



NAO – Keyframe Programming using Choregraphe



Overview –

The NAO humanoid robot is a very powerful tool for programming and robotics development. Part of its power lies with the Choregraphe software used to program the NAO.

Choregraphe can appear complex to the first-time user, and this activity planner aims to make accessible for everyone. Basic workflows for programming a sequence of movements, such as speech and a simple dance, using keyframe programming within Choregraphe.

Note –

Your computer and NAO are required to be connected to the same wireless network for this activity. Please review the full instructions for NAO network connection if you have not set this up.

Downloading and Installing Choregraphe

Visit the Aldebaran Community website - <https://community.aldebaran.com/en/resources/software> and sign in. If you don't have an account for this website, you will need to create one to continue.

There are 2 versions of the Choregraphe suite:

- NAO V6 Only;
- Former NAO Versions

with each version available for Linux, Mac and Windows.

You can identify which NAO version you have by looking at the chest button on the front of the robot. If your chest button displays the word NAO, you have **version 6**, else if it displays the Aldebaran logo then you have a **former version**.



Aldebaran Logo

Download the Choregraphe version for your NAO and computer. Make sure you download the **Choregraphe Setup** and **not the Choregraphe Binaries**.

Once downloaded, install the software onto your computer.

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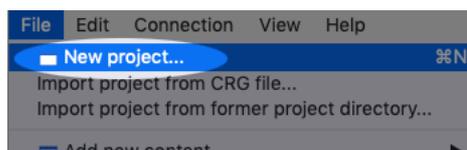
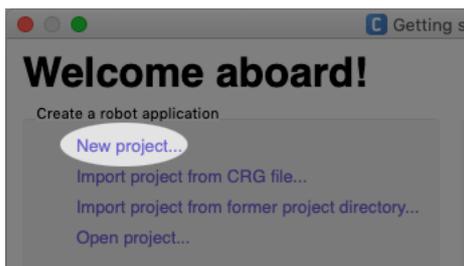
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License Key – Choregraphe for Former NAO Versions requires a license key (NAO V6 Only version do not have this requirement). SoftBank has now released this software for free so use the provided key on the download page.

Creating a New Project and Connecting to the NAO

On the Getting Started window, select **New project...**, If the window does not appear, select **New project...** from the **File** menu



With both your NAO and computer connected to the same wireless network, click the **Connect to**  button in the **toolbar** or select **Connect to...** from the **Connection** menu

A list of virtual/simulated and physical robots will be displayed. If your NAO appears in the list and is green, highlight it and press the **select** button.



A real robot – **not ready to connect to.**

If the robot stays in this state, try restarting the NAO and Choregraphe



A real robot – **Ready to connect to.**



A virtual robot – **You can connect to this robot.**

Some commands in Choregraphe will not be available

If Choregraphe cannot see your NAO try the following:

- Press the NAOs chest button
- The NAO will say the current IP address (if connected to the wireless network)
- Turn on **Use fixed IP/hostname** and set it to the IP address said by the NAO



- Press the select button to try and connect

If you still cannot see or connect to your NAO, your wireless network may have a feature called **device isolation** enabled. Check with your ICT staff to disable this feature for the NAO and computer.

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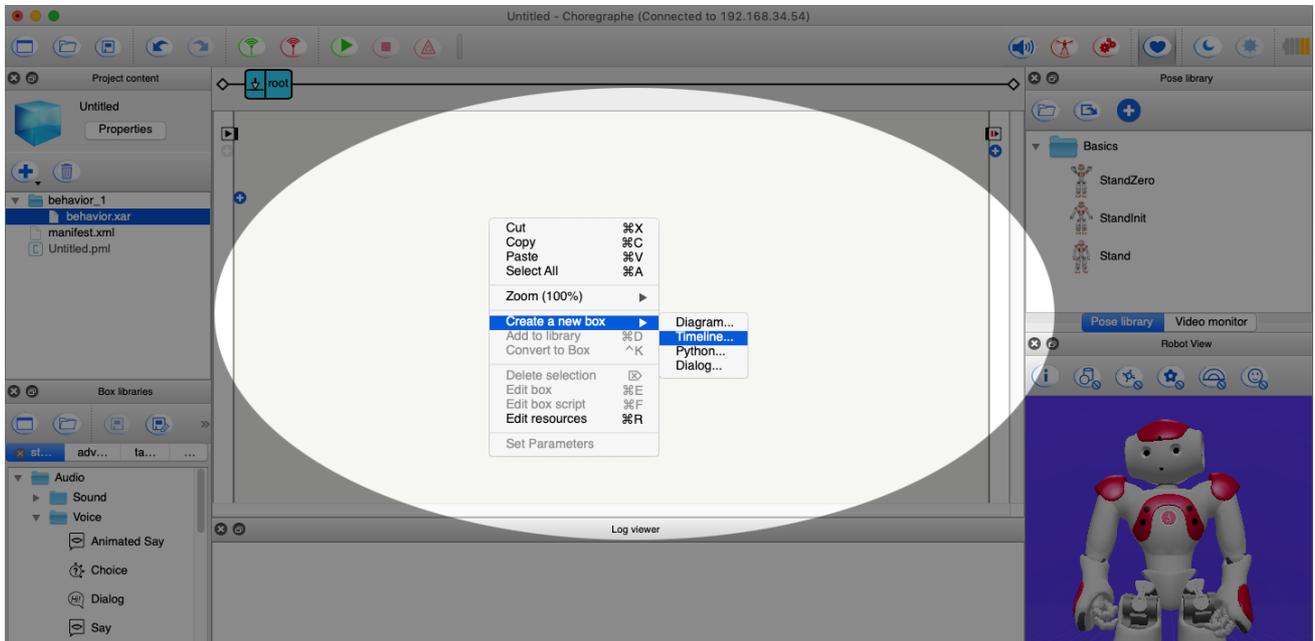
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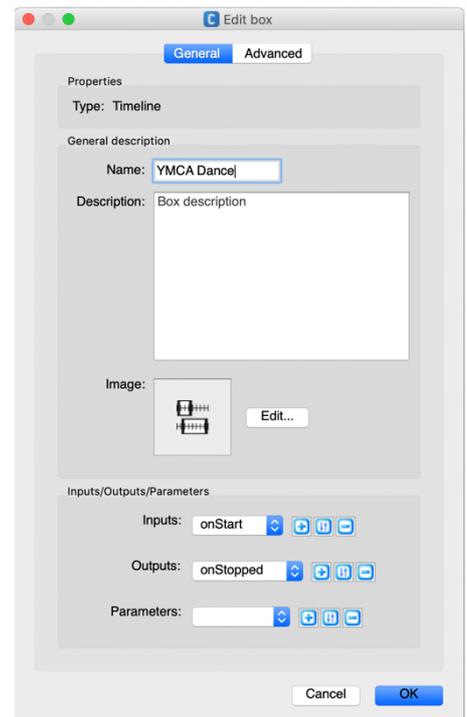
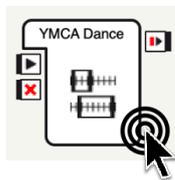
Create and Edit a new Timeline box

Drag the **Template > Timeline** box from the **Box libraries** view on to the **Flow diagram** area or right click the grey area and select **Create a new box... > Timeline...**



Name your Timeline box a descriptive name such as **YMCA Dance** and click **OK**

Now double click the newly created Timeline box and the main Choregraphe window will change to a Timeline view that contains a timeline panel.

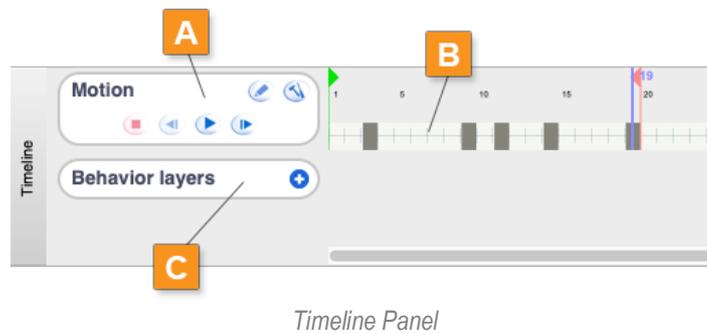


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Timeline Panel

A – Motion

Allows you to define Motion keyframes

-  **Timeline editor** button displays the Timeline Editor
-  **Timeline properties** button allows you to set the Timeline properties
-  **Play motion** button launches the Preview Mode
-  **Step forward** button launches the Preview Mode in a step-by-step mode

B – Time ruler

Represents the time elapsing when the box started. The numbers incrementing by 5 indicate each frame (called a keyframe) along the timeline. By default, the timeline runs at **25 frames per second**, which can be edited using the **Timeline properties** button.

In this example you can see there are keyframes at the 3rd, 9th, 11th, 14th and 19th frames. Since the animation runs at **25 frames per second**, all 4 movements will occur in less than a second!

C – Behaviour layers

Allows you to program secondary behaviours in a timeline to run simultaneously with the main motion keyframes.

For this demo, we are going to create a basic YMCA dance, appropriately positioning the NAO's arms using a mode called Animation Mode.

Animation mode allows capturing different postures and storing them within a timeline. When the timeline is played back, the NAO will move to each posture stored within the timeline (called a keyframe) at the appropriate time.

Enabling Animation Mode

Before we capture the NAOs motion, we need to enable **Animation Mode** with the following steps:

1. Make sure **Autonomous Life** is turned **off** by clicking the **Life**  toolbar button The NAO will go into its resting posture.

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2. Click the **Wake up**  button in the toolbar
3. Ensure that you hold the robot by the waist before the next step to prevent it from falling over
4. Click the **Animation Mode**  button. The button will turn red, meaning the **Animation Mode** is now on

Changing and Storing a posture in the Timeline

The NAO's eyes will indicate the stiffness state of the head and arms (see below) with the leg LEDs indicating the status of each leg. By default, all the limbs are stiffened (indicated by an orange LED) and require you to touch a tactile sensor to allow movement (indicated by a green LED).

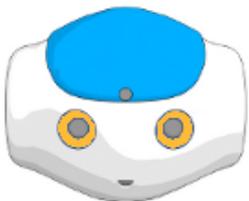
Head – Touch the **middle** head tactile sensor to toggle the stiffness

Arms – Hold the **hand tactile sensor** to maintain stiffness off

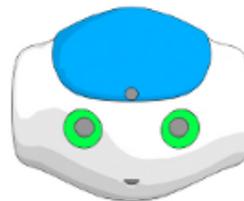
Legs – Press the **foot bumpers** to toggle the stiffness

It is **not** recommended to change the stiffness or position of the legs of a NAO in this tutorial. Moving the legs of a NAO in animation mode takes a degree of thinking, thought and planning as it can cause the NAO to lose balance and is best reserved for advanced users.

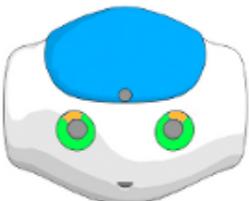
Key of head and arms stiffness status



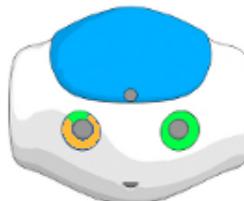
Head – Stiffness On
Left Arm - Stiffness On
Right Arm - Stiffness On



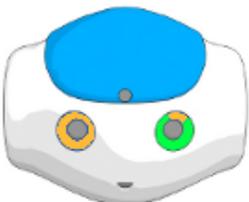
Head – Stiffness Off
Left Arm - Stiffness Off
Right Arm - Stiffness Off



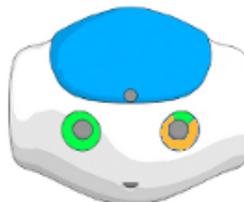
Head – Stiffness On
Left Arm - Stiffness Off
Right Arm - Stiffness Off



Head – Stiffness Off
Left Arm - Stiffness Off
Right Arm - Stiffness On



Head – Stiffness On
Left Arm - Stiffness Off
Right Arm - Stiffness On



Head – Stiffness Off
Left Arm - Stiffness On
Right Arm - Stiffness Off

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To begin with our YMCA Dance animation, we need to move the NAOs arms to the Y position. While holding the waist to support the NAOs stability, press and hold the hand tactile sensor on the left arm. The bottom of the left eye will turn green to indicate that the left arms stiffness has been turned off. Now move the arm gently forwards and upwards in a circular motion to form the left arm of the letter Y. When you release the tactile sensor of the hand, the NAOs eye should return to orange to indicate the arms stiffness has been turned on.

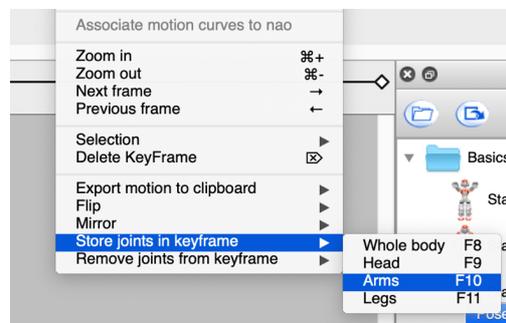


Repeat this with the right arm to form the right arm of the letter Y



Now that we have formed the letter Y posture, we need to save this posture within the Animation mode timeline as a keyframe.

We would like the Y posture to occur 2 seconds after we run the animation. Since the timeframe by default is set to 25 frames per second, we need to right click at the 50 frames point, then select **Store joints in keyframe > Arms**. As we are only moving the arms in this example, we only need to store the arm movement.



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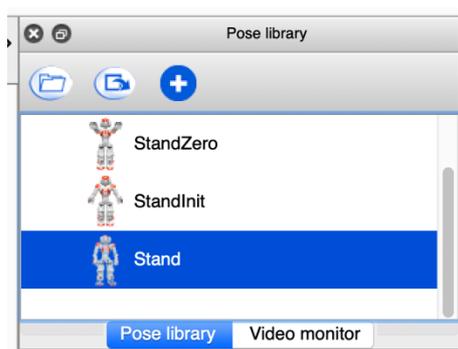
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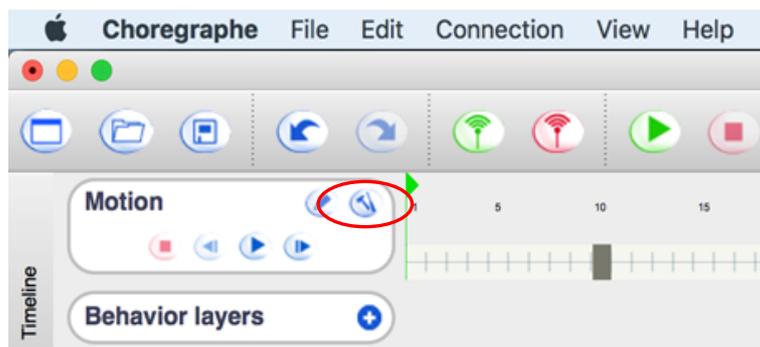
Now that we have completed the Y posture and stored it as a keyframe within the timeline, go ahead and repeat the above steps to make the M, C and A postures, saving them as keyframes within the timeline.

Make sure that you leave at least 2 seconds or 50 frames between keyframes, ie Y is at frame 50, M is at frame 100, C is at frame 150 and finally A is at frame 200.

To finish the movement, it is recommended that you store a standing pose before and after the animation to reset the NAO's posture. To do this, select the **Stand** pose (don't forget to hold the waist to support the NAOs stability) from the **Pose Library** which will move the NAO to that pose. Now save that pose at the beginning of the timeline, at frame 0 as well as at the end of the timeline, at frame 250, 2 seconds after the A pose. When saving the **Stand** pose, select **Whole body** under **Store joints in keyframe** instead of Arms as the **Stand** post moves the **Whole body**.



Before testing your dance, it is advisable to slow down the timeline speed from the default speed, to avoid any damage to the NAO caused by sudden movements. Click the tools button to the left of the timeline, in the "Motion" control panel. Change the Framerate (FPS) to 10. You can always increase this again later once you have seen how your dance routine works.



Finally, to test your routine, press the **Play motion** button. If this is your first test, you may want to be ready to catch the NAO in case the timing is too fast and causes it to fall over!

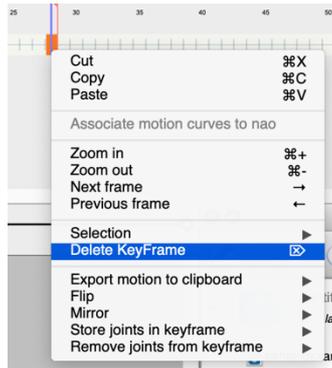


If you are unhappy with the movements, you can select the keyframe that you want to change, delete it and follow the steps above to recreate the posture and save a new keyframe.

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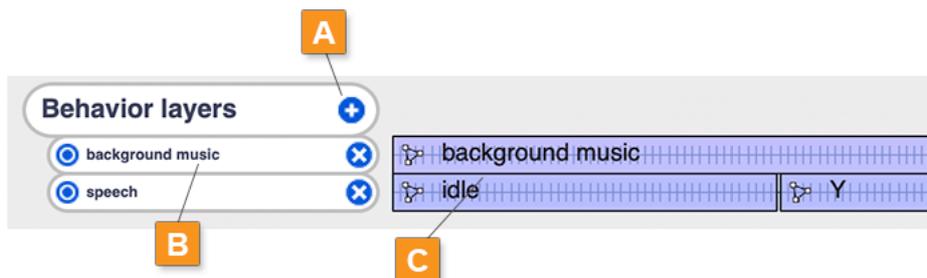


If the movements are too slow or fast, you can drag keyframes along the timeline, closer together to decrease the time between transitioning postures, and further apart to increase the time.



Adding Behaviour Layers to the Timeline

Behaviour layers allow you to place boxes, such as Play Sound or Speech, to run at the same time to keyframe movements. We are going to use layers to play background music and speak the letters in time with the movements we have saved in the timeline.



A – Add button Allows you to add one or more behaviour layers

B – Behaviour layer Click the **Activation** button to enable or disable a **Behaviour layer**:

- means the **Behaviour layer** is enabled
- means the **Behaviour layer** is disabled; it is hidden and will not be loaded nor executed
- Click the name of a **Behaviour layer**, to edit it.
- Click the **Delete** button to delete the **Behaviour layer**.

In this example, you can see 2 behaviour layers, **background music** and **speech**. There is a total of 3 behaviour keyframes visible:

- A **background music** behaviour keyframe in the **background music** layer; and
- A **idle** and **Y** behaviour keyframes in the **speech** layer

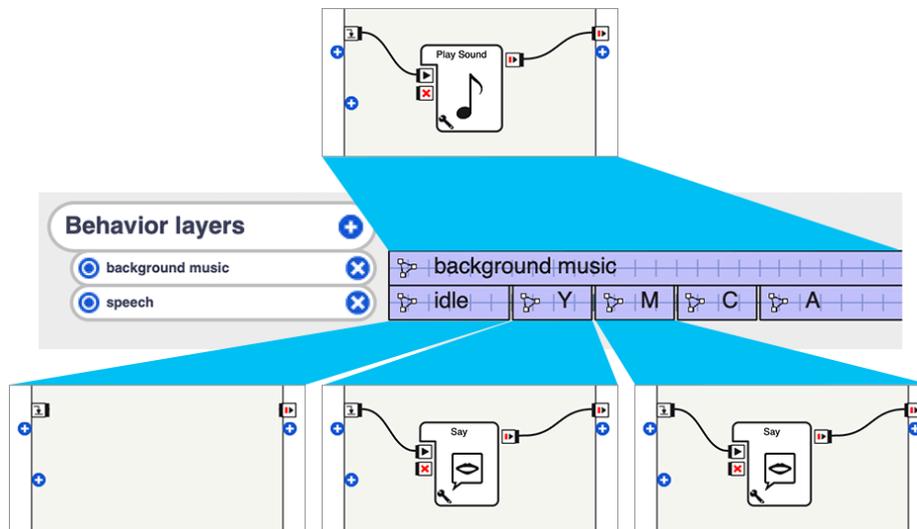
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C – Behaviour keyframe Each **behaviour layer** can run one or several behaviour keyframes sequentially.

Behaviour Keyframes



Layers can contain multiple behaviour keyframes which have their own **flow diagrams**. Each of these **flow diagrams** run in time with the timeline. In the example above, you can see the **background music** layer has only 1 behaviour keyframe which runs a **Play Sound** box for the entire duration of the timeline while the **speech** layer has 5 behaviour keyframes, the first behaviour keyframe does not contain a box so will do nothing, while the Y, M, C and A behaviour keyframes contain **Say** boxes.

When a behaviour keyframe reaches the end of its time within the timeline and is replaced by another behaviour keyframe, such as in the example Y and M, the previous behaviour keyframe is forced to stop, even if the boxes within that behavior keyframe have not completed their actions!

To continue this tutorial, we need to create 2 behaviour layers, **background music** and **speech**. Press the **Add** button beside the **behaviour layers** title twice.



Now we want to rename the 2 new layers to help us identify what they are. We can do this by clicking on the text of each layer and entering the names **background music** and **speech**



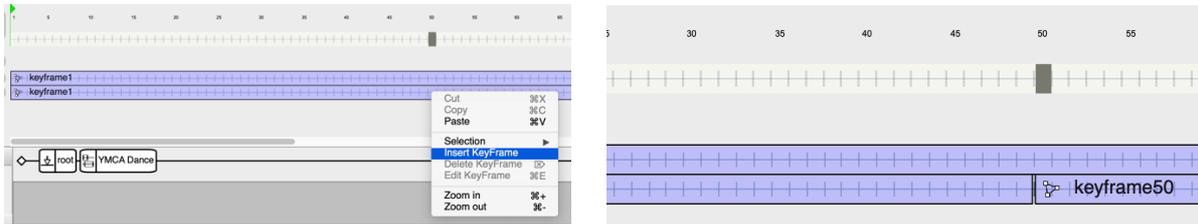
We can see that each new layer starts with a single behaviour keyframe named **keyframe1**. This is fine for the **background music** layer, however we need 5 behaviour keyframes for the **speech** layer, 1 for the **idle** period before the first posture of Y, then a behaviour keyframe of each of the 4 postures, Y, M, C and A.

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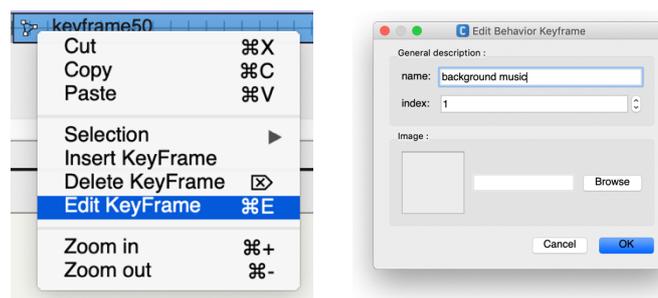
On the **speech** layer, right click under the first stored keyframe on the timeline at frame 50 and select **insert keyframe**. This should create an additional keyframe in the **speech** layer named **keyframe50**. The name **keyframe50** is an indicator that this behaviour keyframe is going to run when the timeline reaches frame 50.



If the name of the behaviour keyframe is not **keyframe50**, you can drag the left edge of the behaviour keyframe to move it to the correct frame. The name of the behaviour keyframe will update to the new frame number.

Repeat the above steps and create keyframes for the additional poses of M, C and A.

With all the behaviour keyframes created, we can rename them to better represent what the **flow diagrams** will perform. Right click each behaviour keyframe and select **Edit KeyFrame**. You can change the name in the **Edit behaviour Keyframe** window and press **OK**.



Now that we have renamed all the behaviour keyframes, it is time to edit their **flow diagrams**. First select the **background music** behaviour keyframe, you know that it is selected because that behaviour keyframe will turn blue (while the others are purple) and the **flow diagram** area will be empty.

Drag the **Play Sound** box from the **Box Libraries** panel and place it into the **Flow diagram**. If you cannot see the **Play Sound** box, you may need to expand the **Audio** and **Sound** folders.

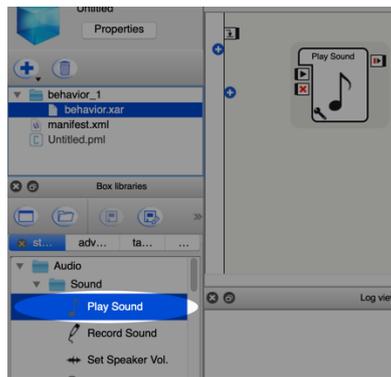
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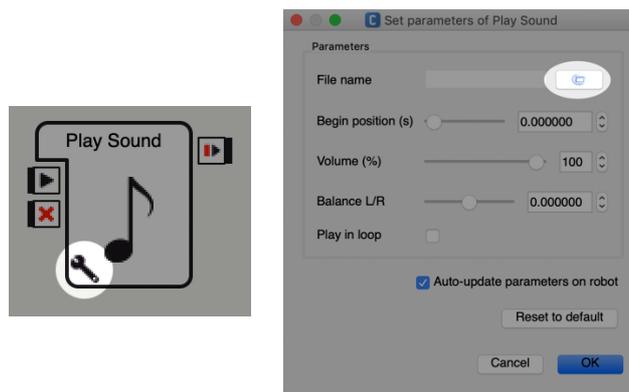
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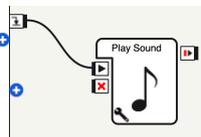
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Press the **Set Parameters** button on the Play Sound box and in the **Set Parameters** window, click the **folder** button to choose the background sound to play. Once selected, press **OK**.

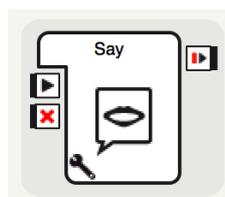


With the **Play Sound** box configured, we need to connect the **onLoad input** to the **Play Sound** box **play input** so that the Play Sound box is run when the keyframe is loaded. Press and hold the mouse cursor on the **onLoad input** and drag over to the Play Sound **play input**. A black line should follow your cursor and connect the two points.



Now we need to do a similar action for each of the **speech behaviour keyframes** for each letter or Y, M, C and A. For each of these behaviour keyframes, we want the NAO to say the letter it is posing.

Starting with the **Y**, select the **Y behaviour keyframe** and drag the **Say** box. The **Say** box is also located in the **Box libraries** under the **Audio / Voice** folder. Be careful not to choose the **Animated Say** box. The **Animated Say** box includes dynamic body gestures of the speech being spoken. As we have created our own poses, we don't want the NAO to override these with its own gestures!



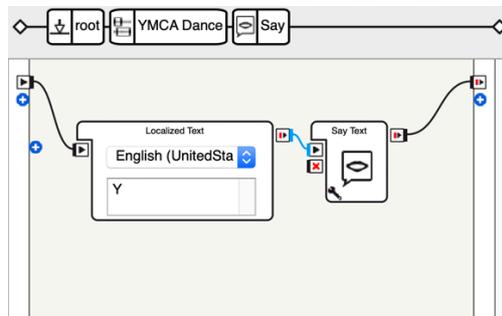
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To edit the text to speak in the **Say** box, we can double click it to open the **flow diagram** inside this box. Similar to the **timeline** box, boxes can also contain additional **flow diagrams** or **programming code**. You will see the **flow diagram** inside the **Say** box contains a **Localized Text** box. Make sure the region is set to **English (United States)** and delete everything inside the text box and simply enter the text **Y**.



Repeat the above actions on the other letter **behaviour keyframes** in the **speech** layer to speak M, C and A.

Now that we have finished adding background music and speaking the letters Y, M, C and A on each of the postures within the timeline, it is time to test it. Press the **play motion** button to watch all the movements and layers work together.



If you are unhappy with the movements or timings, you may need to move the **behaviour keyframes** around before continuing. If you notice that speech doesn't work, make sure that you have connected the **onLoad input** to the **speech play input** and that the NAOs volume (control near top right of main screen) is turned up.



To finish the project, we would like the NAO to say a few words to introduce the dance first.

Click on the **root** diagram in the box path to return to the parent of the **flow diagram**, where we first creating the **timeline** box.

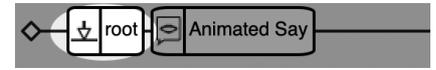
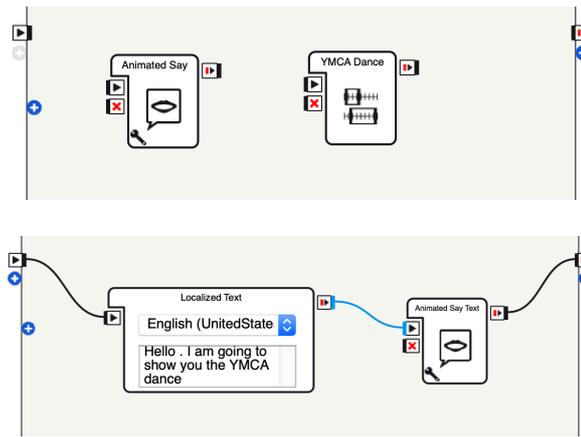


Drag an **Animated Say** box from the **Box Libraries** into the flow diagram. Similar to the **Say** box, we are going to double click the **Animated Say** box and change the region and text to introduce the dance. Then click on the **root** diagram in the box path to return to the parent of the **flow diagram**.

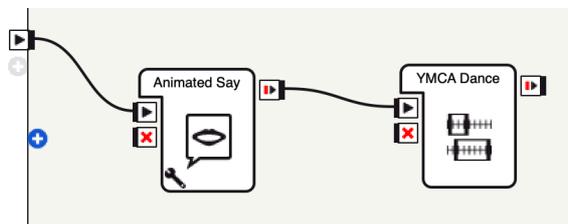
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To finish, we need to connect the **onLoad** input to the **Animated Say** play input and the **Animated Say** onStopped output to the **YMCA Dance** play input



Now that all the connections are completed, we can run the program by pressing the **Play behaviour** button in the **toolbar**



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