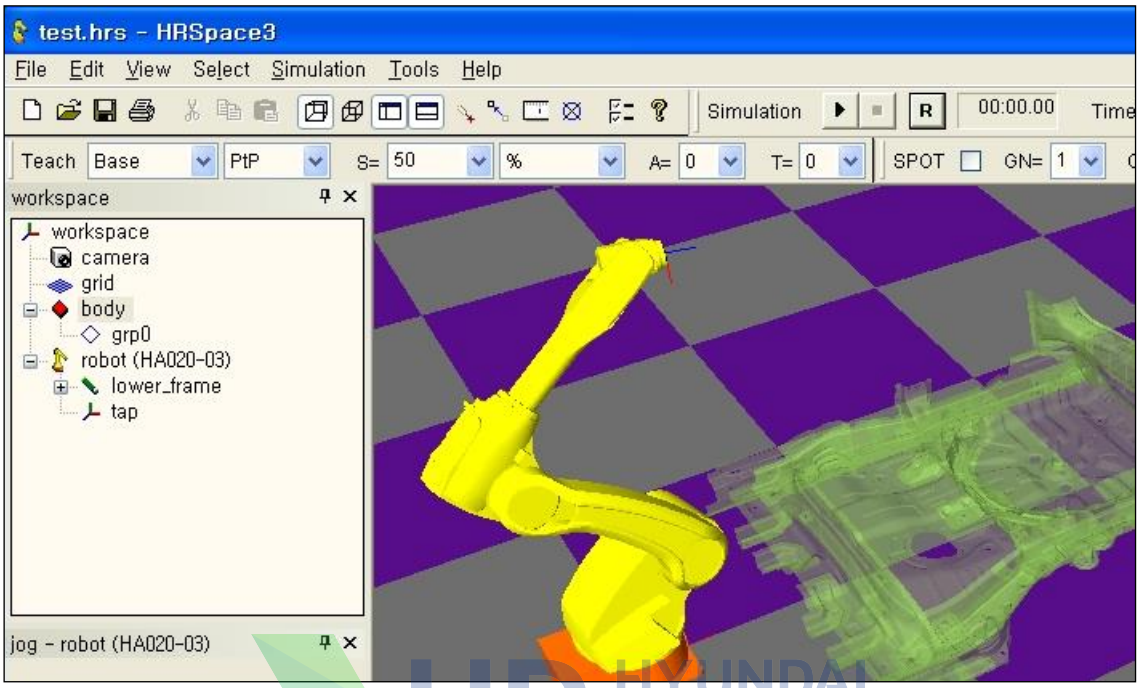
It generates a text file as below. (Only X, Y, and Z teach locations are extracted.)

weld_points.txt - 메모장

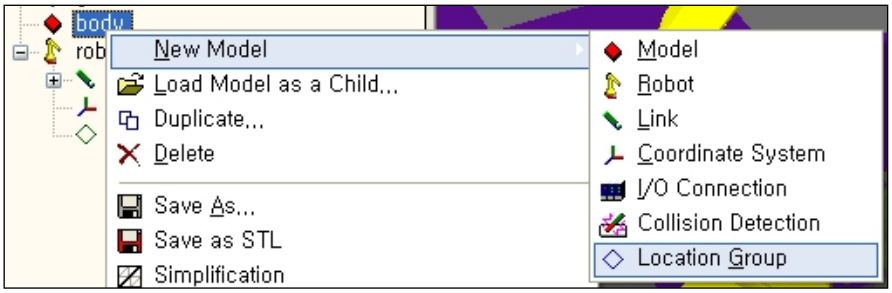
파일(F) 편집(E) 서식(O) 보기(V) 도움말(H)

```
프로덕트 :      MultiSelection
날짜     :      금요일, 10 12월 2010 16:03:59
작성자   :      hhi
-------------------------------------------------------------------------------------------------------------------
Component                          | Sub-Component                    | Gx[mm]          | Gy[mm]          | Gz[mm]
-------------------------------------------------------------------------------------------------------------------
UDF_SPT_S_GN_3.83...655003W000     |                                  | 2613.974        | -259.464        | 176.408
UDF_SPT_S_GN_2.213...655003W000    |                                  | 2586.095        | 234.365         | 176.422
UDF_SPT_S_GN_2.302...655003W000    |                                  | 2650.255        | -288.258        | 169.705
UDF_SPT_S_GN_2.217...655003W000    |                                  | 2721.551        | -372.440        | 229.757
UDF_SPT_S_GN_2.219...655003W000    |                                  | 2547.267        | -425.007        | 243.000
UDF_SPT_S_GN_3.85...655003W000     |                                  | 2529.338        | -339.510        | 242.950
UDF_SPT_S_GN_2.222...655003W000    |                                  | 2462.649        | -267.553        | 246.727
UDF_SPT_S_GN_2.301...655003W000    |                                  | 2650.255        | 288.258         | 169.705
UDF_SPT_S_GN_2.226...655003W000    |                                  | 2721.551        | 372.440         | 229.757
```

Suppose there're work space that has a robot and a body shape comes from CATIA.

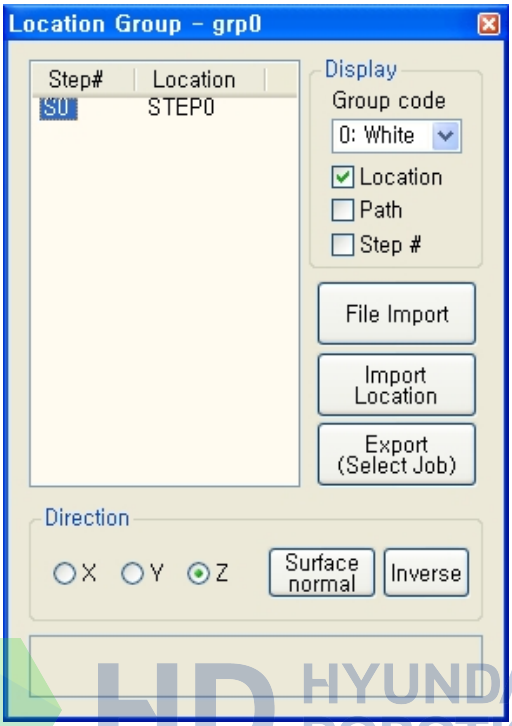


Click the right mouse button on the body and create a new location group.

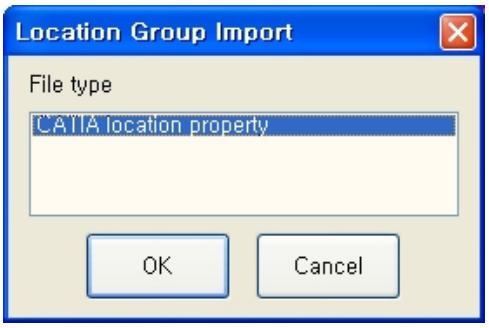


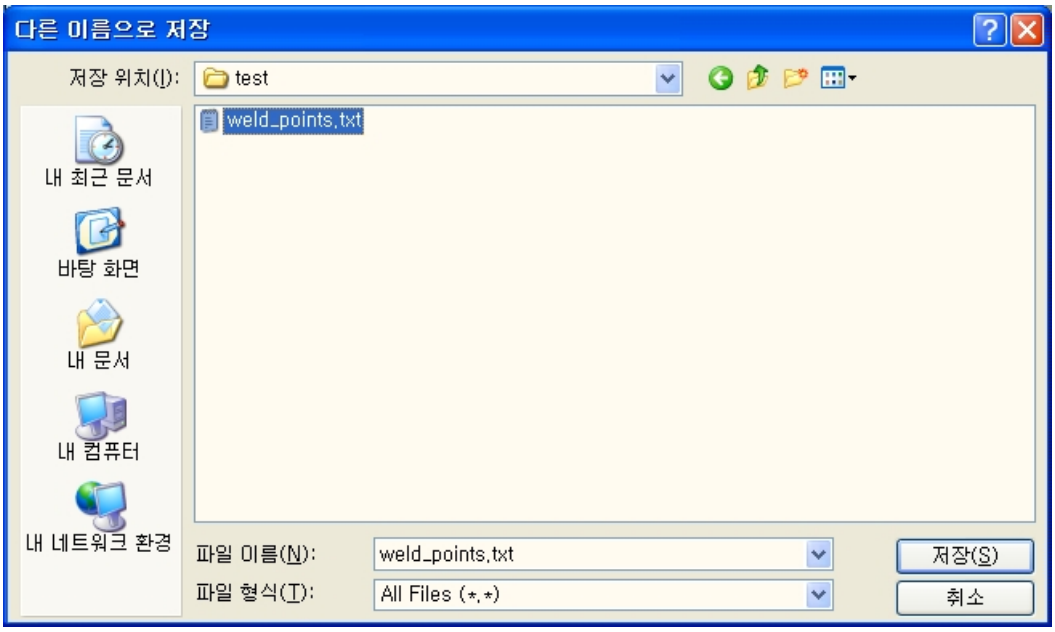
Assign a name to the created group, open popup menu, and click Location Group Properties…

Location Group Properties dialog box is open as below.

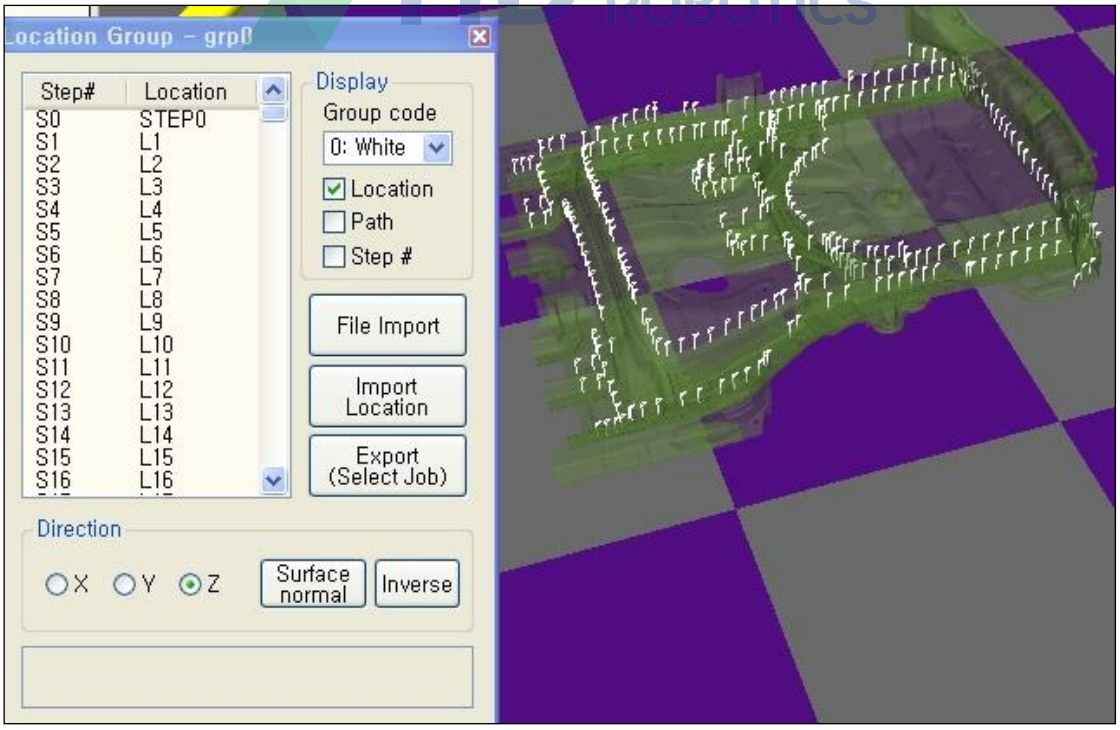


First, click [File import] button, select CATIA file type, and specify teach location data that are prepared.

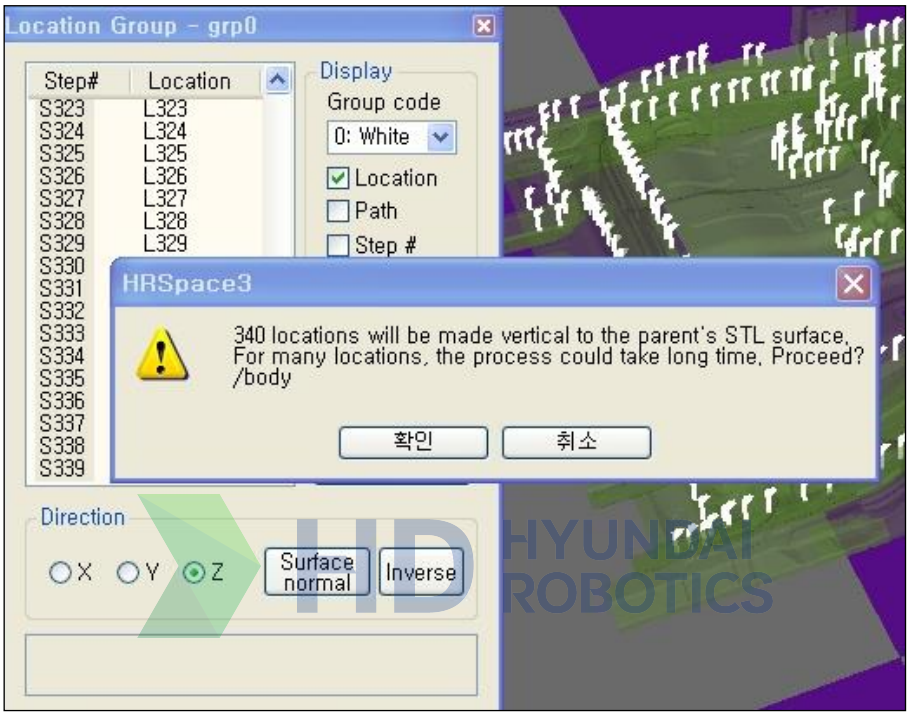




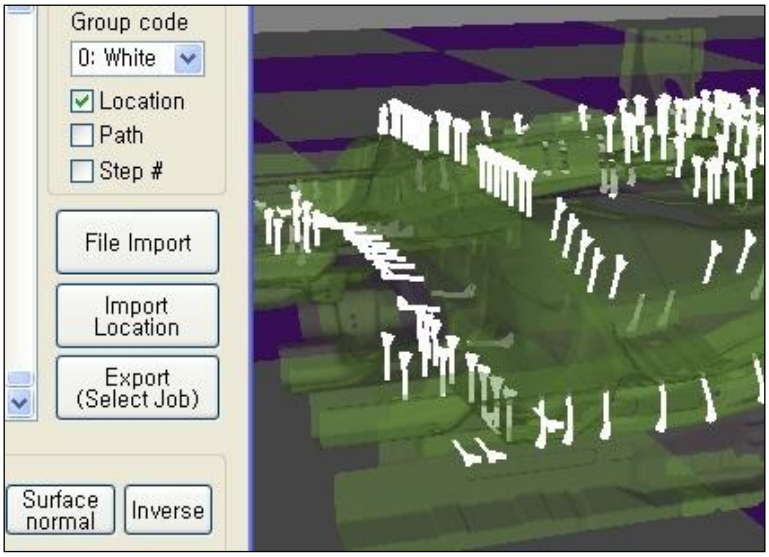
Teach locations are created on the body as below. The teach location model that is created with this method is called Location and its set is called Location group. Locations and Step look very similar but Location only has location/direction/order and doesn't include various parameters and functions.



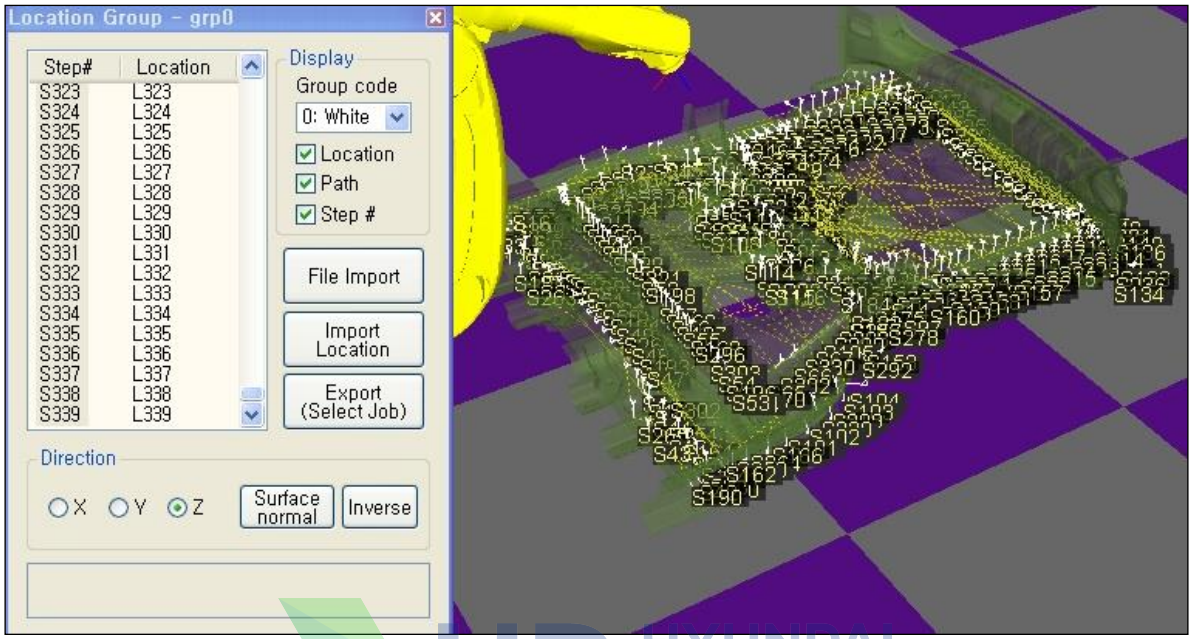
Data exported from CATIA only has teach location and doesn't have direction. If you want to make locations be vertical to the surface of parents' body, select locations that you want to modify and click [Surface normal] button. (You can click step # from Step # in the left box of the dialog box or select it from a 3-D screen. Use [SHIFT] key or [CTRL] key together to select several locations at a time.) You can adjust the axis to be verticalized if you select a radio button for X, Y, or Z in advance.



Below is the result after verticalizing. Since the parents of location grp0 are a body, surface of the body is used as a base. If directions of some locations are inversed, you can inverse them by selecting them and clicking [Inverse] button.

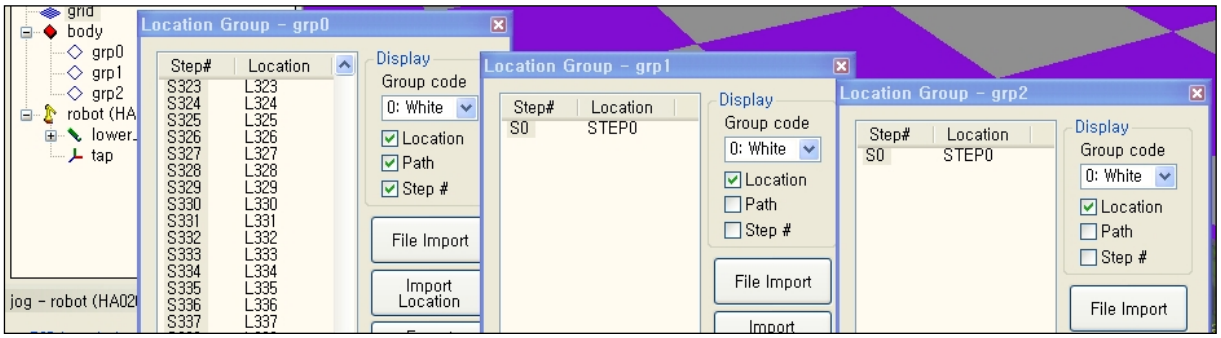


You can also display path and step # if you check the check boxes for them of Display group in Location Group dialog box.

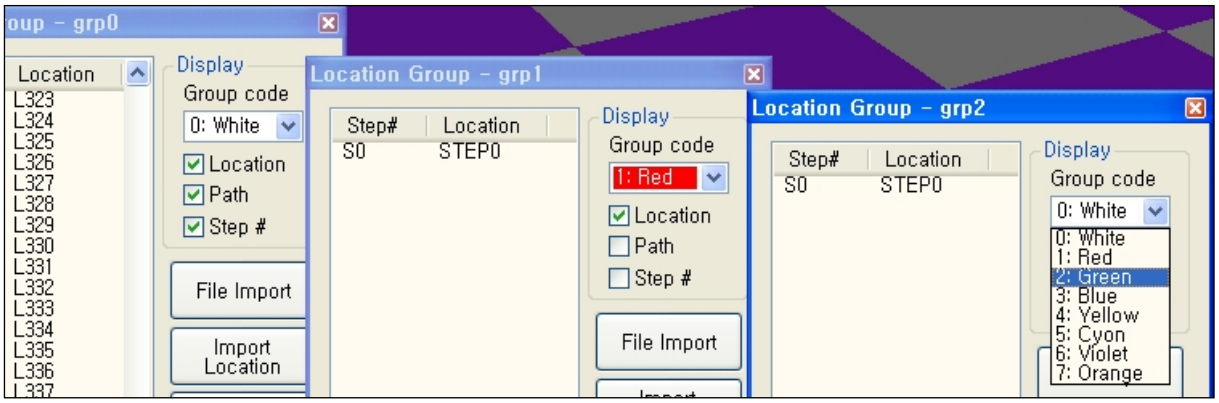


In the picture as above, the locations are widely distributed and the order is very complicated for one robot to do the work. Let's distribute the work to 3 robots and make the order better to do the work.

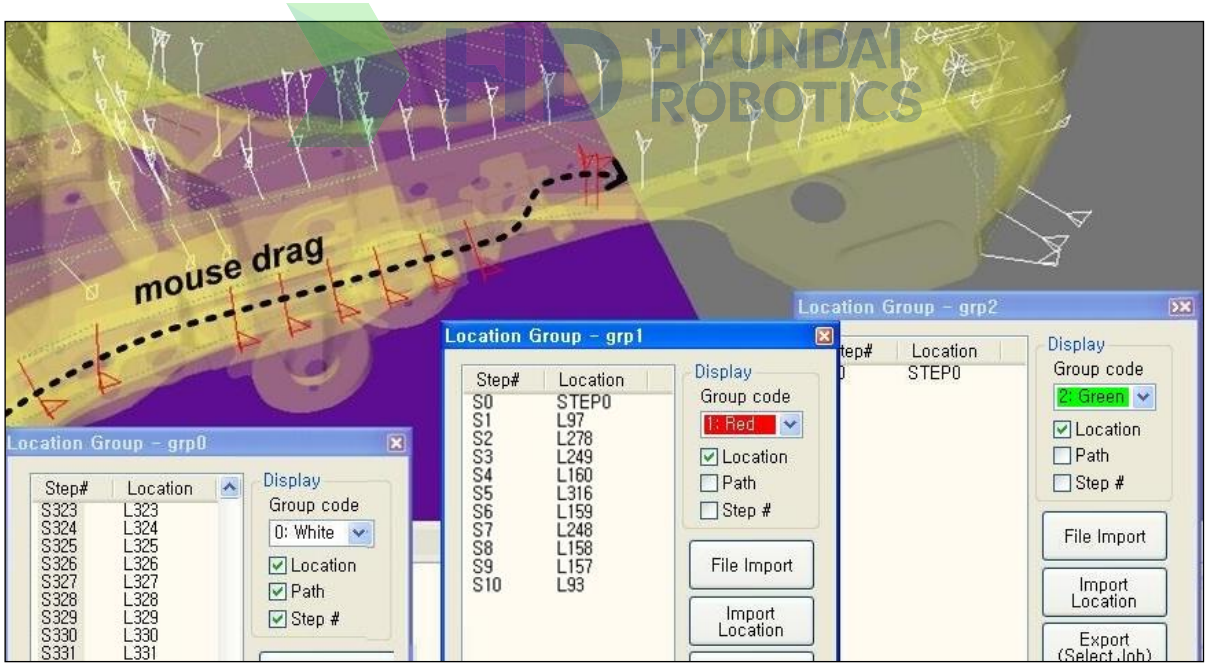
Add 2 location groups as children to the body and open Location Properties dialog box for each group.



Use different colors to distinguish the two groups.

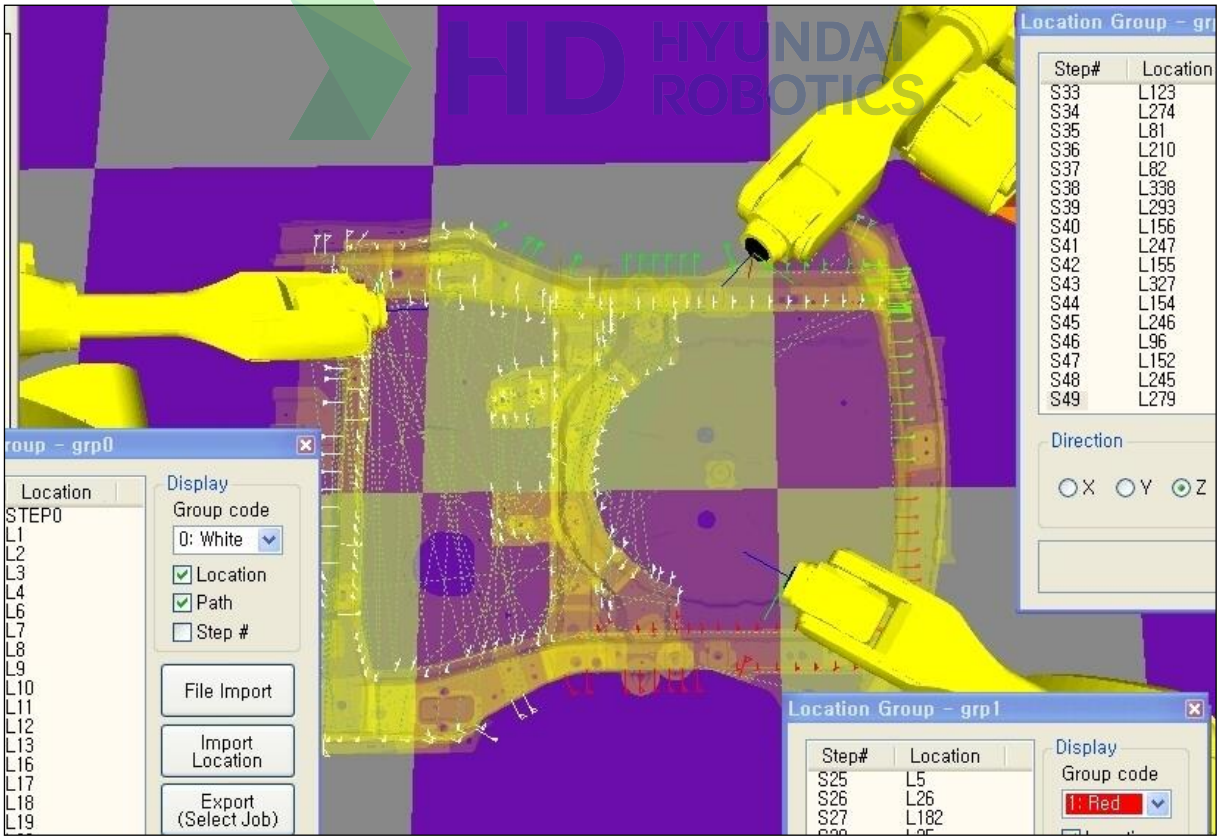


Click [Import Location] button from grp1 dialog box and drag target locations on a 3-D screen by keeping pressing the left mouse button. Locations in white have been changed to red and a path is created according to the order that is dragged. You can see target locations in grp0 list box are moved to grp1 list box.

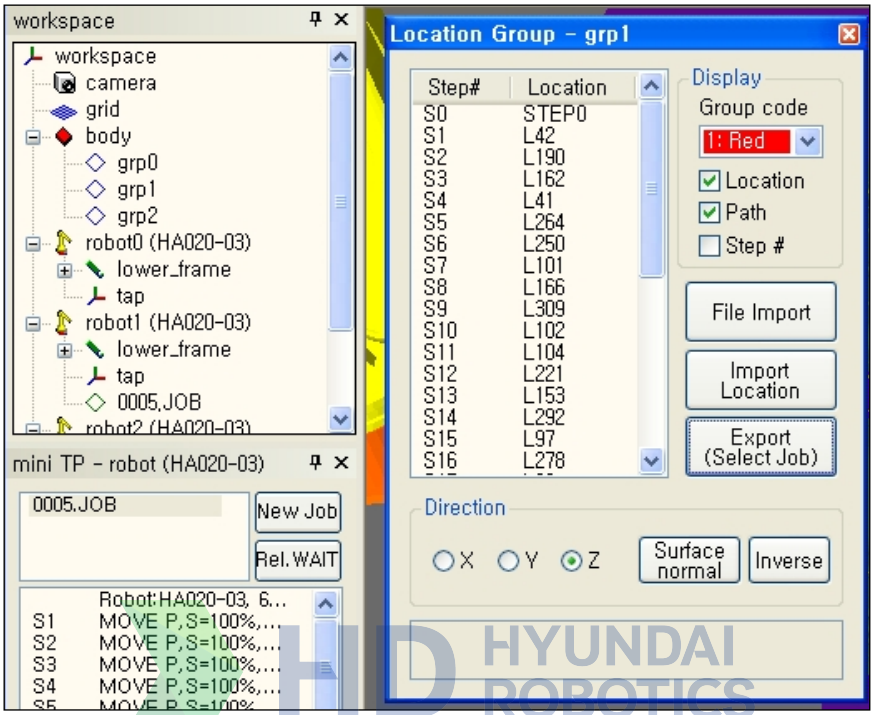


If you select one location from the list box or on the 3-D screen and drag it, it is inserted to the next location that you select. By applying this, locations that are already moved to grp1 can be reordered by dragging them again.

Parts of grp0 locations are moved to grp2 also in the same way.

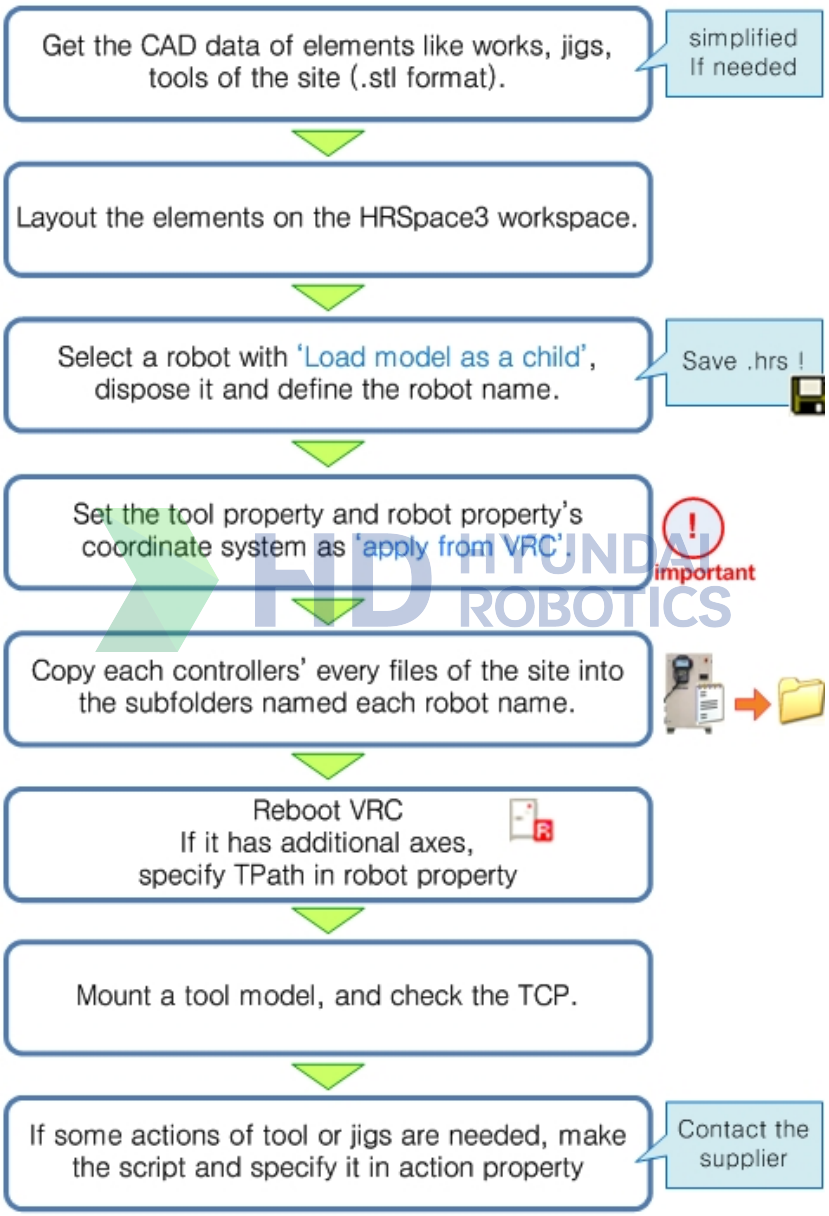


If you click [Export (Select Job)] from the dialog box and select an empty JOB program from tree window, locations are created by JOB steps that are selected.



7.6. Import onsite robot process

Do the procedure as below if you want to observe/modify robot processes that are already installed on production sites by making HRSpace3 simulation.

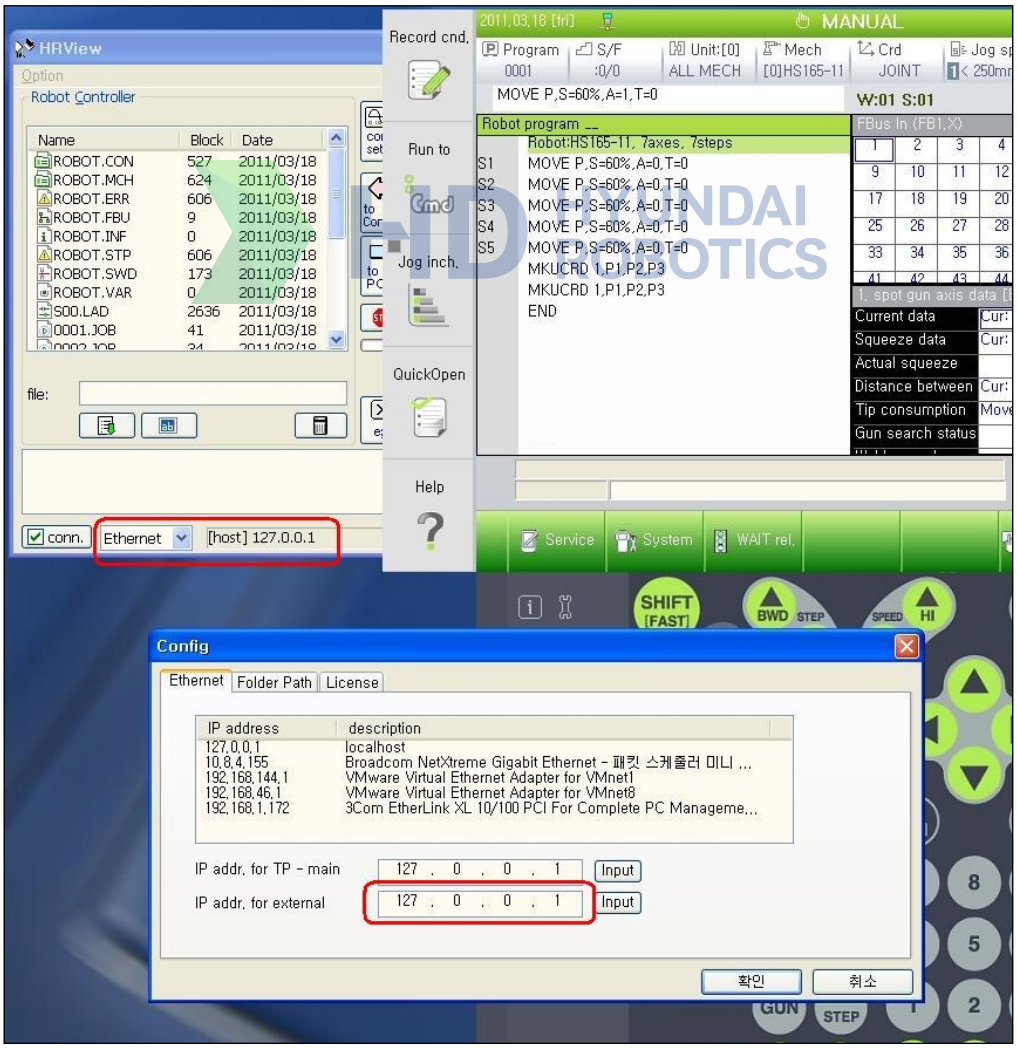


7.7. Connect HRView and HRLadder

HRView and HRLadder can be connected to HRSpace virtual controller in the same PC. (It can also be done in different PCs. In this case, the 2 PCs should be connected via Ethernet.)
Communication between support software and the virtual controller is only done via Ethernet device and doesn't support RS-232C.

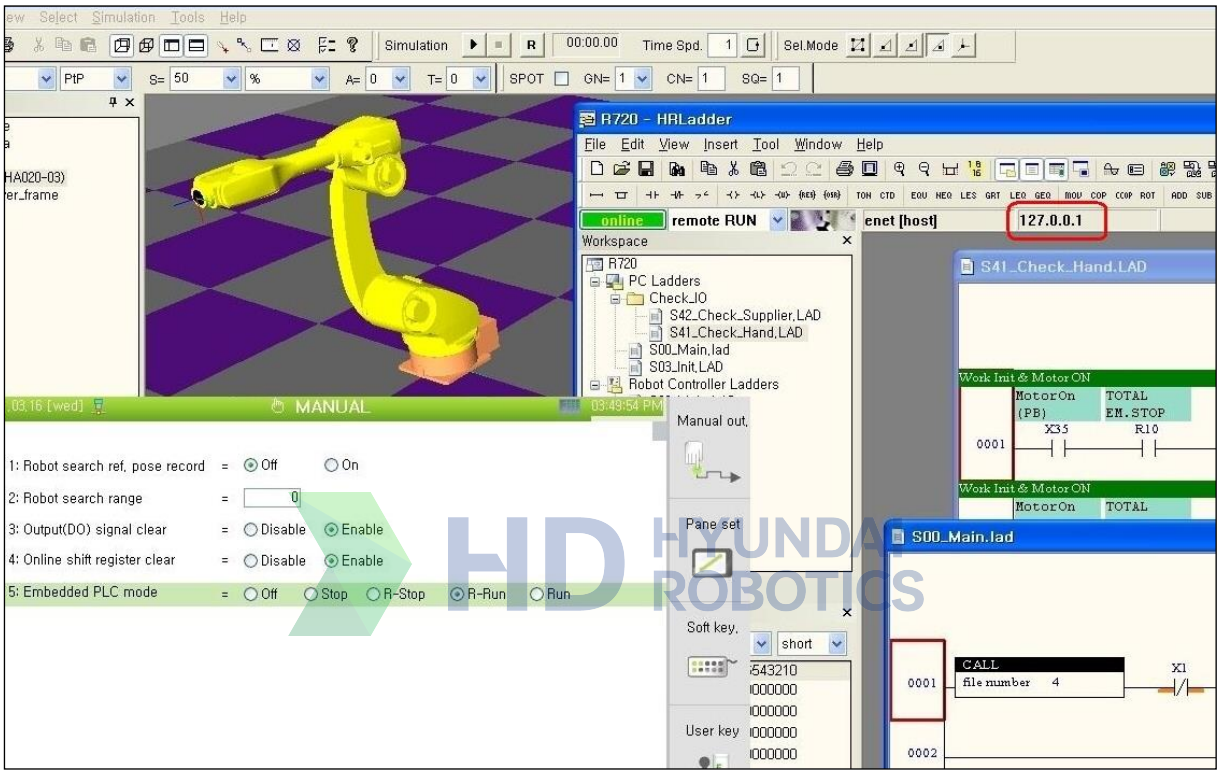
A picture as below is an example that HRView and a virtual controller are connected in one PC. It shows all back up controller files from onsite copied to a virtual controller via HRView.

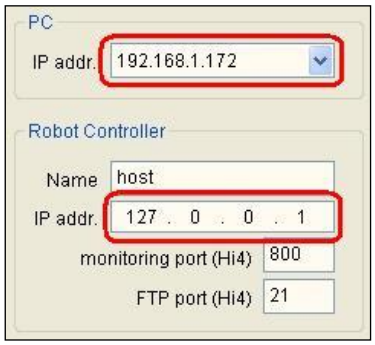
"IP address for external" of virtual TeachPendant should be the default value, "127.0.0.1". (127.0.0.1 is the standard IP address that represents local host (i.e. this computer).
For HRView, don't change the exiting IP address of PC and let "127.0.0.1" be IP address of a robot controller.



A picture as below is an example that do download and monitoring by connecting HRLadder to the virtual controller of HRSpace3.

For HRLadder, don't change the exiting IP address of PC and let "127.0.0.1" be IP address of a robot controller.



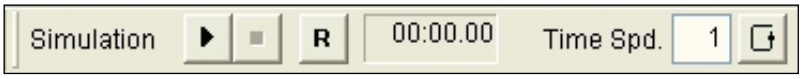


HYUNDAI ROBOTICS

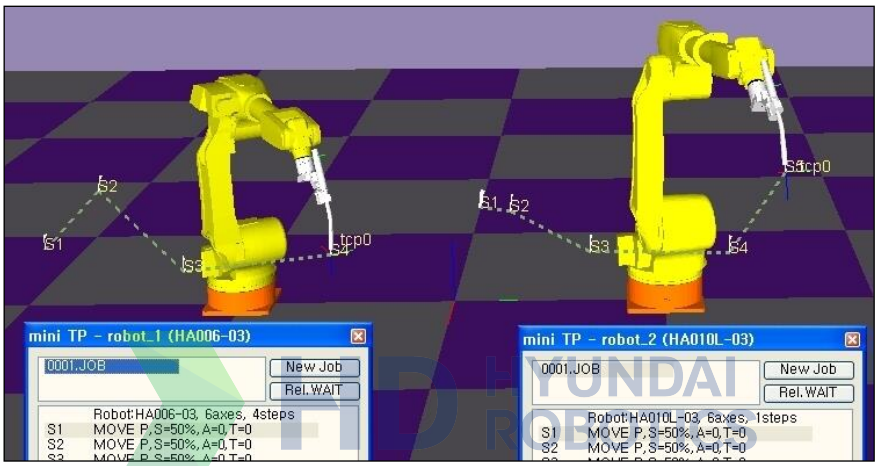
8 Simulation

8.1. Simulation

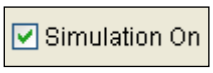
You can simulate 1 or multiple robots by using the simulation bar.



For example, if the 2 robots below were taught respectively, let's try to playback the robots simultaneously.

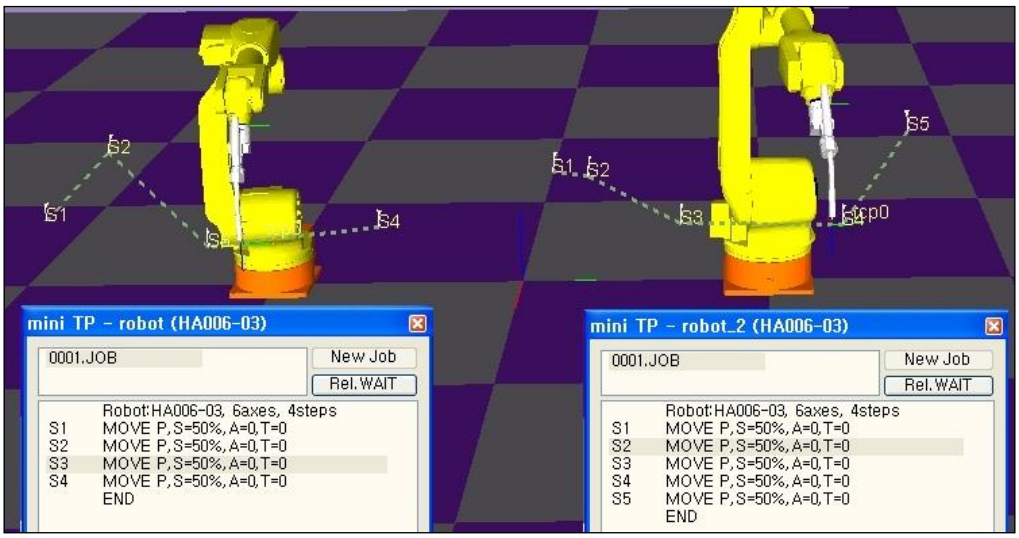


The simulation option must be check in the model properties of each robot.

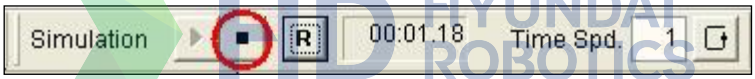


First, click on the reset button of the simulation bar to initialize the robot.

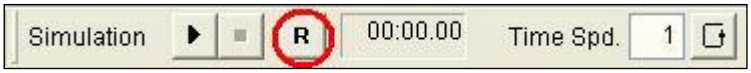
When you click on the playback button, the timer will operate and the two robots will playback simultaneously.



When you click on the stop button, the robot stops playing. When you click on the playback button again, the robot continues to playback.
Simulation stops when all robots' work is completed and you can check the total cycle time on the simulation bar.

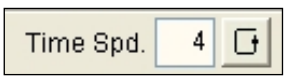


When you want to start the simulation from the start, click on the reset button and initialize the robots.



If you want to repeat the simulation cycle, click on the repeat button and then click on the playback button. This button is a toggle button.

Increase the number of Time Speed if you want to play simulation fast. (The virtual time and actual time is the same if you use the default value, 1. If Time Speed that you enter exceeds the performance of a PC, it plays the simulation with the highest available speed.)



8.2. I/O signal

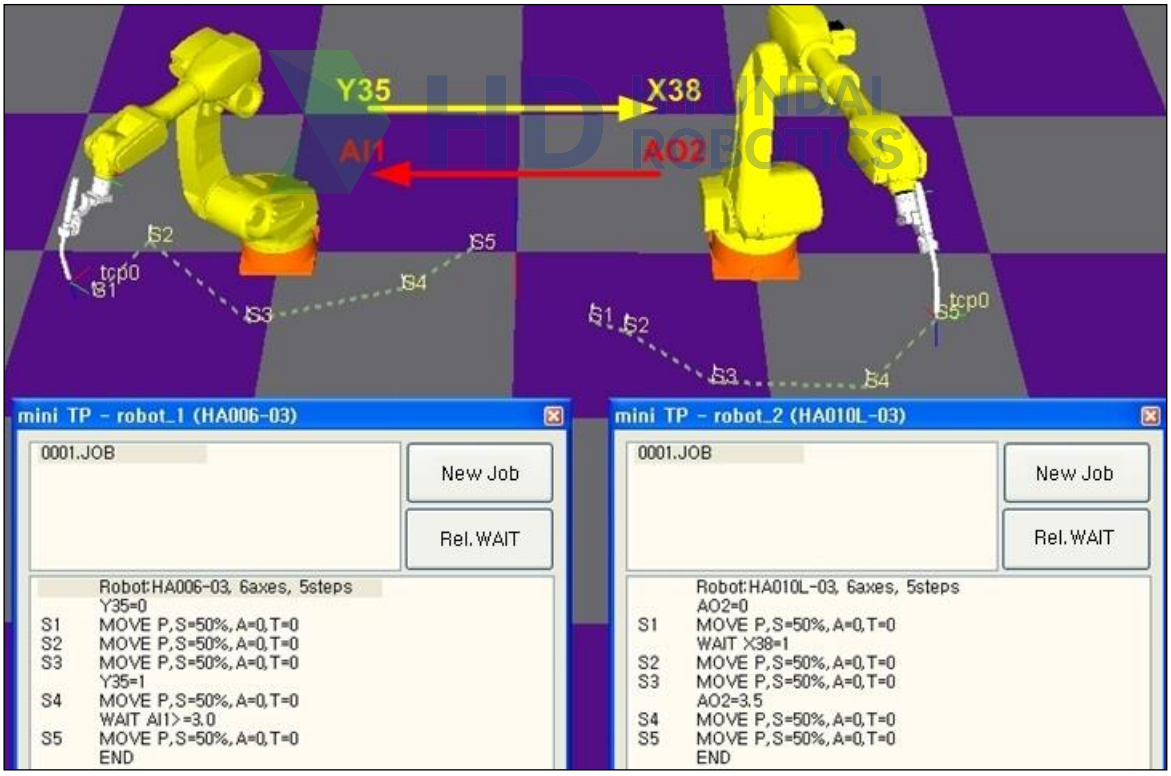
In HR-BASIC, there are commands to output or wait digital / analog signal. The operation of this command can be simulated.

Let's assume the following for each of the robots for the 2 robots.

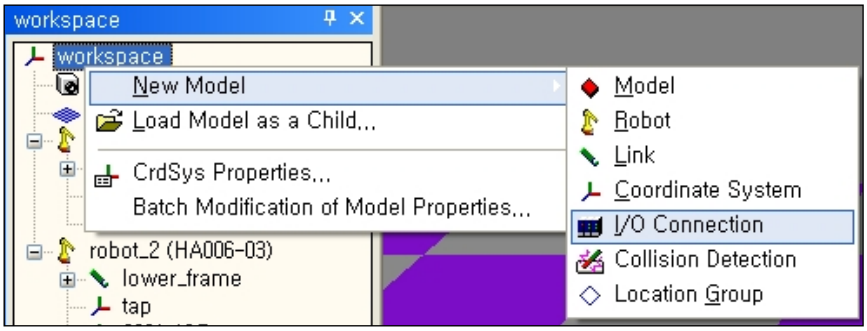
- Robot1 outputs the DO25 signal in 1 when it reaches step 3.
- DO25 signal of robot1 is connected to the DI32 signal of robot2.
- Robot2 wait for the DI32 signal to change to 1 in step 1.

- Robot2 outputs A02 signal in 3.5 when it reaches step 3
- AO2 signal of robot2 is connected to AI1 signal of robot2.
- Robot1 wait for the AI1 signal to be 3.0 or above in step 4.

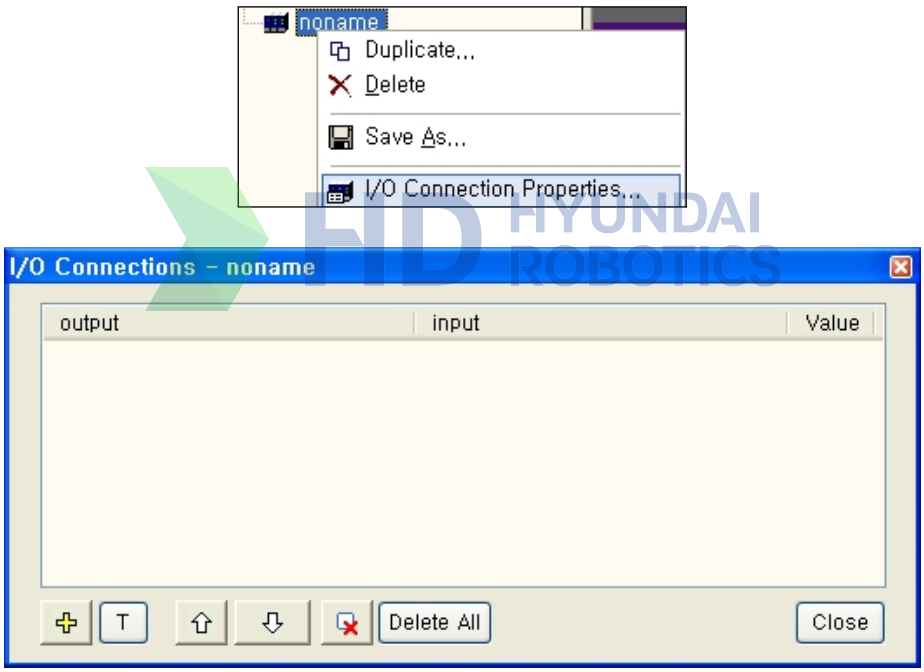
The taught results are as follows. (The arrows indicating signal connections are drawn to help your understanding.)



To connect the 2 signals, you need to create an I/O connection model for the workspace model as shown below.

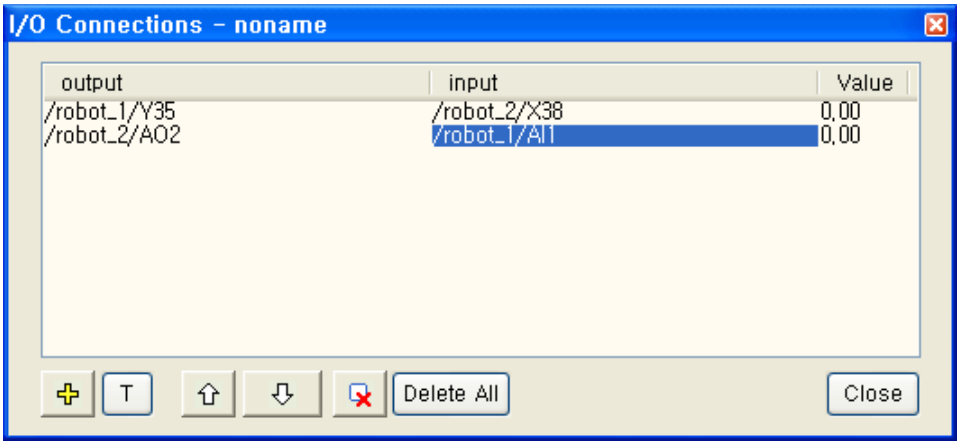


When a new I/O connection model is created, the I/O connection properties window appears.

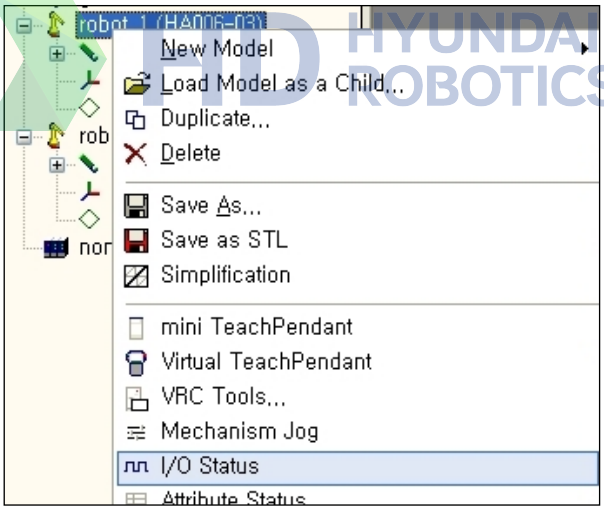


When you click on the  button, a new row will be added to the list. Enter the T path and the I/O signal name of each robot separated by the '/' as follows. (Type in after double clicking on the row. Or you can click on the T path button and select the robot from the tree window, and add the signal name.)

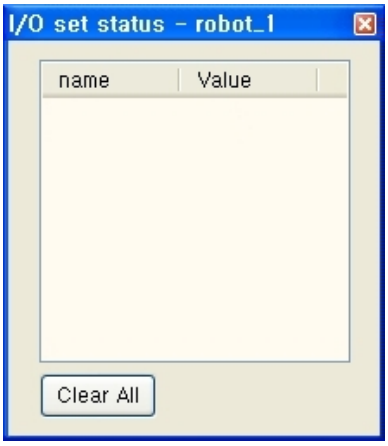
Click on the  button again and enter the second connection in the same method. The results are as follows.



Click on the  button (or close button) to close the window.
Open the individual popup menu of the two robots and select I/O status.



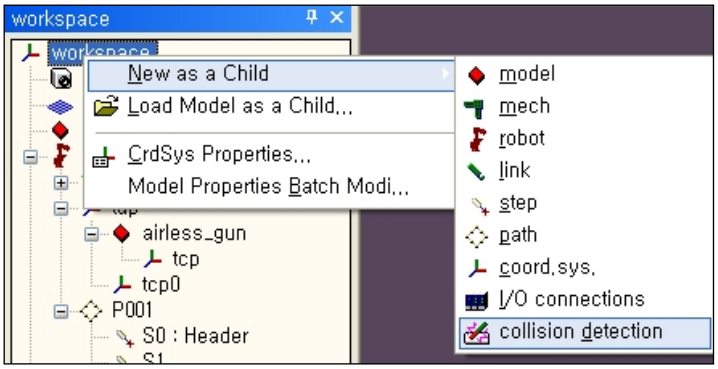
The names and values of the signal output/input from/to the robot are displayed on the I/O set status dialog box.



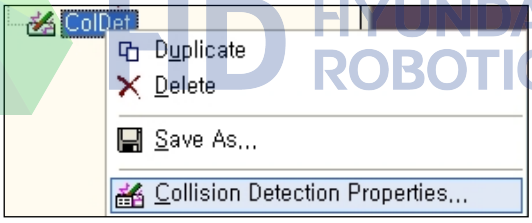
Now, play the robot and observe whether the waiting signal is done properly.

8.3. Collision Detection

This is a function that checks whether there're any collisions among robots, tools, works, and JIG. First you should create a collision detection model in workspace. The position in a hierarchical structure doesn't matter.

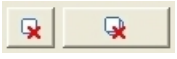


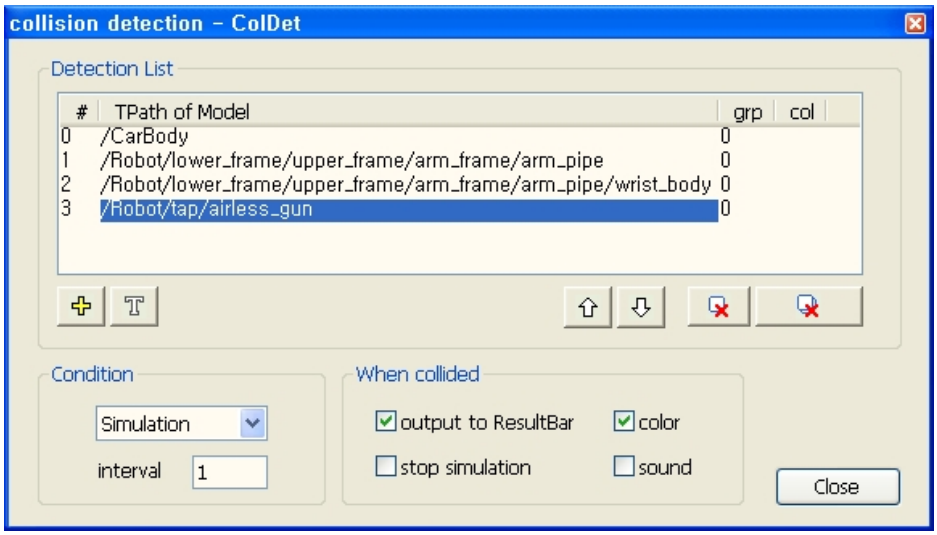
Open popup menu of a collision detection model and select Collision Detection Properties.



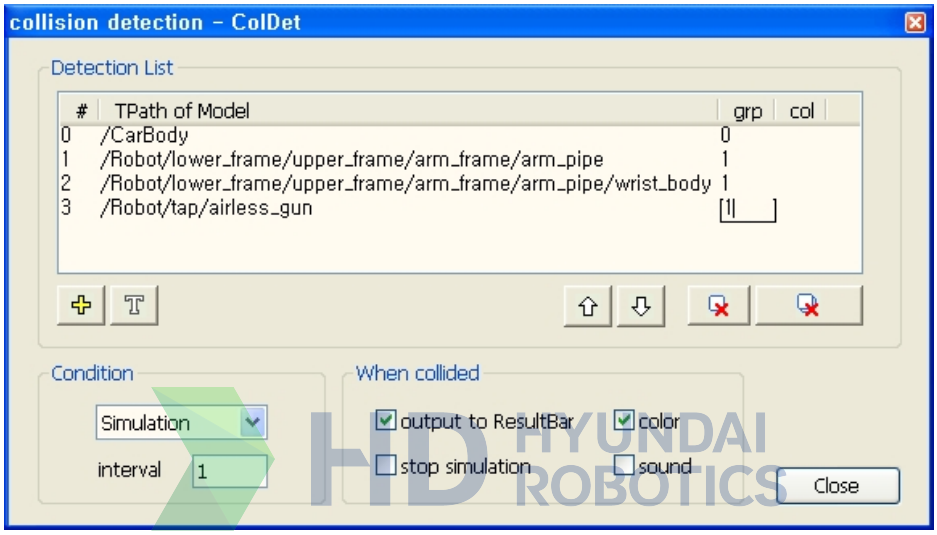
Add rows to Detection List by using  button, press  button, click nodes in tree window, and enter T path of a model that you want to check.

Use  buttons to adjust the order of items.

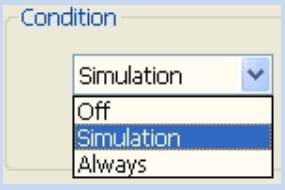
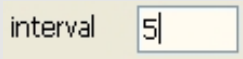
 buttons are to delete selected items and delete all the items, respectively.


collision detection – ColDet
Detection List
TPath of Model grp col
0 /CarBody 0
1 /Robot/lower_frame/upper_frame/arm_frame/arm_pipe 0
2 /Robot/lower_frame/upper_frame/arm_frame/arm_pipe/wrist_body 0
3 /Robot/tap/airless_gun 0
Condition
Simulation
interval 1
When collided
output to ResultBar
color
stop simulation
sound
Close

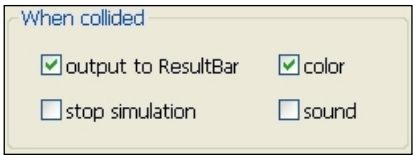
Collision detection lowers the simulation speed so it's good to enter models only that are needed.
In a model that is entered, there may be sets that don't need collision detection. In the picture as below, collision detection is not required among airless_gun (the tool mounted on the robot), arm_pipe (i.e. a robot's upper arm), and wrist_body (i.e. wrist). (They should not be checked because they are always stuck together.) If we assign same group number to this model, collision detection won't be done for this model. Use any number bigger than or equal to 0 for the group number.
The total number of items should not be more than 100 and there're no limitation in the total number of groups.

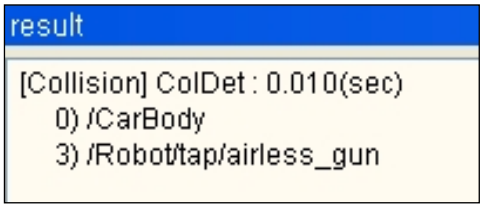
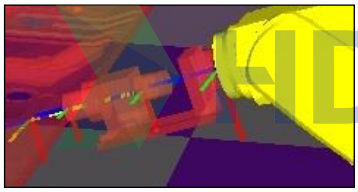


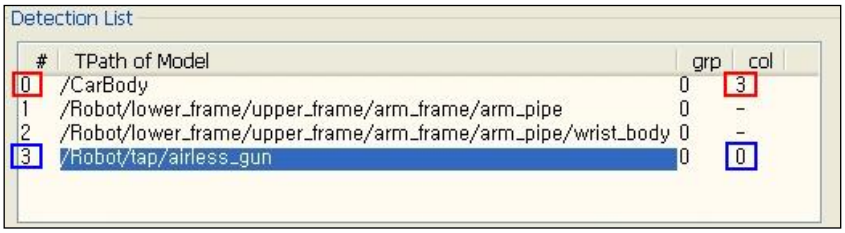
Select when you want to detect collisions in Condition.

	**OFF**	Do not detect collisions.
	Simulation	Detect collisions only when Step GO or playback simulation.
	Always	Always detect collisions such as when do JOG or layout models.
	Determine how often detect collisions. Detection requires lots of time and makes the simulation very slow or even makes it difficult to run the simulation when the scale of CAD model is large or there're many items to be detected. In this case, it gets faster if you increase a detection interval. However this may cause inaccurate results because detection is not done every time unit.	

Options as below are how to indicate collisions when they happen.



output to ResultBar	It reports T path of models whose collisions are detected in Result window. 
stop simulation	If checked, simulation is stopped when collision happens. If not checked, simulation keeps going even though there're collisions.
color	It displays models whose collisions are detected in red. 
sound	Sound effect is generated when collision happens.



If there're collisions, the collision status by model is displayed in the col of Detection List. A number other than '-' in 'col' represents there're collisions with the model in that row number. In the picture above shows a model in row 0 collides with a model in row 3.

Note	Collision detection lowers the speed of simulation or the operation because it does lots of calculations. Deleting parts (holes in bolts and internal structures) that are not needed for simulation in CAD data helps to improve the operation. Import huge CAD files after simplifying it if possible. Increase the detection interval properly if the operation of collision detection is too slow.

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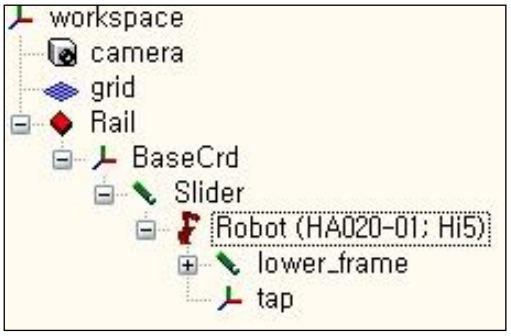
9

Teach Method and Coord.Sys. Properties

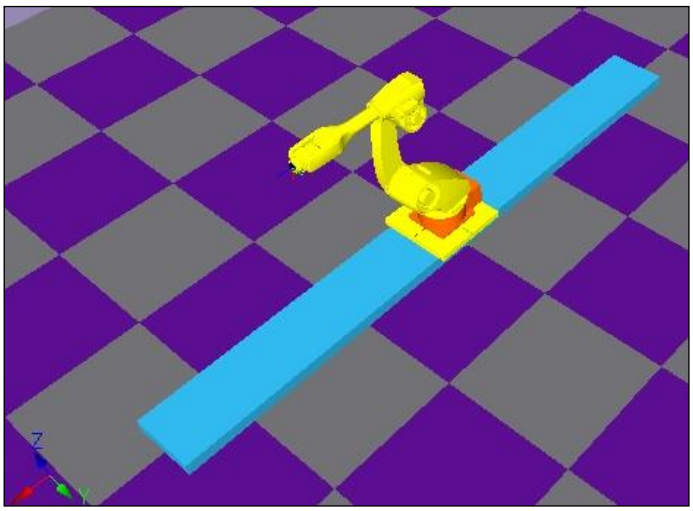
9.1. Traverse axis

You can configure and simulate the traverse axis of the robot.
First, configure the rail, slider and robot as shown below. Rail is just a model but the slider is a moving part of the robot controller and must be made as a link.



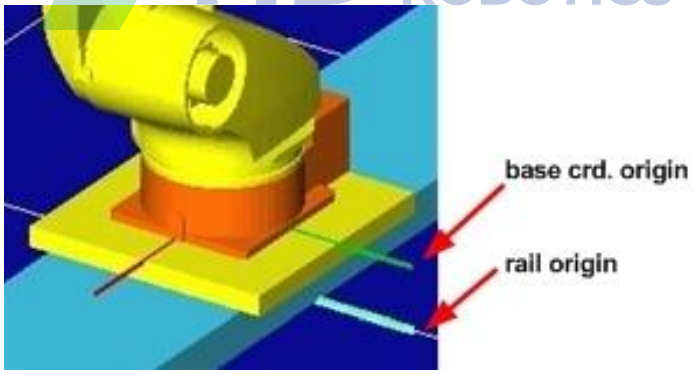
Set the properties of each rail, slider and robot as shown in the below table and attach the tool to the robot.

Name	Location			Shape parameter		
	X	Y	Z	X	Y	Z
Rail	0	0	0	5000	500	100
Base coordinate system	0	0	150	N.A.		
Slider	0	0	100	600	600	50
Robot	0	0	50	N.A.		



Base and robot coordinate system is quite matched only except X value (when moving on the traverse axis), so we aligned the origins of base coordinate system and robot coordinate system (when the traverse axis value is 0).

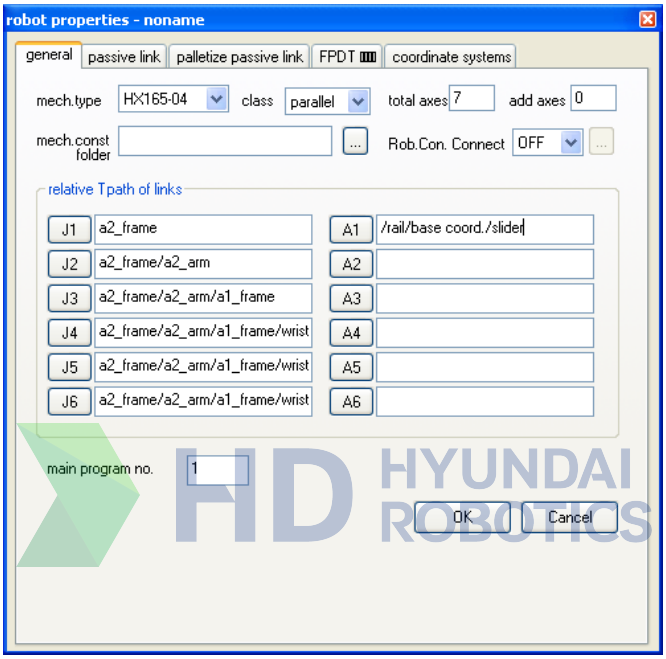
Because the origin coordinate of the robot based on the origin of the rail is (0, 0, 150), the location of the model properties of the base coordinate must also be (0, 0, 150). ((Rail height 100mm) + (Slider height 50mm) = 150mm)

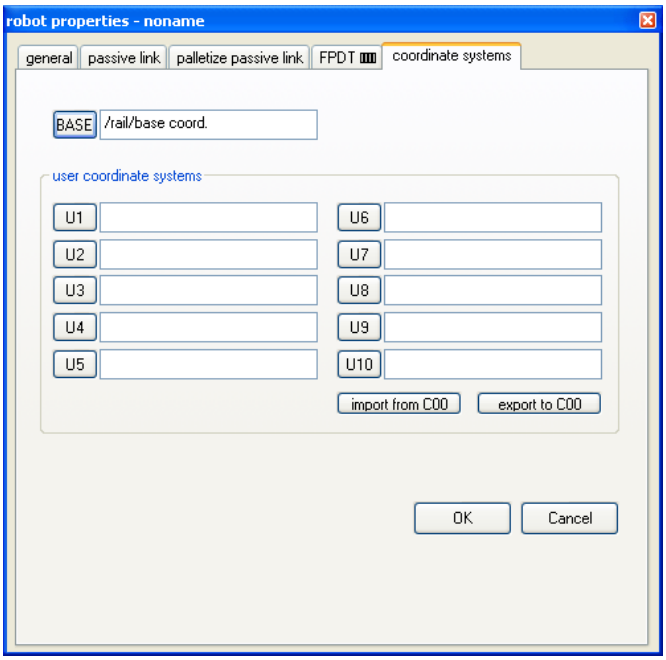


Specify the additional axis 1 of the robot as the traverse axis. Open the robot properties window.

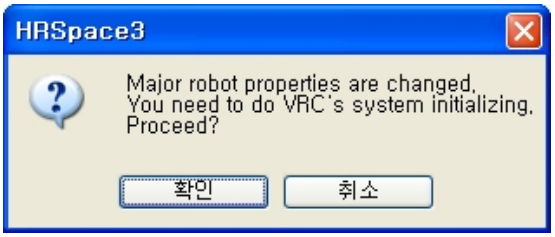
- Set the total number of axes to 7 and number of additional axes to 1.
- Click on the A1 (Additional axis 1) button and click on the slider from the tree window.
- Click on the base button and click on the base coordinate system in the tree window.

Now, click on OK to close the robot properties window.

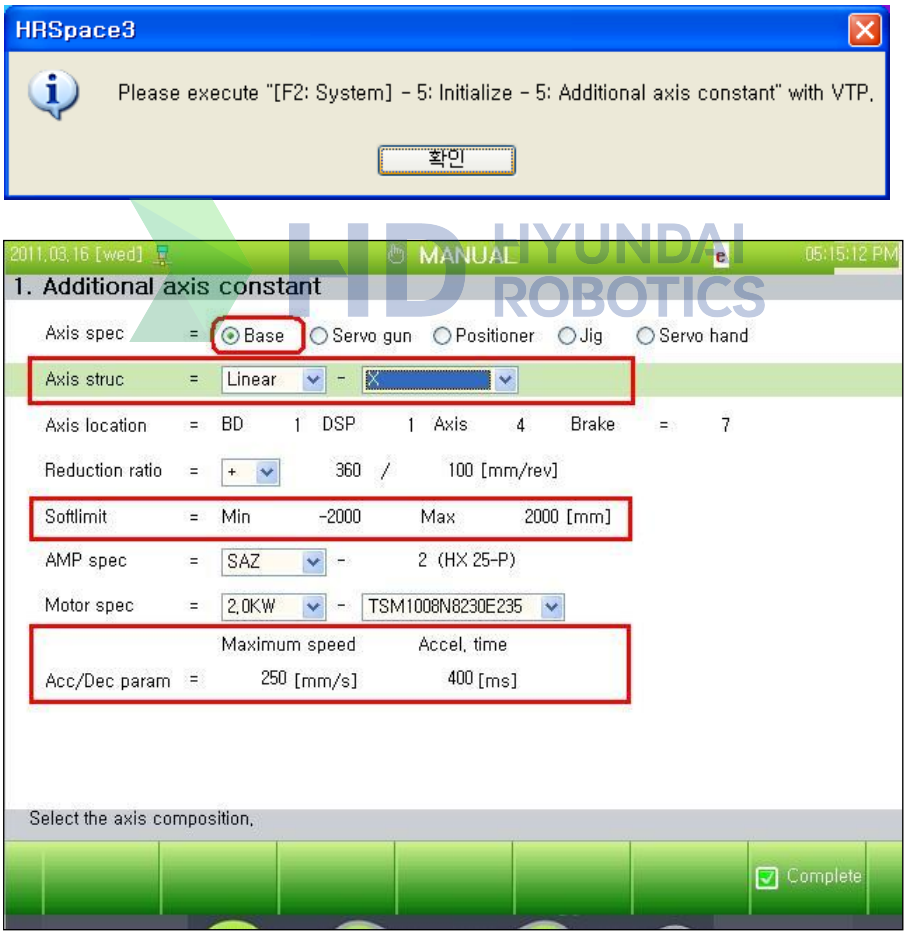




It displays a message that says you need to initialize VRC because axes are changed. Click 'OK' button.

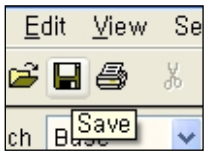


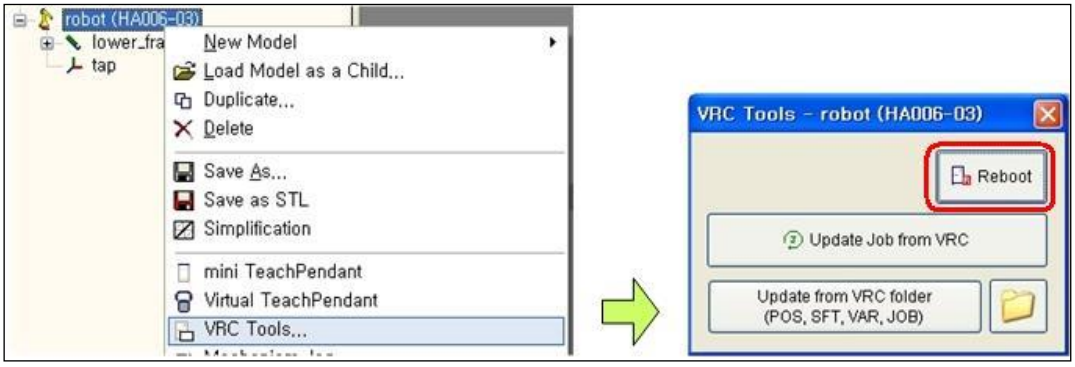
A message as below is displayed and virtual TeachPendant is automatically open. Go to the setting screen in the message and set additional axis settings of 7th axis. As you can see the picture as below, set Axis spec to Base, set 'Axis struc' to X, adjust 'Softlimit' and 'Acc/Dec param' appropriately, and press [F7: Complete] key.



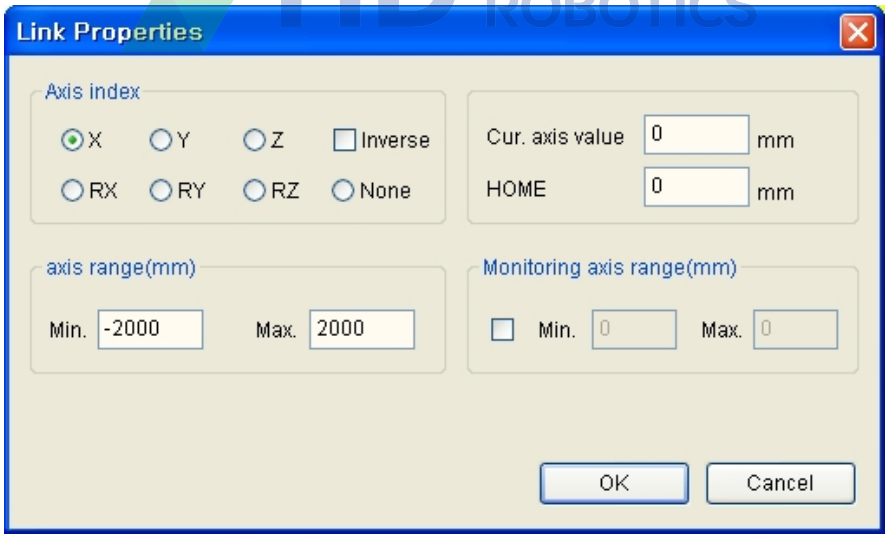
Save the document and reboot VRC to apply the settings.

In order to apply the setting, save the document and reboot the VRC.

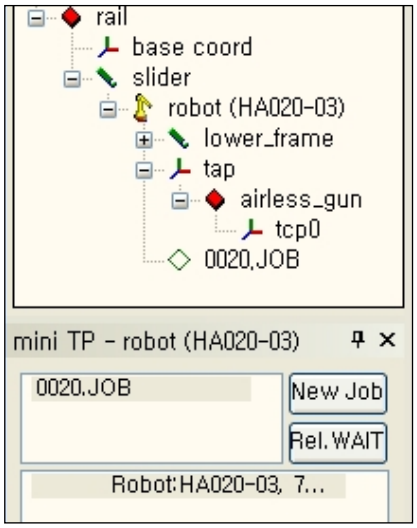




Open Link Properties dialog box of a slider. Since the robot should move to the left and right along with X axis, set Axis index to X and set the range of the axis.

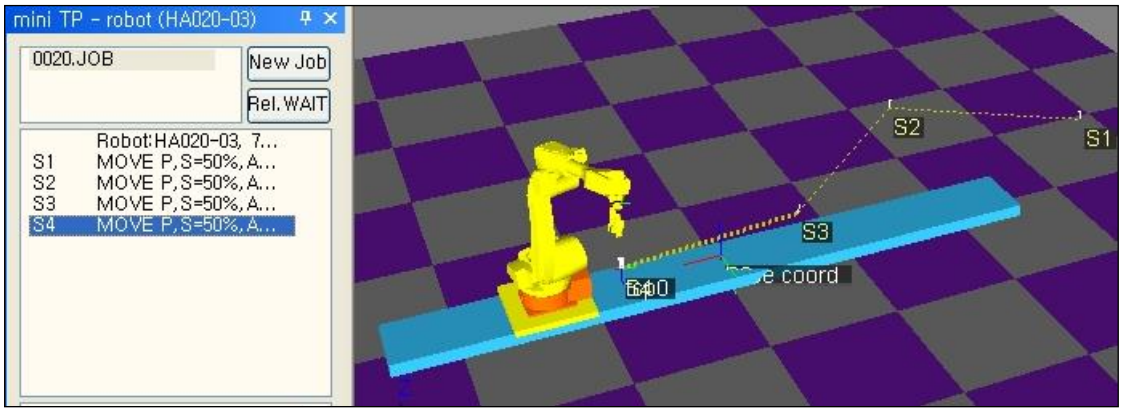


Now let's create work. First, create job with mini T/P.



Set the coordinate system on TeachBar to Base. Steps that are the robot's coordinate system move along with the movement of the robot's traverse axis.

Teach by using Record button while moving the traverse axis shown as below.

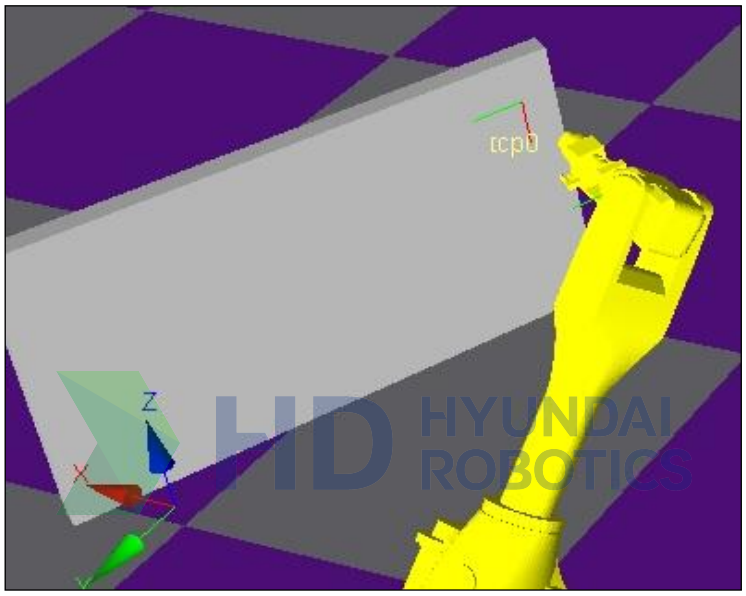


Confirm the moves by executing the simulation when Teach is completed.

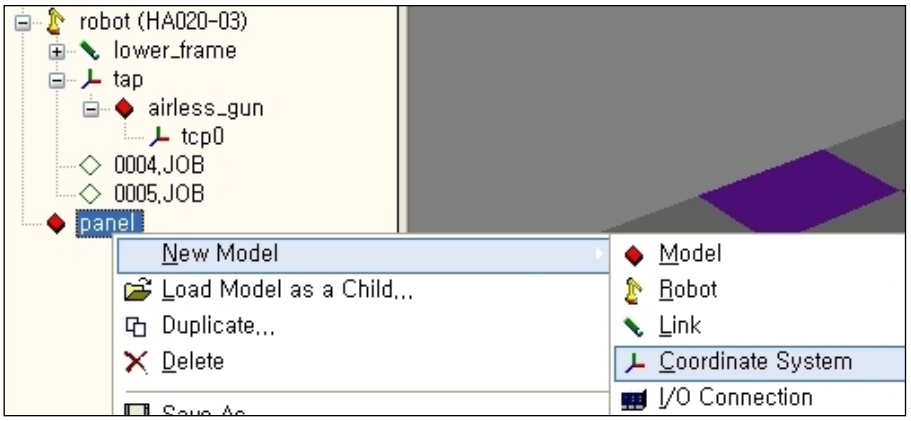
9.2. User coordinate

HRSpace3 supports maximum of 10 user coordinates. The advantage of using this function is that because you can specify a job's RefPos as the target work not as the robot, so the job will move with the target work when the work is moved.

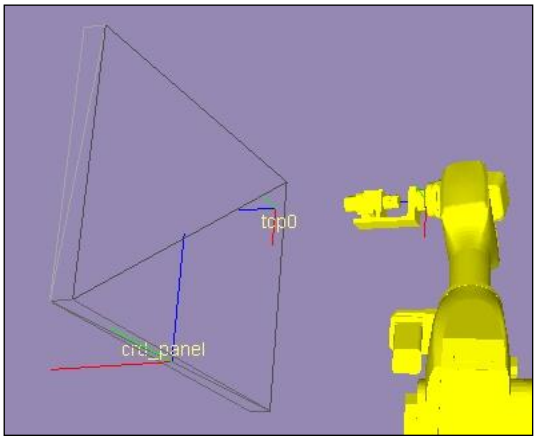
For example, let's try to teach the steps in the user coordinate for the 4 corner surfaces of the rectangular panel as shown below.



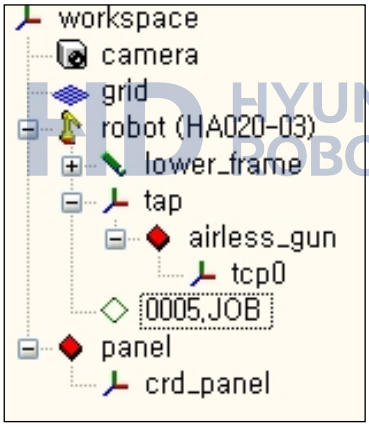
First, create the user coordinate as the child model of the panel and set the name to 'crd_panel'.



The coordinate will be created at the origin location of the panel as shown below. If needed, edit the model properties of the coordinate to adjust the location/direction of the origin.



Open mini T/P of the robot and create new job. Tree window looks like as below.

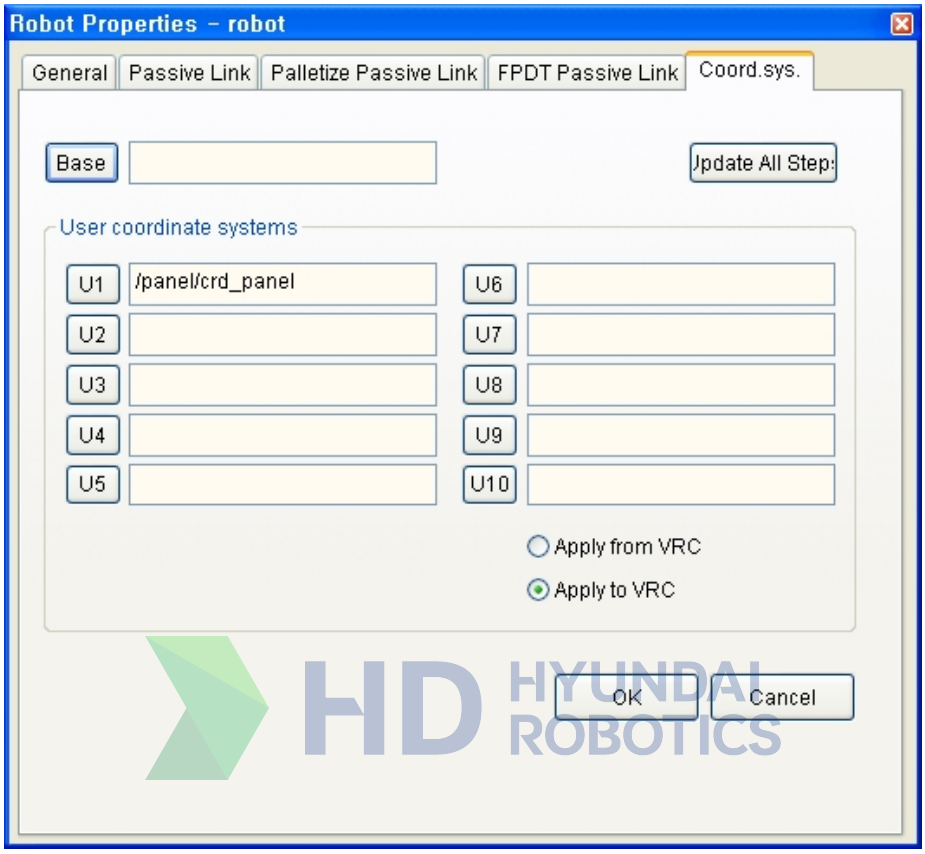


Now open Robot Properties and select Coordinate System tab. Click U1 button in User coordinate systems and click 'crd-panel' in tree window.

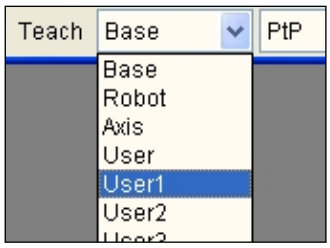
Choose one from two options as below to connect with a virtual controller.

Apply from VRC	The changes in user coordinate systems in VRC are immediately applied to the virtual controller. This is useful when you import onsite robots' controller files and observe them on a 3-D screen or utilize virtual TeachPendant to practice operations.
Apply to VRC	The changes in user coordinate systems on HRSPace3 are immediately applied to the virtual controller. This is useful when you create robot controller files by designing work cells on a 3-D screen.

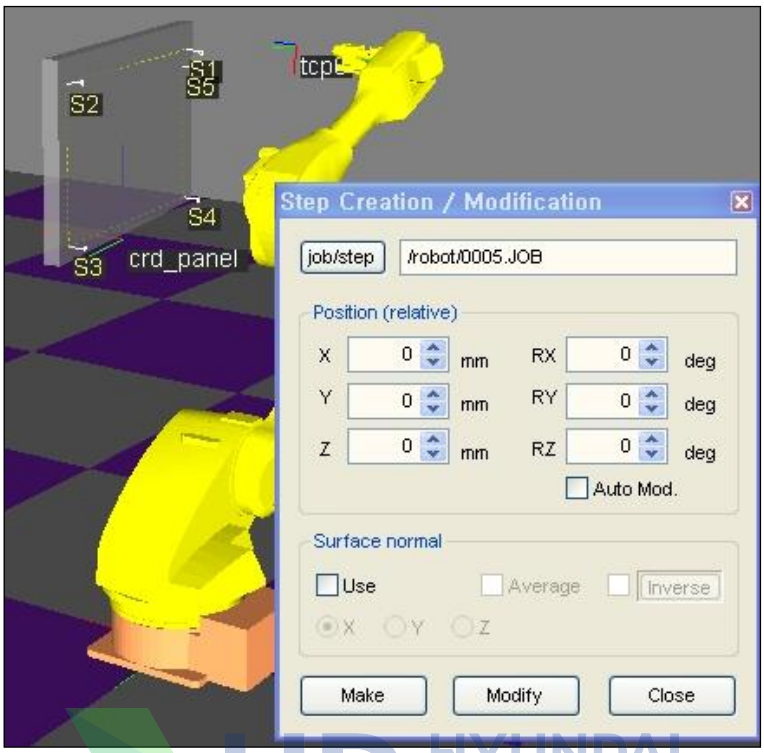
Click 'OK' button to close the dialog box.



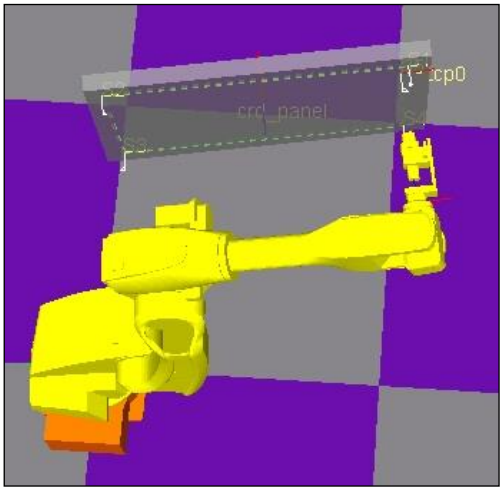
Teach steps on the surface of a panel by using Step Creation/Modification dialog box. At this time, dropdown list box on Teach bar for the coordinate system should be set to user1.



You may recognize coordinates displayed in Step Creation/Modification dialog box is user coordinate system, not robot coordinate system.

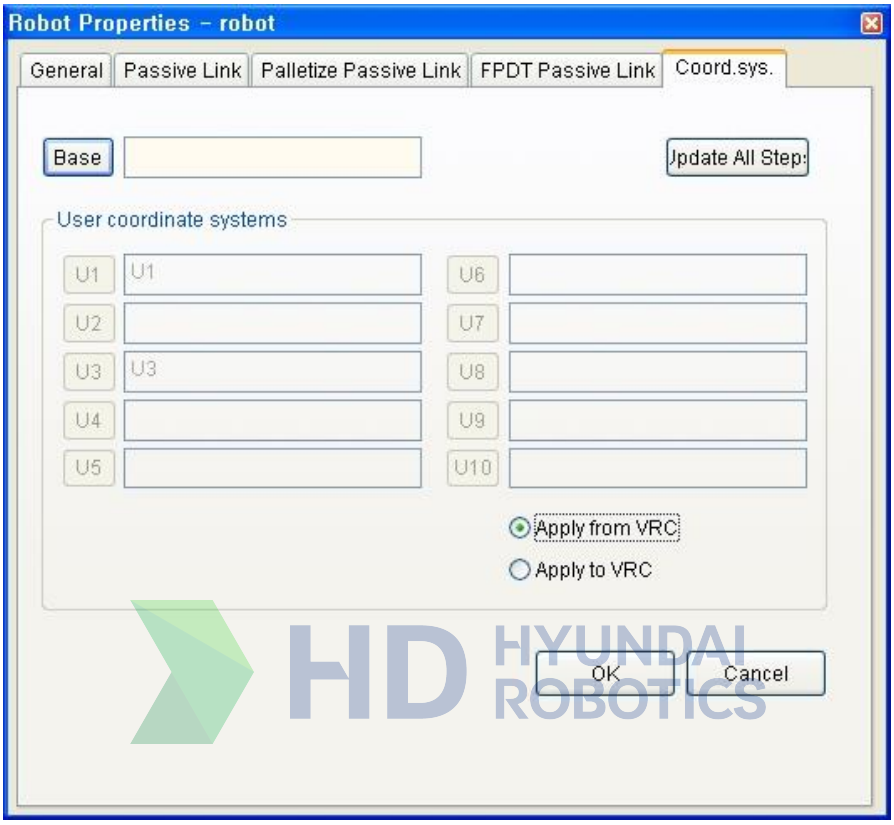


Run simulation when Teach is completed. If the result is normal, change the location/direction of the panel, press 'Apply to VRC' button in Coord. sys. Tab of Robot Properties dialog box, and run the simulation again. You may notice that tool end is moved to the same panel surface location before the change.



Virtual Controller may have 10 user coordinate systems at the most by setting control parameters. Select 'Apply from VRC' radio button if you need to utilize this information in HRSpace3. It creates coordinate system models as children models to the robot model and automatically set coordinate system properties of the robot model.

Later, when the values in user coordinate system are dynamically changed in a virtual controller, this is also applied to HRSpace3.



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10 Application Function

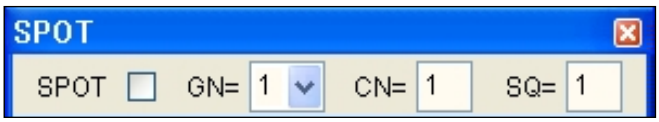
10.1. SPOT welding application function

Hi5a controller function manual –Please refer to spot welding section and understand how to use spot welding function first.

10.1.1. Enter SPOT commands

In Hi5a controller, SPOT commands are used for both Air gun and Servo Gun welding.

It's convenient if you use SPOT Tool bar to enter SPOT commands. When you press REC button, it only records MOVE command if the check box is OFF (via point) and it records MOVE with SPOT command if the check box is ON (weld point). Parameters are automatically entered according to the settings of Gun number (GN=), condition (CN=), and sequence (SQ=) in SPOT Tool bar when SPOT commands are saved.



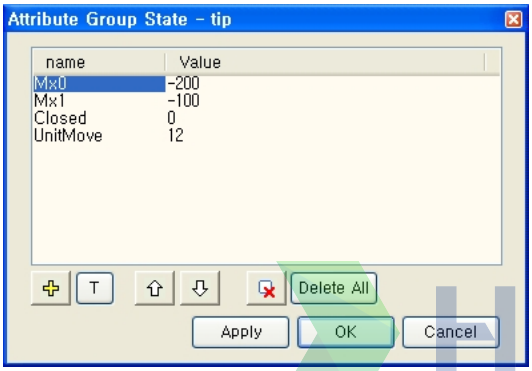
Let GUN button of a keypad ON and press REC button when you record it with virtual TeachPendant. (Please refer to SPOT welding function manual for the details such as how to modify SPOT command and change conditions.)

10.1.2. Perform welding – Air gun

The operation of Air gun is executed by script file. Script get Weld, welding instruction signal, show the pressing movement of moving tip, and produce Complete command.

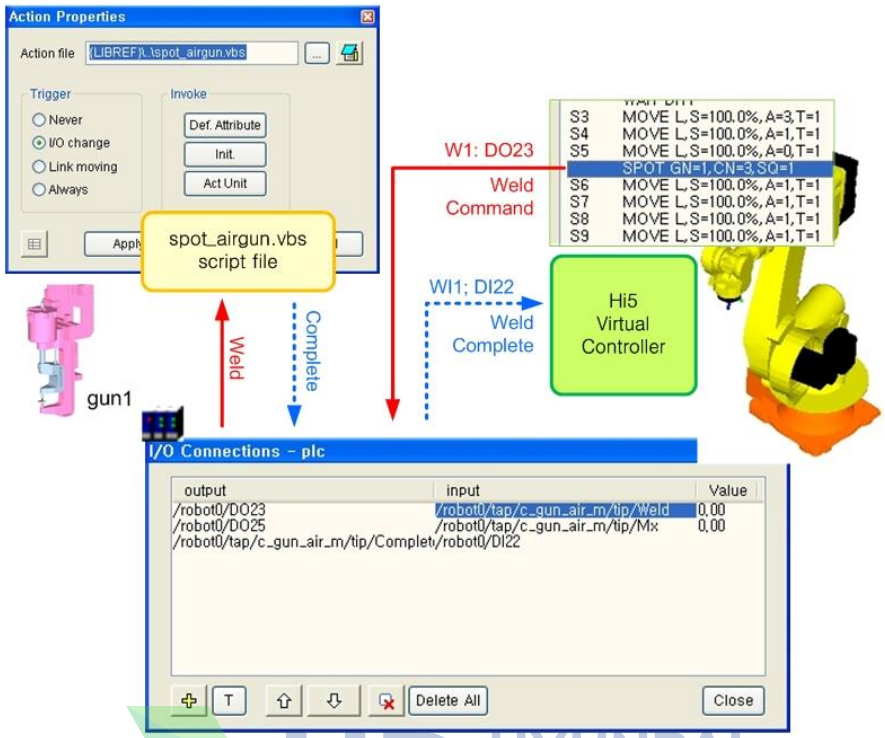
spot_airgun.vbs	For C gun. Control Air gun with signal.
x_gun.vbs	For X gun. Control Air gun with signal and control X gun link

These scripts need attribute settings as below.



Name	Description
Mx0	Value of moving tip axis when the value of Mx is 0
Mx1	Value of moving tip axis when the value of Mx is 1
Closed	Value of moving tip axis when pressed.
UnitMove	Unit for the movement of moving tip (Bigger number means higher speed)

As you can see in a picture as below, the robot produces W1 assigned output signal and is on standby. (Assigned output and assigned input are set in System/Application parameter/SPOT welding menu by using Virtual TeachPendant.)



Set I/O connection to plc model as you can see an example as below since this signal should be entered to moving tip as Weld signal. (Set path appropriately to fit workspace configuration.)

Output	Input
/robot0/DO23	/robot0/tap/g_gun/tip/Weld

spot_airgun.vbs, scripts of moving tip, do welding operation when it receives Weld signal, and then produces Complete signal. Set I/O connection to plc model as you can see an example as below since this signal should be entered to the robot as WI1 assigned input signal.

Output	Input
/robot0/tap/g_gun/tip/Complete	/robot0/DI22

The VRC that was waiting moves to the next command when it receives WI1 signal. This I/O connection is the same as the operation method of Air gun in actual processes.

10.1.3. Perform welding – Servo Gun

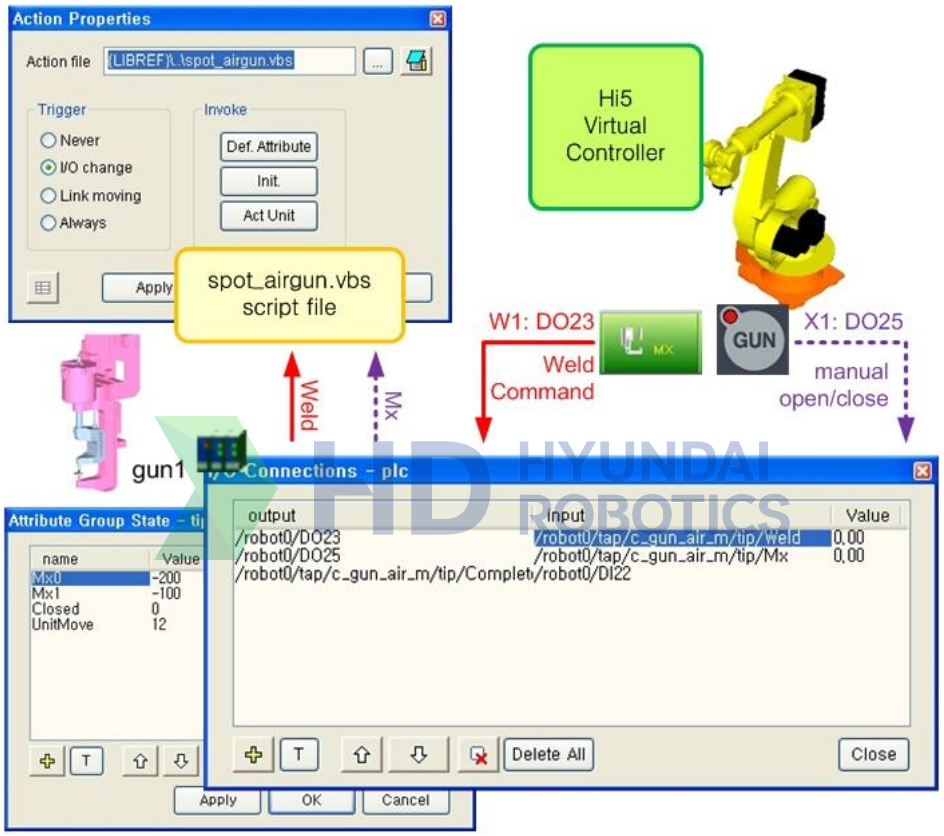
Unlike Air gun, Servo Gun doesn't need scripts and only needs to set it as additional axes appropriately in real situation via virtual TeachPendant. For the 1st function, steps that have SPOT GN=1.. command are

recognized as welding points. The virtual controller executes MOVE command and controls additional axes that are set as guns and moving tip moves the same trajectory in real situation according to this.

* Scripts are used when moving tip is not simple such as X gun.

10.1.4. Large stroke/Small stroke and manual pressing – Air gun

For steps that are via points and not welding points, it needs a function that sets it to small stroke or large stroke.
In case of Air gun, set it with X1~X4 output option in MOVE command. For example, a virtual controller produces X1 assigned output signal if there's X1 output option. Connect this signal to Mx signal that input to moving tip as below by using I/O connection model.



Output	Input
/robot0/X1	/robot0/tap/g_gun/tip/Mx

Scripts of moving tip execute small stroke or large stroke according to the value of Mx0 and Mx1 in attribute settings when Mx input signal is changed.

In Hi5a virtual T/P, manual open/close is executed because X1~X4 assigned output signal manually toggles between 0 and 1 when you click user key MX while pressing [Shift] key.

In addition to this, when you press [Shift] and [GUN] key together, manual pressing operation is executed because W1 ~ W4 signals are produced.

10.1.5. large stroke/small stroke and manual pressing -Servo gun

In case of servo gun, X1~X4 output option is ignored and moving tip is open by a virtual controller according to recorded location of gun additional axis.

In Hi5a virtual T/P, manual open/close is executed when you click “svgun man open/close” button in user key and [Shift] key together.

In addition to this, manual pressing operation is executed when you click “svgun man press” button and [Shift] key together.

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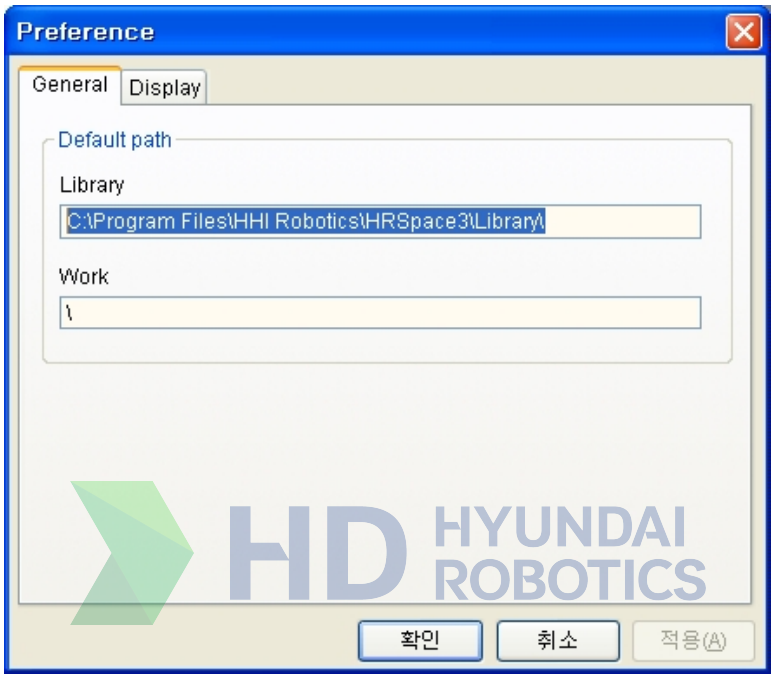
11 Misc. Functions

11.1. Preference dialog box

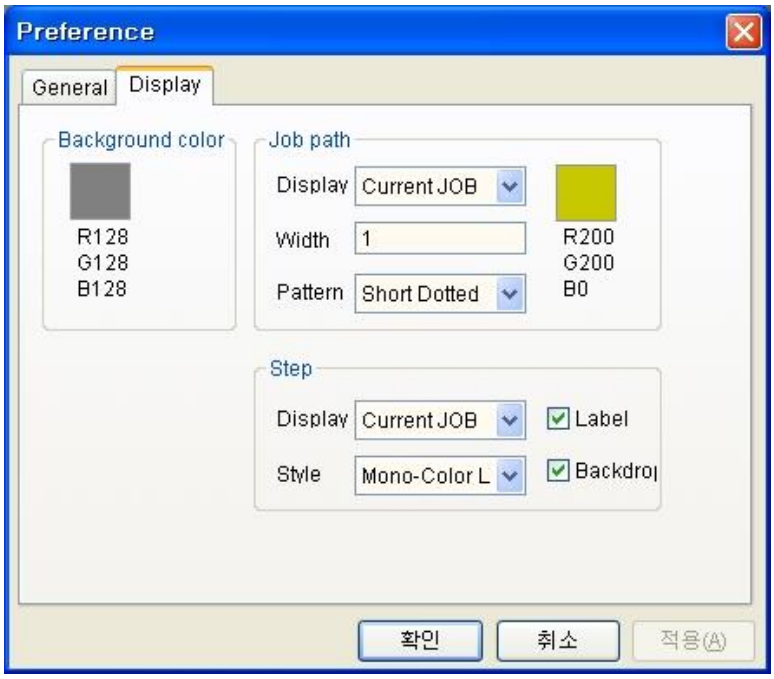
Various options of HRSpace3 can be set in Preference dialog box.

These settings are saved in Windows registry not in documents.



- General - Library
  Set a default folder path when you select Import models in popup menu. Basically it is set to HRSpcace3/Library.

- General - Work
  Basic location that users' work will be saved.



■ Display – Background color
Set background color on a 3-D screen.

■ Display – Job path
Select how to display a straight path between steps in Job. You can choose color, width, pattern such as solid or dotted line.

● **Display method**

Hide	Don't display a path between steps.
Selected JOB	Display a path only to JOB that is selected by clicking in tree window or on a 3-D screen.
Current JOB	Display a path only to JOB that is a current program counter.
All	Display paths in all steps of all Job for all robots. There're chances that readability get worse and the speed of 3-D display gets poor when the number of steps are too many.

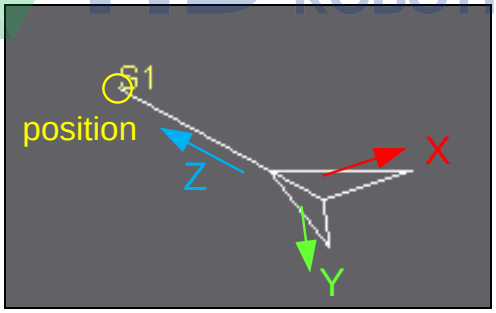
■ Display – Step

Determine how to display steps. You can choose the displaying style of step, and whether to show the step label, and background.

● **Display method**

Hide	Don't display steps.
Selected JOB	Display a path only to JOB that is selected by clicking in tree window or on a 3-D screen.
Current JOB	Display a path only to JOB that is a current program counter.
All	Display paths between all steps of all Job in all robots. When the number of steps are big, there're cares that readability and the speed of 3-D display get poor. Display paths in all steps of all Job for all robots. There're chances that readability get worse and the speed of 3-D display gets poor when the number of steps are too many.

Steps are displayed as an arrow shape if Mono-Color Line is chosen for step style. In this case, the position and direction are as below.



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