FTV322904-L

The Mechanics of Motion Automation

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Learning Objectives

- Wire parameters for rotational motion animation in 3ds Max 2018.
- Simulate pivot constraints using 3ds Max tools suitable for animation.
- Rig a mechanical assembly using bones and inverse kinematics.
- Create a keyframe animation to drive the assembly.

Description

Mechanical motion is all around. From a simple door hinge to a car cylinder piston, it is easy to forget that even the simplest real-world motions can be complex operations in 3D animation software. This class will explore several methods for automating complex motion animation in 3ds Max 2019. Designers will learn how to wire parameters, then import the assembly into 3ds Max, as well as how to create similar constraints using 3ds Max tools. You will learn strategies for building a hierarchy based on the animation requirements, basic parameter wiring, and setting up links and Inverse Kinematics to mimic specific constraints. The class will step through multiple short lessons that allow you to create the animation of specific moveable parts. Finally, attendees will see what advantages each tool has for different steps in the animation of complex motion.

About the Speaker

Steven Schain is the post-production supervisor for all CADLearning products from 4D Technologies, as well as the content development manager of CADLearning's Media & Entertainment and Design products for Autodesk, Inc. software, including 3ds Max, Maya, Inventor and Fusion 360. In 1998, Autodesk recognized Steven as one of only 16 Autodesk Training specialists worldwide. He has since contributed to Autodesk's certified courseware for 9 releases of 3ds Max, was a co-developer of Autodesk's ACI Program and 3ds Max's fundamental standards and is currently an Autodesk Certified Instructor. As a premier Autodesk trainer, he has continued teaching end users, companies, and many others, including The Walt Disney Company, Guess, and the United States Army. As a 7-year veteran of Autodesk University and a featured speaker for AU 2018, Steven has taught classes ranging from creating particle fountains in 3ds Max, to classes on 3D printing and entrepreneurship.

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Introduction

Whether it's for serious production development, simple visual design, or just for fun, as an animator or artist, you can use Autodesk's 3ds Max software to create animatable mechanical models for anything from simple doors or gears, all the way to highly complex mechanical assemblies. There are many instances in which it can be helpful to animate a design, to see how the parts will function together. While simulation can be performed in a program like Autodesk Inventor or Fusion 360, it is often important to have a higher level of control over the animation of an assembly.

Animation is a tool for showing the operation of an assembly in a way that still pictures and diagrams cannot convey. 3ds Max is the ideal environment for creating animated versions of your designs. You can either import your design into 3ds Max or create it completely from scratch. Once created, you can add helper objects, create hierarchical structures, and animate your design using multiple types of animation.

Controlling animated elements and animation timing is what makes 3ds Max a better solution than simply performing a simulation in Autodesk Inventor or Fusion 360. While a simulation can portray the motion of a complex assembly, presenting a compelling animation involves being able to coordinate the animation of multiple objects within the same scene. Once the animation is complete, you need to decide what the output will be for the animated sequence.

In many cases, an animation is rendered to a sequence that can be played back at full speed. The level of quality of the final rendering will usually be based on certain requirements, such as the purpose of the animation or the delivery method. If you're running a test to see if the animation looks the way you want it to, you can save a preview rendering of the viewport. When it comes time to create a final rendering, Arnold or ART can create a high-quality, realistically rendered animation.

This class will discuss and outline the steps you would take to animate several different assembly types. Each assembly type represents a different need because how its parts are controlled is unique.

Animatable Assemblies

Autodesk Inventor and Fusion 360 are powerful design tools that allow you to create a wide array of mechanical assemblies. You can also create assemblies within 3ds Max that fill your needs. Assemblies do not have to be complex either; they can be as simple as a hinged arm, or as complex as a bucket excavator assembly.

Each assembly type can be animated using a number of different techniques, which employ a variety of tools available in 3ds Max. In this class, you will set up three different types of assemblies, using three different techniques that all tie in to the same excavator assembly.

The first exercise is how to wire parameters together to link the animation of one object to another using a simple equation. The second is how to create a hinged piston animation using a helper object and a constraint to maintain the piston's alignment. The third uses bones and Inverse Kinematics to create an operating set of joints on an excavator assembly. Lastly, you will use wired on-screen manipulators to add animation to a rigged excavator.

Setting the Project Directory

1. In the **File** menu, choose **Set Project Folder…**

2. In the **Browse for Folder** dialog, navigate to the "**FTV197415-L_Project**" directory, then click **OK** to set it as the current project directory.
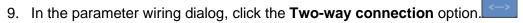
Wiring Parameters for Connected Animation

Open the file **Gear_Wiring_01.max** for this exercise.

1. To make it easier to wire the gear shafts, freeze the gears. Select the small gear.

2. Hold the **Shift** key and select the large gear.

3. Right-click and choose **Freeze Selected** from the Quad menu.

With the gears frozen, it's easier to select the gear shafts to work with them.

4. Select the **Shaft_Small_Gear** object.

5. Right-click and select **Wire Parameters** from the Quad menu.

6. From the parameters options popup, choose **Transform** > **Rotation** > **Y Rotation**. A rubber band line will appear.

7. With the rubber band line active, select the **Shaft_Large_Gear** object.

8. From the parameter options popup, choose **Transform** > **Rotation** > **Y Rotation**.

The Parameter Wiring Dialog

9. In the parameter wiring dialog, click the **Two-way connection** option. <--->

10. Leave this **Shaft_Small_Gear** object as the master for this animation. However, since this is a two-way connection, animating either shaft will rotate both.

IMPORTANT: In order to cause the larger gear shaft to rotate at half the speed of the smaller gear and in the opposite direction, you need to edit the expression for the large gear shaft. It's important to understand the relationship between expressions. By setting the small gear shaft as the master, you must edit the expression for the large gear shaft.

11. In the expression for the **Shaft_Large_Gear** object, enter "**-Y_Rotation/2**."

12. Click **Connect** to connect the two parameters, wiring them together.

13. Close the parameter wiring dialog.

14. From the main toolbar, click **Select and Rotate**.

15. Select the **Shaft_Small_Gear** object.

16. Rotate the object around the Y-axis.

Configuring Pistons on an Industrial Hinge

1. From the **File** menu, click **Open**.

2. Open the file, **Excavator_Arm_Hinge_01.max**.

Hiding Scene Layers

3. Make sure the **Scene Explorer** is set to **Sort by Layer**.

4. In the layers list, turn **off** the visibility for the Bucket Geometry, Cameras, Excavator Body Geometry, Ground, Lighting, Manipulators, and Objects.

Hierarchies for Animation

To start here, use: **Excavator_Arm_Hinge_02.max**

Adding Look-At Helpers

5. Click the **Create Tab** in the **Command Panel**.

6. In the **Create Tab**, choose **Helpers**.

7. Set the **Scene Explorer** to **Sort by Layer**.

8. Set the **Arm_Helpers** layer as the current layer by clicking the layer icon to the left of the layer label.

   This will create the new dummy object on the Arm_Helpers layer.

9. Click the **Dummy** helper object.

10. To create the dummy object, click and drag in the **Top** viewport. Make the dummy object a little wider than the arm geometry.

11. Once the dummy is created, click the **Modify** panel.

12. In the **Name** type-in, change the name to "**Dmy_Boom Piston Link**" and press **ENTER**.

Positioning the first helper

13. With the **Dmy_Boom Piston Link** selected, click the **Align** tool.

14. In the **Front** viewport, click on the **Boom Piston Upper** object. The Align Selection dialog opens.

15. In the **Align Selection** dialog, make sure the **Align Position X**, **Y**, and **Z** axis options are all checked.

16. Set both the **Current Object** and **Target Object** alignment options to **Pivot Point**.

17. Click **OK**.

Copying the Second Helper

18. From the main toolbar click **Select and Move**.

19. In the front view, hold the **SHIFT** key, then click and drag the **Dmy_Boom Piston Link** object over to the pivot point of the **Boom_Cylinder Upper** object and release the mouse button.

20. In the **Clone Options** dialog, set the **Object** option to **Copy**.

21. Change the **Name** to "**Dmy_Boom Cylinder Link**", the click **OK**.

22. With the **Dmy_Boom Cylinder Link** selected, click the **Align** tool and click on the **Boom_Cylinder Upper** object.

23. In the **Align Selection** dialog, make sure the **Align Position X**, **Y**, and **Z** axis options are all checked.

24. Set both the **Current Object** and **Target Object** alignment options to **Pivot Point.**

25. Click **OK**.

Setting up the Hierarchy
To start here, use: **Excavator_Arm_Hinge_03.max**

Linking the Piston Parts and Helpers

26. In the **Scene Explorer**, select **Sort by Hierarchy**.

    *If needed, expand the **Name** column so that you can see the complete name by clicking on the vertical separation line to the right of the name category heading and dragging to the right.*

27. Select the **Display** menu and make sure the **Display Children** option is checked.

28. To begin creating the hierarchy for the piston, select the **Boom Piston Upper**.

29. Click the **Select and Link** tool in the main toolbar.

    (Optionally, you can use a drag-and-drop operation instead.)

30. Starting on the **Boom Piston Upper** object, drag and drop it onto the **Dmy_Boom Piston Link** object and release the mouse button.

    If this is done correctly, the Dmy_Boom Piston Link will flash once, and you will see the change in the hierarchy in the Scene Explorer:

31. Now select the **Dmy_Boom Piston Link** object, and carefully drag and drop it onto the **Lower Arm** object and release the mouse button.

32. Select the **Boom_Cylinder Upper** object, and carefully drag and drop it onto the **Dmy_Boom Cylinder Link** object.

    If you need to zoom the viewport, scroll the mouse wheel up to get closer to the objects you are working on.

33. Select the **Dmy_Boom Cylinder Link** object, and drag and drop it onto the **Upper Arm** object.

34. Select the **Dmy_Boom Piston Lookat** object and drag and drop it onto the **Upper Arm** object.

35. To stop the Select and Link tool, click the **Select Object** tool.

To start here, use: **Excavator_Arm_Hinge_04.max**

Adding the Look-At Controllers

36. In the **Front** viewport, select the **Dmy_Boom Piston Link** object.

37. From the **Animation** > **Constraints** flyout menu, choose **Look-At Constraint**.

    A rubber band line appears from the origin of the dummy object once the constraint is chosen.

38. Click the **Dmy_Boom Piston Lookat** to add the **LookAt Controller** to the helper.

39. In the **Motion** panel, scroll to the **LookAt Constraint** rollout; set the **LookAt Axis** to **Z**.

40. Select the **Dmy_Boom Cylinder Link** object.

41. From the **Animation** > **Constraints** flyout menu, choose **Look-At Constraint**.

42. Click the **Dmy_Boom Piston Link** object, to add the **LookAt** controller.

43. In the **Motion** panel, scroll to the **LookAt Constraint** rollout; set the **LookAt Axis** to **Z**.

Rigging an Excavator Bucket Scissor Joint
Open the file **Excavator_Rig_01.max** for this exercise.

Adding the Bones

1. From the **Command** panel, click the **Create** tab, then click the **Systems** option.

2. In the object type rollout, click **Bones**.

3. Click towards the top of the screen in the Front viewport at the center of **Bucket Link A1** top joint, to create the start of the bone chain.

4. The end of the first bone should be at the pivot point where the bucket links meet. Click there to create the first bone and start the second.

5. To place the end of the second bone, click at the pivot point for **Bucket Link A2** towards the bottom of the screen.

6. Right-click to create the second bone and add the bone end. Then press ESC to exit the bone creation tool.

Linking the Assembly

To start here, use: **Excavator_Rig_02.max**

7. From the **Main** toolbar, click **Select and Link**.

8. In the **Front** viewport, select **Bucket Link A1**, hold the left mouse button, and drag over the first bone in the chain. You'll see a rubber band line appear with a link icon.

9. Release the mouse button, and the bone will flash once, indicating it is linked as the parent of the Bucket Link A1 object.

10. Now select Bucket Link A2, hold the left mouse button, and drag it over the second bone in the chain.

11. Release the mouse button, and the bone will flash once, indicating it is linked as the parent.

12. Select the first bone in the chain. Holding the left mouse button, drag the cursor over the **Dmy_Arm-Bucket Link** helper object.

13. Click **Select Object** in the **Main** toolbar to get out of Select and Link mode.

This configures the bone chain and the hierarchy required to make the scissor joint work.

Creating the IK Chain
To start here, use: **Excavator_Rig_03.max**

14. In the **Front** viewport, select the first bone in the chain.

15. From the **Main** menu, choose **Animation** > **IK Solvers** > **HI Solver**. A rubber band line will appear from the origin of the first bone.

16. Click the last bone in the chain, the very small end bone, to create the IK chain.

17. Make sure the IK chain end effector is selected.

18. Click **Select and Link** from the **Main** toolbar.

19. Click and drag from the end effector to the **Dmy_Bucket-Arm Link** helper object. The helper object will flash once to let you know that it has been linked as the parent of the end effector.

20. Click **Select Object** in the **Main** toolbar to get out of Select and Link mode.

Rotate the Bucket
21. In the viewport, select last bone in the bucket arm bone chain.

22. From the **Main** toolbar, click **Select and Move**.

23. Move the bone down to close the scissor joint, and up to open it.

Animating a Rigged and Wired Assembly
Open the file **Excavator_Animate_01.max** for this exercise.

Creating Keyframe Animation

1. Click **Auto Key** in the lower right of the interface, to activate the auto keyframe animation feature within 3ds Max. Auto

2. From the **Main** toolbar, click **Select and Manipulate.**

3. Drag the **body rotate** slider to about **-0.4**.

4. Drag the **bucket Z** to the right to about a value of **90**, raising the bucket.

5. Drag the **bucket X** to the right to a value of about **275**, pushing out from the main body.

6. Drag the **bucket rotate** to the left to about **1.9**, extending the rotation of the bucket.

    The excavator rig positioned for the start of the animation.

7. Drag the **time slider** to frame **100**.

8. Drag the **body rotate** slider to **0.3**, and then drag the other three manipulator sliders over one notch. This will cause a keyframe to be made at frame 100 for this value.

9. Drag the **time slider** to frame **150**.

10. Drag the **bucket Z** slider to the left to about **-63**, and the **bucket rotate** slider to about **2.8**.

11. Drag the **time slider** to frame **200**.

12. Drag the **bucket rotate** slider to about **4.0**, the **bucket X** slider to about **230.0**, and the **bucket Z** slider to about **-19**.

13. Scrub the **timeline** from frame **0** to frame **200** and watch the animation.

14. Slide the **time slider** to frame **270**.

15. Adjust the **bucket Z** value to about **37.6**, the **bucket X** to about **200**, and the **bucket rotate** to **4.4**.

16. Slide the **time slider** to frame **340**.

17. Adjust the **bucket Z** value to about **32**, the **bucket X** to **330**, and the **bucket rotate** to **2.0**. and **Body Rotate** to **-0.8**.

18. One last keyframe. Slide the **time slider** to frame **200**.

19. Adjust the **body rotate** back to **0.3**. This sets up a keyframe at frame 200 for the rotation of the body, keeping it stationary between frame 100 and frame 200.

20. Turn **off** Auto Key.

21. In the animation controls, click **Go to Start**.

22. Click **Play** to play back the animation.

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