NextGen Head Kit

V2.0
Dennistries Ltd
dennistries.com

“*At bottom, robotics is about us. It is the discipline of emulating our lives, of wondering how we work.*”

-Rod Grupen

Law 1
A robot must never harm a human, or through inaction, allow a human to come to harm.

Law 2
A robot must obey any orders given to it by human beings, except where such orders would conflict with the First Law.

Law 3
A robot must protect its own existence as long as such protection does not conflict with the First or Second Law.

Isaac Asimov, 1942

Welcome to the exciting world of Robotics!

Robotics is an exciting field that is growing in importance. Slowly, robots have been entering into our lives, whether by building our cars, serving us drinks or even a robot lawn mower, robots are now everywhere.

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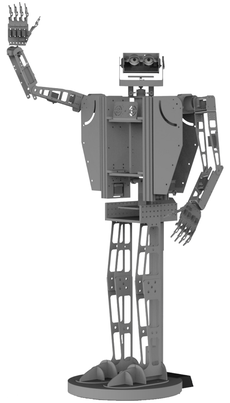
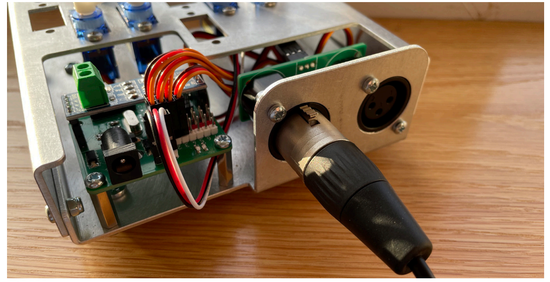
NextGen Head Kit

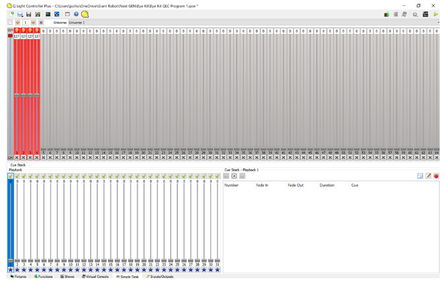
The NextGen Head Kit brings the excitement of human like robotics to the table top in a small kit form. We have taken the head and neck out of our world renowned GREG NextGen unit, put it together with a base, added some special electronics and turned it into a kit just for you, with no soldering or programming required.

Throughout the construction of this kit you will begin to understand the basics of robotic mechanics, which is called 'mechatronics'. You will learn about how motors can move parts of a robot in a life like way, and then you will learn how to build shows using specialised show control software, just like Disney do with their Audio Animatronics.

Starting below, and continued on the next two pages, you will be introduced to the software protocol used to control this kit, DMX. You will then be introduced to some of the key parts of the kit. Following this we have the instructions to build this kit, and to control it, plus a section on how to take your projects further.





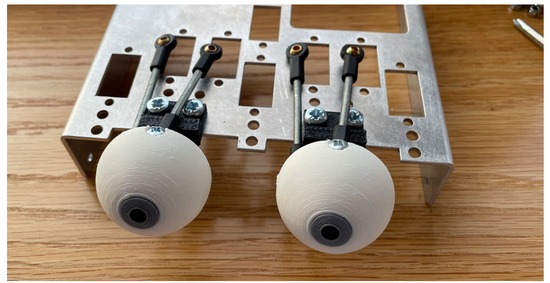


DMX

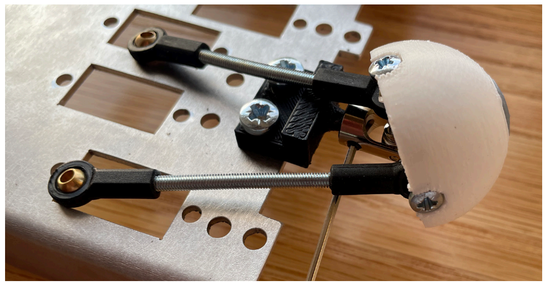
Digital Multiplex 512 (DMX 512, or just DMX) is a protocol based on RS485. The protocol, which can theoretically span a 1km long cable, is most commonly used for controlling disco equipment such as lighting. It sees a lot of use in the theatre industry for controlling lights, where in a single theatre the cable could loop around every light and not reach its maximum length. The '512' is because DMX can control up to 512 addresses in a single DMX 'universe', so an RGB light is three addresses, one for each colour. This can be a quick and easy way to control the unit, with the addresses mapped to the various motors. Each DMX receiving device will have two sockets, one for in, and one for out. Devices are then connected together in a long chain, with the controller at the start.

Servo Motors
Servo Motors are a special type of motor that allows for accurate positioning. Most motors have two cables, positive and negative. Servos have a third cable, a data cable. Servos can be set to a certain degree, as opposed to just spinning. Servos also come with ‘Servo Horns’ which enable parts to be screwed to the servo motor’s shaft.

Lock Nuts
Lock nuts are very similar to normal nuts, but are slightly longer, with a blue nylon ring. When the bolt cuts into the nylon, it becomes much harder to turn the screw. This ensures the screw is locked in place. You will need to hold the lock nut with pliers when tightening. Bolts come in either M3 (for 3mm holes) or M4 (for 4mm holes) in this kit.

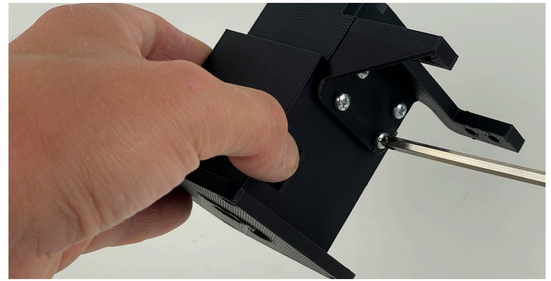


Eye Balls
The eyes for the unit are 3D printed in various colours to give the impression of an eye ball, an iris and a pupil. There are two mounting holes for pusher arms, one on the top, and one on the left (when looking at the eye from the front.

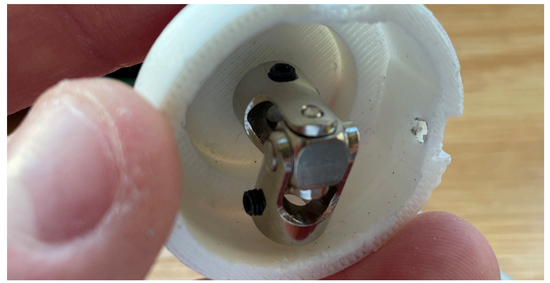


Eye Pusher Arms
The eye pusher arms enable the eye to be moved by the servo motors. There are two types, Vertical types, where the holes on the end of the pusher arms are at the same angle, and Horizontal types, where the holes on the end of the arms are at ninety degrees to each other.

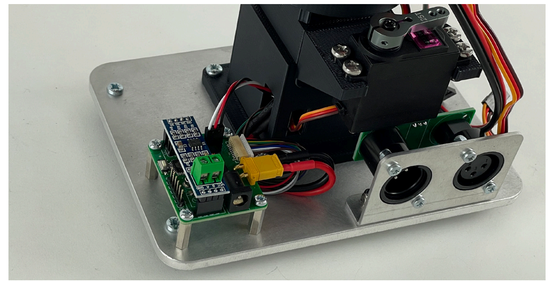
Aluminium Components
The head is based around many aluminium components, mostly out of 2mm thick sheet aluminium that has been cut and folded into shape.



Plastic components
There are numerous components that are 3D printed in PLA plastic, making up the neck, eye and mouth mechanisms. Some of these contain heat set nuts, allowing you to screw directly into the parts.



Universal Joints
Universal Joints are mounts that allow parts to be moved in two axis of motion. These are used to allow the eyes to move up and down, and left and right, but do not enable forward and backward motion.



Circuit Boards
There are three circuit boards in this kit, the first is the Main Controller, which is mounted on four stand-offs, the DMX interface, which is screwed into a mount on the base, and the Servo Board, which is in the head.

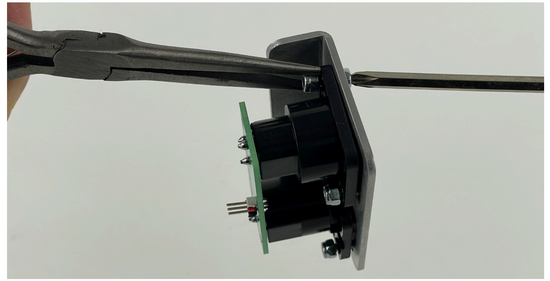
It’s time to build!

Clear a space where you can construct the product. The box contains numerous parts in bags. Be sure not to mix the parts, as some look similar to others.

On the opposite page you can see a full parts list. Be aware that some components come with spares too, so there may be more of that part than listed here.

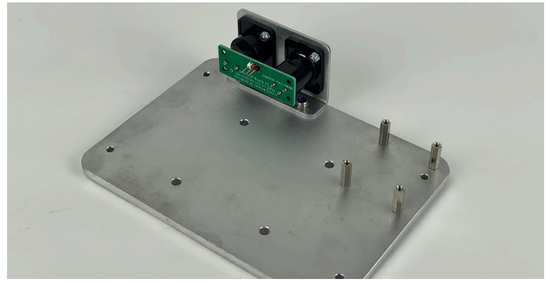
x8	No4x6.5mm Self Tapping Screws	A
x15	M3 Lock Nuts	A
x8	M3 Washer	B
x4	M3x16mm Stand-offs	C
x4	M3x10mm Countersunk Screw	D
x6	M3x6mm Machine Screws	A
x6	M3x8mm Machine Screws	B
x10	M3x10mm Machine Screws	C
x7	M3x12mm Machine Screws	D
x4	M3x16mm Machine Screws	E
x39	M4 Lock Nuts	E
x4	M4x16mm Stand-offs	F
x44	M4x10mm Machine Screw	G
x12	M4x12mm Machine Screw	F
x4	M4x16mm Machine Screw	H
x1	M4x40mm Machine Screw	F
x3	M6 Lock Nuts	G
x2	M6x40mm Hex Bolt	G
x4	M6x100mm Machine Screw	G
x1	Neck Bearing	IN BOX
x2	Linear Rails	IN BOX
x7	3mmx3.5mm Spacer	D
x2	4mmx2mm Spacer	F
x2	6mmx16.5mm Spacer	H
x2	Eye Assembly	J
x1	Neck Base	IN BOX

x1	Neck Lower Servo Mount	IN BOX
x1	Neck Mid Servo Mount	IN BOX
x1	Neck Upper Servo Mount	IN BOX
x1	Neck Top	IN BOX
x1	Base	IN BOX
x1	Neck Plastic Pusher Rod	I
x2	Neck Pusher Rods	I
x2	Base Feet	I
x1	Hinge	I
x2	Eye Mounts	I
x1	Control Circuit	IN BOX
x1	DMX Socket Circuit	IN BOX
x1	Servo Control Circuit	IN BOX
x1	Data Cable	IN BOX
x1	Power Cable	IN BOX
x1	BLACK/RED/WHITE Cable	IN BOX
x3	Standard Servos (labelled)	IN BOX
x2	20Kg Servos (labelled)	IN BOX
x4	Micro Servos	IN BOX
x1	Power Supply 5V 3A	IN BOX
x1	USB to DMX Cable	IN BOX
x1	Screw Driver	IN BOX
x1	Needle Nose Pliers	IN BOX
x1	Allen Key	H
x1	Plastic Spanner	H

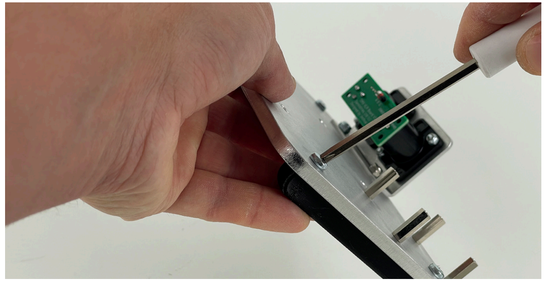


Using four M3x10mm machine screws and four M3 lock nuts, secure the DMX Sockets to the DMX Mount. You will need to use the screw driver and the needle nose pliers for this step.

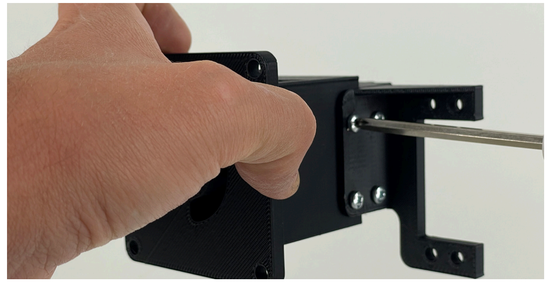
With two M4x12mm machine screws and two M4 lock nuts, we will now secure the DMX Mount to the Base. Insert the machine screws from the bottom of the base, and reach under the DMX Mount to secure the lock nuts in place. Be sure to get the Base the correct way around.



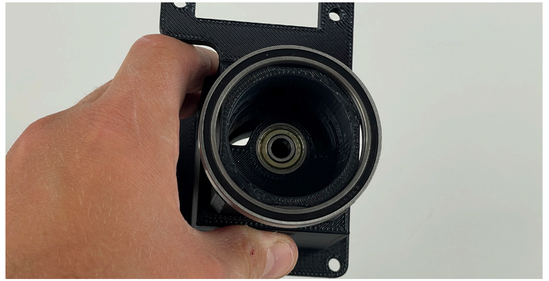
On the other side of the Base there is four 3mm holes which are countersunk on the bottom of the part. Using four M3x10mm countersunk screws, mount four M3x16mm stand-offs. This will be for the control circuit.



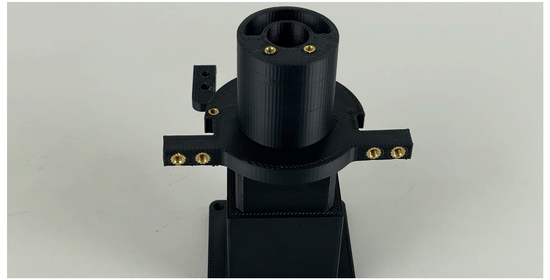
Next we will put the feet on the base. Using four M4x10mm machine screws, secure these parts in place.



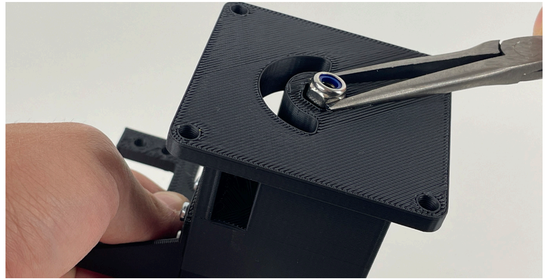
Place the Base assembly to the side for the moment, and pick up the neck and neck servo mount. On the back of the neck are four M3 hear set nuts. Using four M3x8mm machine screws, secure the Neck Servo Mount to the Neck.



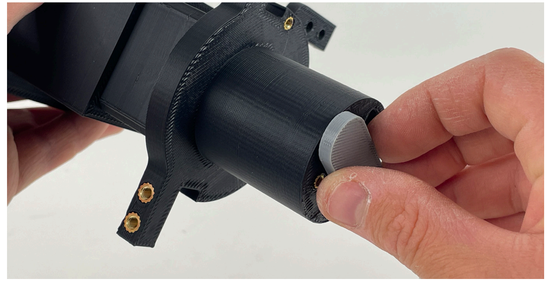
Next, push the large bearing over the top of the Neck. This will be a tight fit.



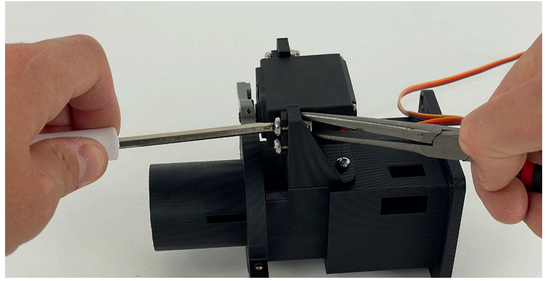
On top of this bearing, push the Neck Mid Servo Mount into place.



Looking at the bottom of the neck, there is a space for a M6 lock nut to be inserted. Push this in, ensuring the blue nylon ring will be facing down when the neck is standing the right way up. This lock nut may slide down after you insert it, make sure it does not fall back out the neck.

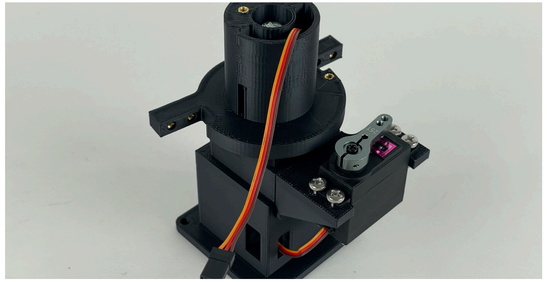


From the top of the Neck Mid Servo Mount, insert the M6 100mm machine screw. To screw it into the M6 lock nut inserted in the last step, use the plastic hex socket spanner.

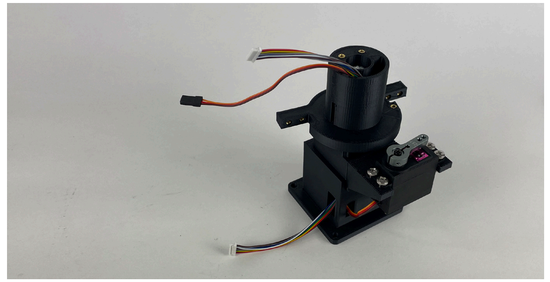


Using four M4x12mm machine screws and four M4 lock nuts, secure the servo labelled ‘Lower Neck’ into the Lower Neck Servo Mount. Ensure it is in the correct orientation.

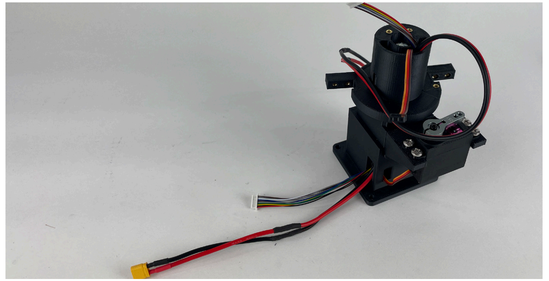
Using two M3x10mm machine screws, secure the neck pusher arm to the outer hole on the Lower Neck Servo servo horn and the base of the Neck Mid Servo Mount.



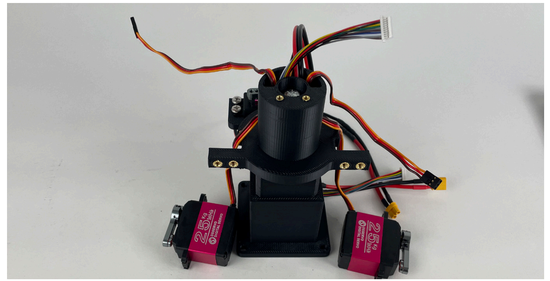
Insert the cable for the Lower Neck servo into the hole at the back of the neck. Thread it through the Neck and the Neck Mid Servo Mount.



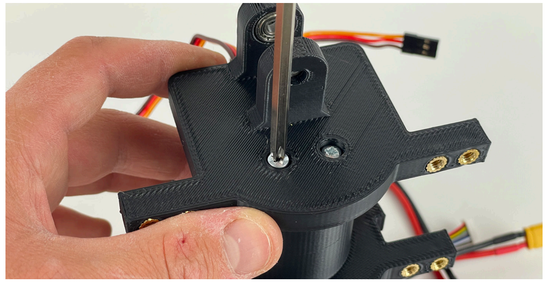
Thread the data cable through the neck, inserting it in the side of the neck where the circuit mount goes, and then up through to the top of the neck.



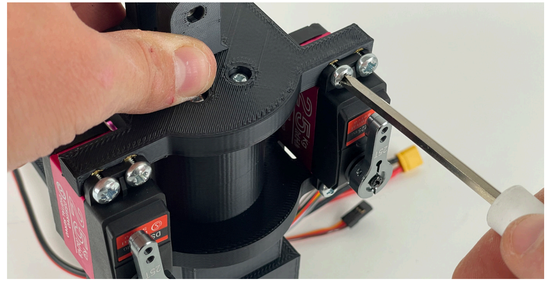
Thread the power cable the same way as the data cable.



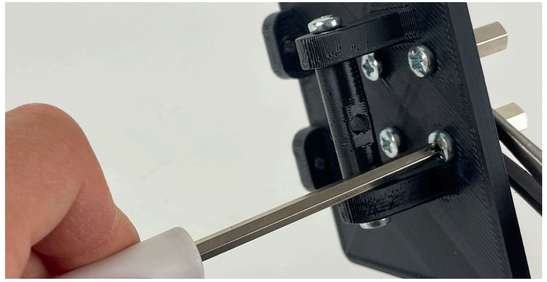
Thread the cables for both the ‘Left Neck’ and the ‘Right Neck’ servos. Ensure you get them the correct way round. Please note this is the left and right for the robot, not as you are looking at it. It can be difficult to fit the cable and connector through the holes, be gentle to avoid damaging the connectors. Thread through to the top of the neck.



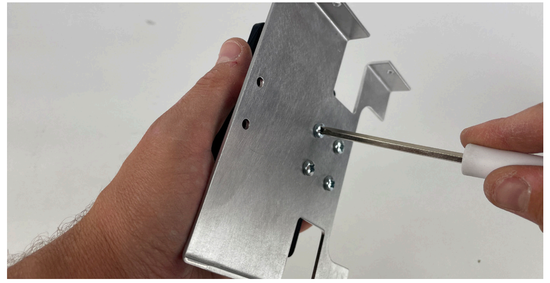
Secure the Neck Top Servo Mount into place using two M3x8mm machine screws.



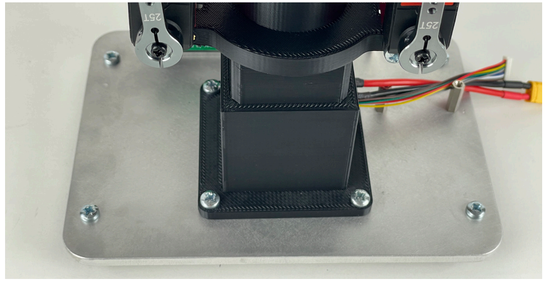
Secure the two neck servos into place, using eight M4x10mm machine screws.



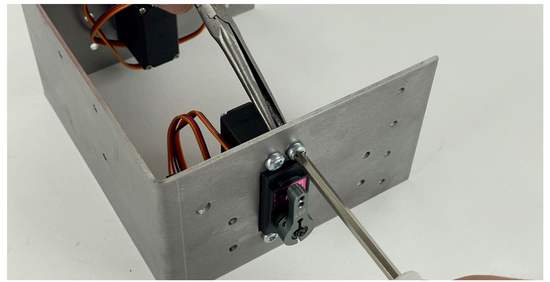
Place this neck assembly to the side for the moment and pick up the Neck Top. Using four M4x10mm machine screws, secure four M4 16mm stand offs into the Neck Top part. The stand offs should be mounted on the flat side.



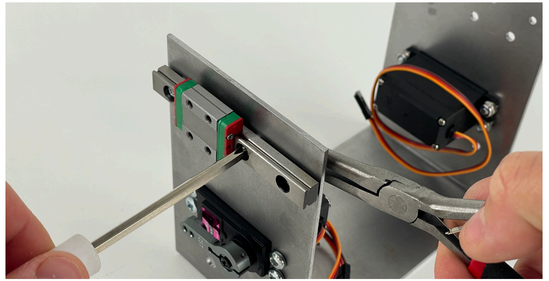
To the other side of these stand offs, secure the Head Base using four M4x10mm machine screws.



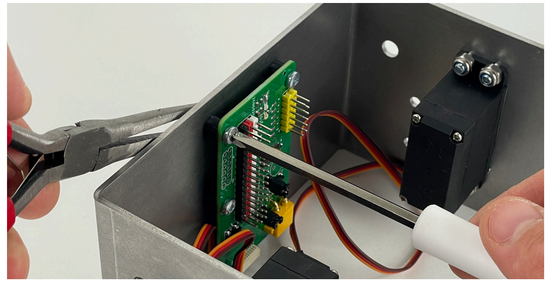
It is time to secure the main neck assembly to the base assembly. Using four M4x16mm machine screws and four M4 lock nuts, secure the neck so it covers the ‘Top’ label.



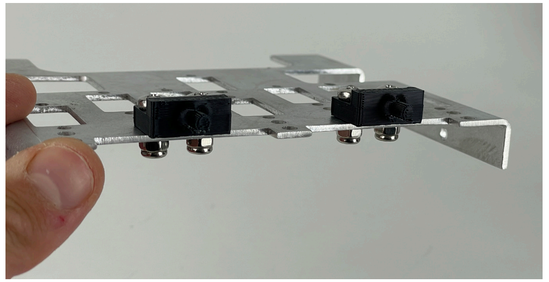
Pick up the Head part, and the ‘Left Mouth’ and ‘Right Mouth’ servo motors. Secure these into the head using eight M4x10mm machine screws and eight M4 lock nuts. Be sure to get these the correct way around. The open side is the front of the head, and the two holes on the rear panel of the Head are at the top.



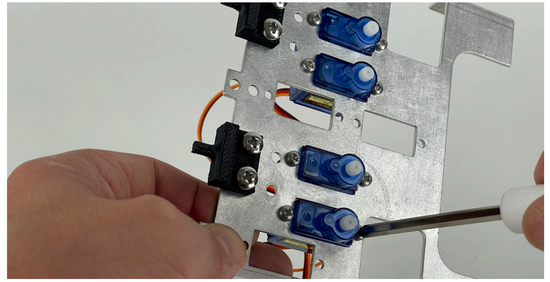
We will next install the linear rails. Be aware that these may have oil on them. Be careful, if the carriage comes off the rail, the ball bearings will fall out and the part will be unusable. Attach these on each side of the mouth, putting a bolt in the top and third holes. Place two M3 washers on each bolt (four to a side, eight in total) between the slider rail and the Head part. Use four M3x12mm and four M3 lock nuts for this.



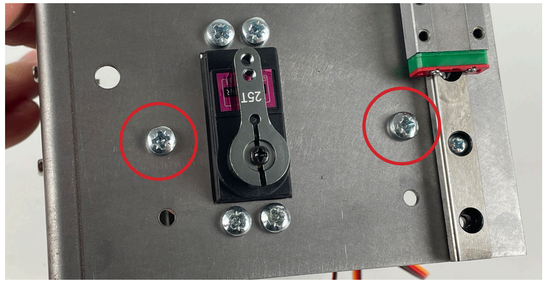
Next, we will mount the Servo Board to the rear of the head. Using three M3x12mm bolts, three 3mmx3.5mm spacers and three M3 lock nuts, secure this part in place.



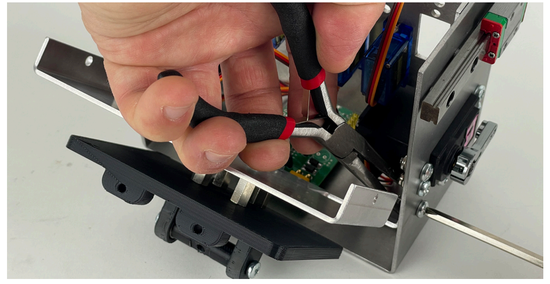
Secure the Eye Mounts to the Eye Plate using four M4x12mm machine screws and four M4 lock nuts. Ensure the Eye Mounts are the correct way around.



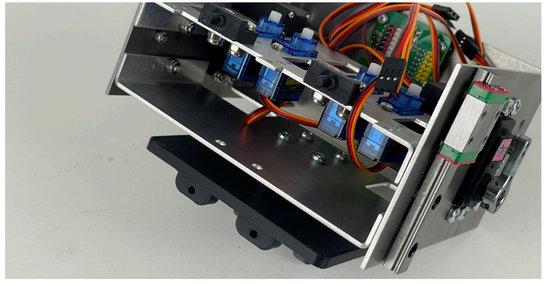
Install the four micro servos into the correct holes using eight self tapping screws.



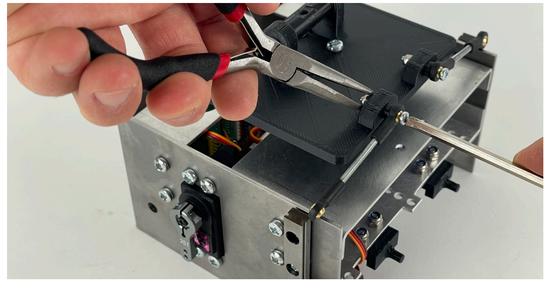
Slide the eye plate down into the head and mount it on the top side holes, using four M4x10mm machine screws and four M4x10mm lock nuts.



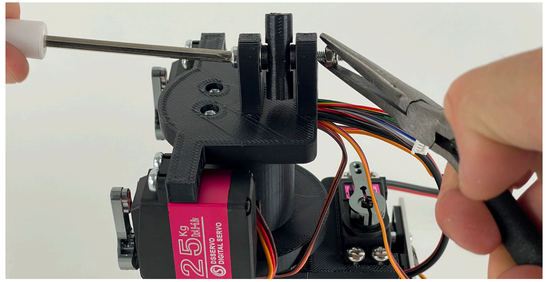
To mount the Head Base part, side it in from the bottom of the head and insert a M4x10mm into each of the back holes. Tilt the part so you can reach in with the needle nose pliers and secure these bolts with two M4 lock nuts.



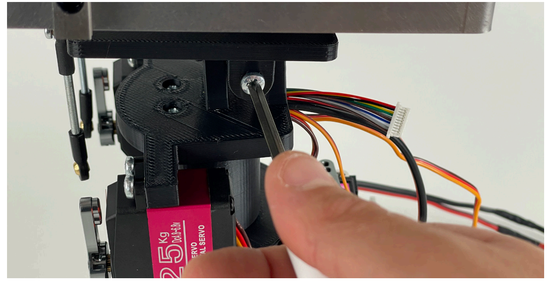
Tilt the Head Base part up so you can repeat the last step using the front holes.



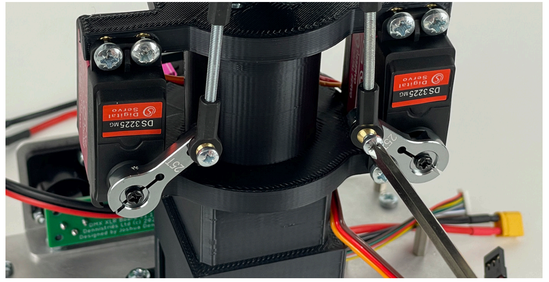
Secure the Neck Pusher Rods using two M3x16mm machine screws, two 3mmx3.5mm spacers and two M3 lock nuts.



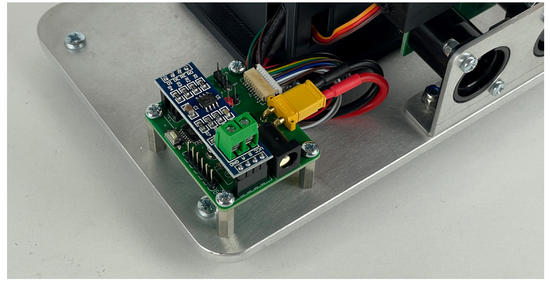
Place the head assembly to the side and move back to the main assembly. Using a M4x40mm, two 4mmx2mm spacers and a M4 lock nut, secure the hinge into the top of the neck.



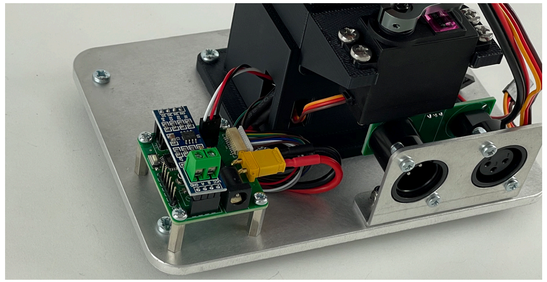
Secure the head assembly to the hinge using two M4x12mm machine screws.



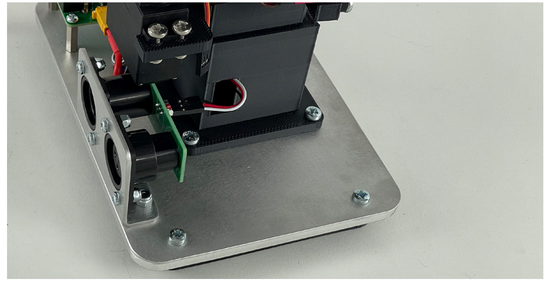
Secure the bottom of the Neck Pusher Rods into the two neck servos using two M3x10mm machine screws. These should be screwed into the end holes of the servo horns.



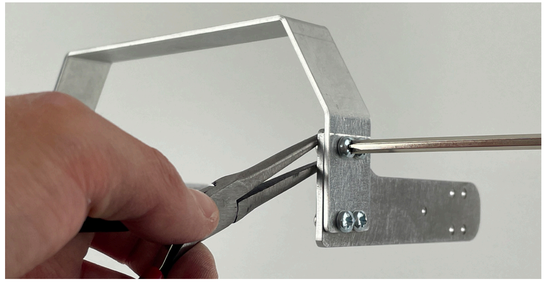
Using four M3x6mm machine screws, mount the Control Circuit onto the M3 stand offs. Connect the power cable and the data cable.



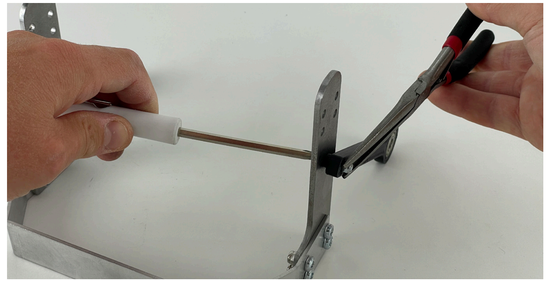
Through the same hole as the data and power cables, push the black/red/white cable. This should go right across the head, coming out the other side, next to the DMX sockets. Connect this into the matching colour coded connector on the control circuit.



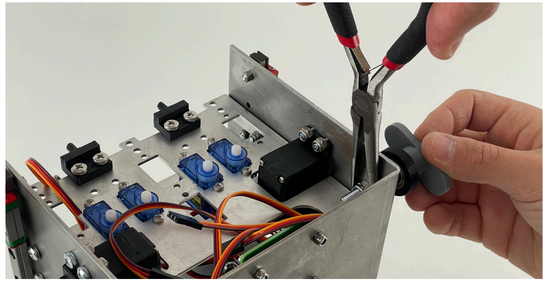
On the other side of the base, connect this cable into the DMX sockets.



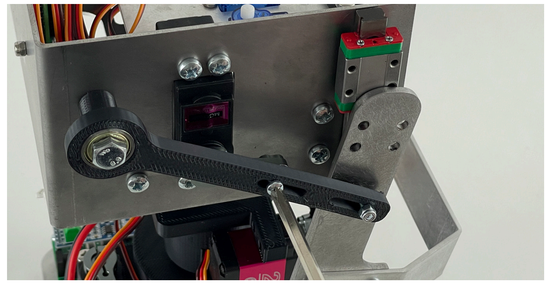
Place this main assembly aside for the moment, and pick up the Jaw part and two Mouth Side Parts. Using eight M4x10mm machine screw and eight M4 lock nuts, connect these together.



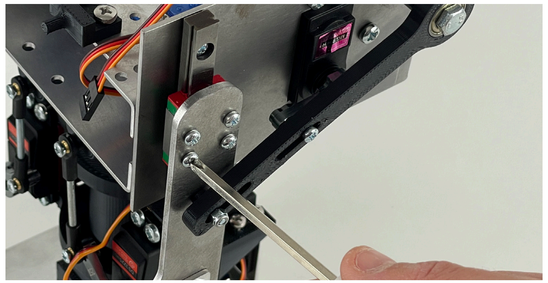
On one side of this assembly we will connect a Mouth Pusher Rod. Insert a M3x16mm machine screw from the inside of the assembly, then place a 3mmx3.5mm spacer on the other side of the Mouth Side. Insert the Pusher Rod, placing the bolt through the lower slot. Secure together using a M3 lock nut. Ensure there is enough freedom for the Pusher Rod to slide along the machine screw. Repeat for the other side of the jaw assembly.



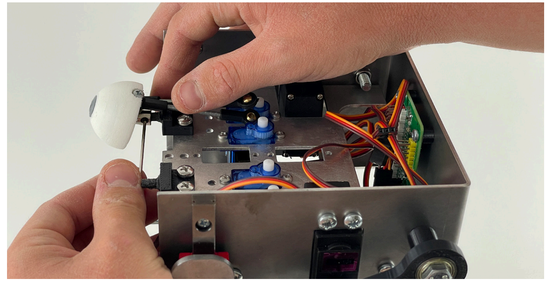
To connect this to the main assembly, we will use two M6 lock nuts, two M6x40mm hex bolts and two 6mmx16.5mm spacers. Thread a hex bolt through one of the bearings. Insert a spacer on the machine screw and then place it through one of the 6mm holes in the back of the head. Use the needle nose pliers and the plastic spanner to secure this in place. Repeat for the other side.



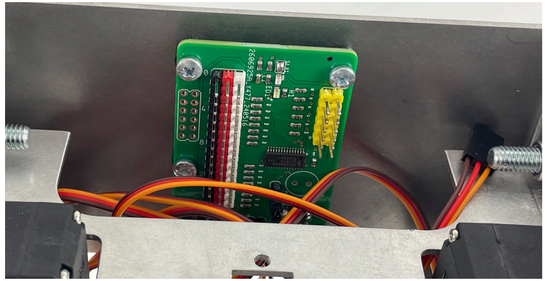
Using a M3x10mm machine screw, secure one of the Mouth Pusher Rods to the matching servo. Screw the machine screw through the mid slot, and into the second hole (not the outer hole) in the servo horn. Repeat this for the other side.



Using eight M3x6mm machine screws, secure the Mouth Sides into the two linear rail carriages. You may need to actuate the servos to connect these in.



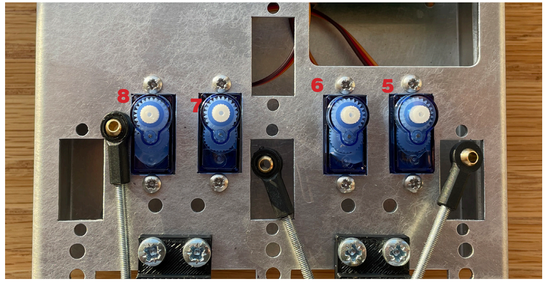
Next, we will secure the eye assemblies into place. Using the included Allen Key, carefully secure each eye assembly into place. These are delicate parts, so be gentle with them. Ensure the eye pusher rods are in the correct orientation.



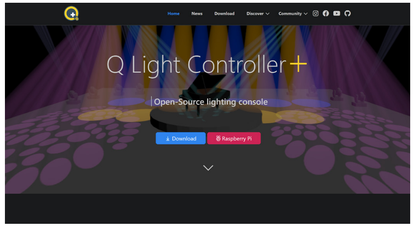
Connect the power and data cables to the bottom of the Servo Board.

It is time to connect the servo motors to the Servo Board. The pins on the board start at 0, and should be connect in the order of;

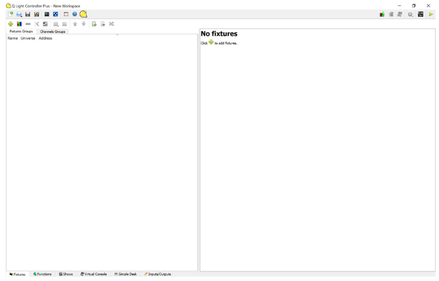
0: Lower Neck Servo
1: Neck Left Servo
2: Neck Right Servo
3: Mouth Left
4: Mouth Right



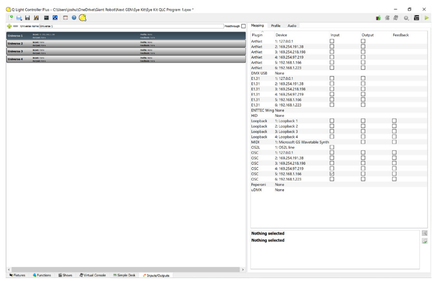
We will now connect the eye servos to the servo board. Connect them in the order shown above. You have now nearly completed the assembly. The next stage will be to connect the eyes to the servo motors. To do this we need the motors to be in the correct position, and we will do this using the control software. The next steps will guide you through downloading the software ‘Q Light Controller Plus’ (QLC+).



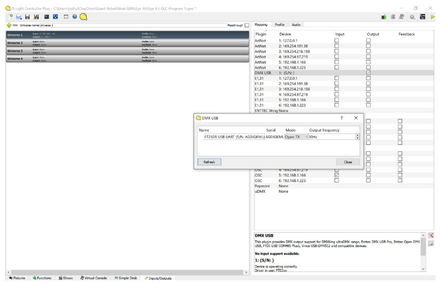
Go to the website https://qlcplus.org/ and follow the download steps, including the download wizard. If you are constructing this as part of a school or university project, speak to your teacher regarding the downloading of the software.
These instructions will only show you how to program the eyes to move, but you can then create your own programs to control the neck and mouth.



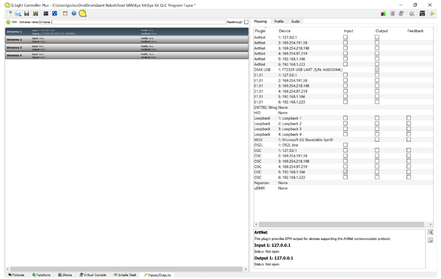
When you open QLC+, you will be greeted by this page. Click the ‘open’ button and open the program you would have downloaded with this manual. If you are constructing this as part of a school or university project, speak to your teacher as to where to find this program.



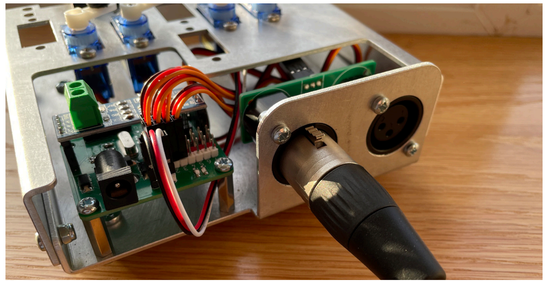
At the bottom of the window, click on the Inputs/Outputs button which will bring up this window. Next, connect the DMX Cable into a USB port on your computer. Double click on the ‘DMX USB’ line on the ‘Mapping’ section



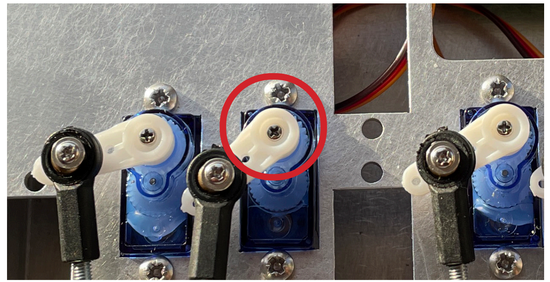
This dialog box will appear. If it is empty, like the one shown, click refresh until your DMX Cable appears, then click close.



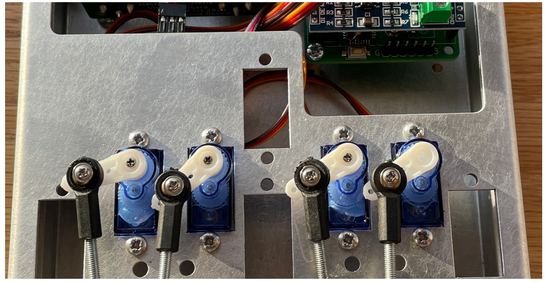
Back on the Inputs/Outputs page, the DMX USB cable should now be an option. Click the tick-box next to this, under the heading ‘Output’. If these has worked, the DMX Cable should start flashing blue. If this has not worked, repeat the previous steps.



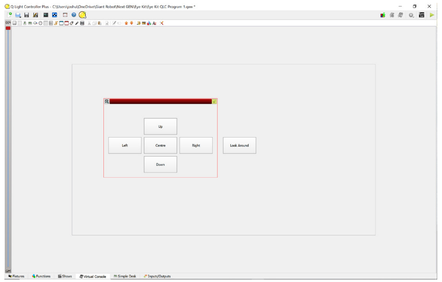
Connect the Power Supply into the Control Circuit. A blue light should turn on. If it does not, immediately unplug your cable and check you have connected the Servo Motors correctly. Then reconnect. Next, connect the DMX Cable into the DMX Interface. It will only fit in one of the two sockets.



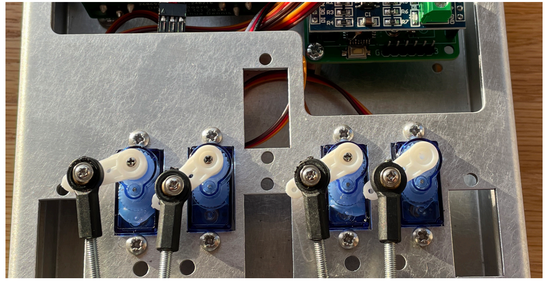
Using the smallest screws in the servo horn pack, secure the servo horns into the servos.



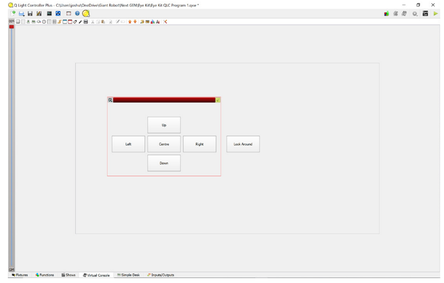
Using the self tapping screws in the servo horn packs, fix the Eye Pusher Arms into their corresponding servo horns. These should be secured into the third hole from the end on each horn, as shown above. This completes the mechanical assembly.



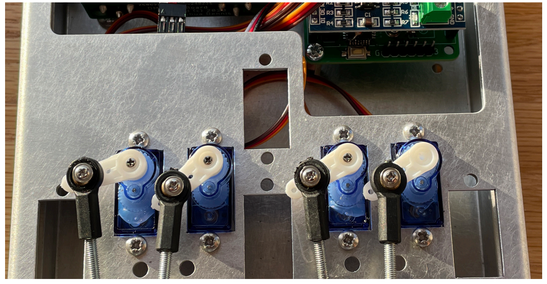
Back in QLC+, click on the ‘Virtual Console’ at the bottom of the window. This will bring up the above page. In the top right corner there is a green ‘play’ button. Click this. It will be replaced with a red ‘stop’ button. Next, click the button in the middle of the page labelled ‘Centre’. You should hear and see the Servo Motors move.



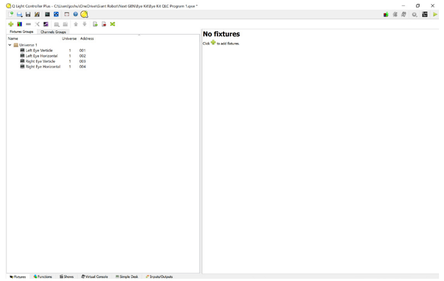
The Servo Motors have been moved into the ‘centre’ position, as if the eyes are looking straight ahead. It is now time to connect them. Take the servo horns that came in the packet with your servos and place each one onto the servos in the above configuration.



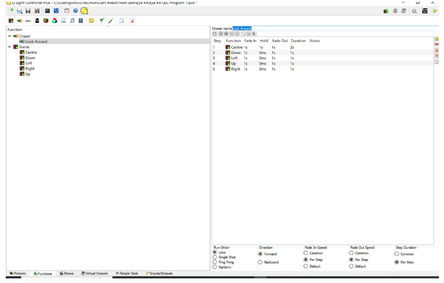
Returning to QLC+, each button in the red box will move the eyes to a corresponding position. The red box is ‘exclusive’, meaning only one button in the box can function at a time. Try pressing the buttons to see where the eyes look. There is another button labelled ‘Look Around’. This button will run the eyes in a sequence where they look around the room.



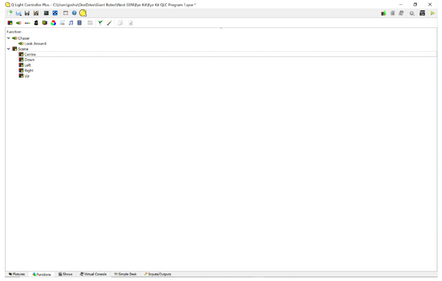
The following steps will take you through the pages of QLC+, enabling you to create your own functions for the eyes.



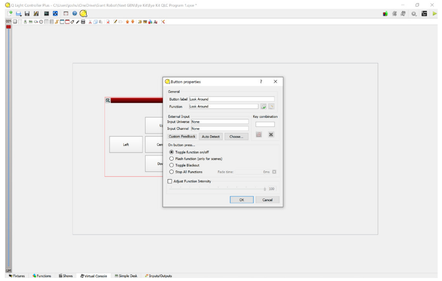
The ‘Fixtures’ page shows the individual fixtures registered in the program. You can see there are four (one for each servo), linked in addresses 001-004. You can have up to 512 fixtures in each DMX ‘universe’. If you wanted to add more fixtures (if you had multiple kits connected together with the eyes on different addresses for example), you click the green ‘+’ symbol.



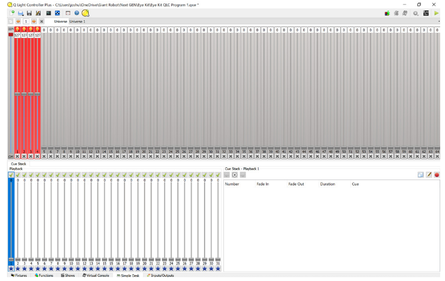
There has also been one chaser created. Chasers allow you to group scenes together into a full motion. Think of scenes like the pages in a flip book, and chasers as the book itself. When you run through a chaser, you are flicking the animation book!



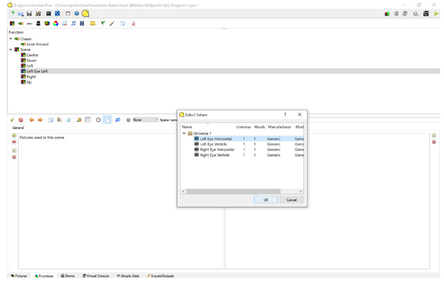
The next page is the ‘Functions’ page. Here you can see five scenes have been created. If you click on a scene, a separate box will appear, and there are sliders for each fixture.



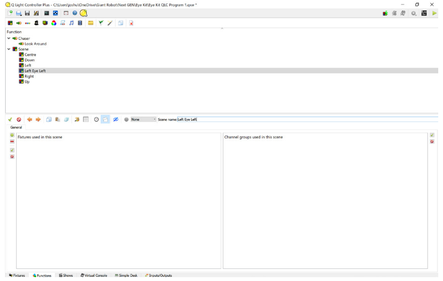
Head back to the Virtual Console page. Ensure the show is not running by clicking the ‘stop’ button in the top corner (if a ‘play’ button is there instead of stop, the show is not running). Double tap on one of the buttons, a dialog box will appear. Here you can see the settings for that button, including what chaser or scene it is linked to (under the ‘Function’ label).



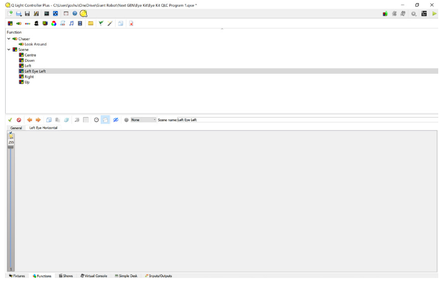
Finally, we arrive at the ‘Simple Desk’ page, where we see a series of sliders. Here you can manually adjust the values for all 512 fixtures that can exist in the DMX universe, but as we only have registered, only sliders 1-4 have a light bulb symbol, showing they are connected to functions. Try moving one of the sliders and see the eyes move!



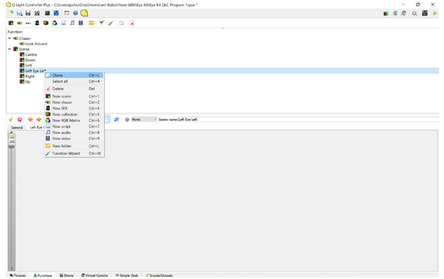
Click the green ‘+’ to add a fixture, and select the ‘Left Eye Horizontal’ fixture. Then press ‘Okay’. This will add the fixture to our scene.



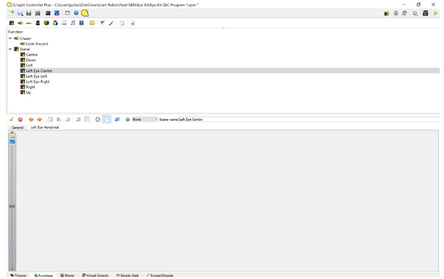
The final part of this manual will be showing you how to build your own chaser and button on QLC+ to make the eyes move how you want them to. For this demonstration we will make just the left eye move. Go back to the ‘Functions’ page and selected the ‘New Scene’ button. The window will display the scene editor with your new scene. Name it ‘Left Eye Left’



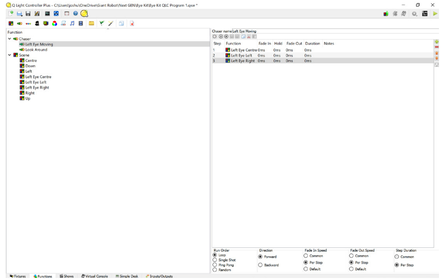
Click on the ‘Left Eye Horizontal’ tab that has now appeared in the scene editor. To enable the fixture, click the check box at the top of the slider, and move the slider to the top.



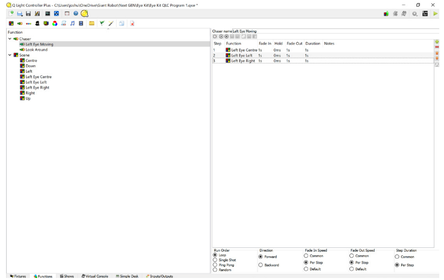
To save time with creating another scene, we can right click on the scene in the main window and select ‘Clone’. This will produce a copy. Rename this copy ‘Left Eye Right’ and adjust the slider to a value of 0, or all the way to the bottom.



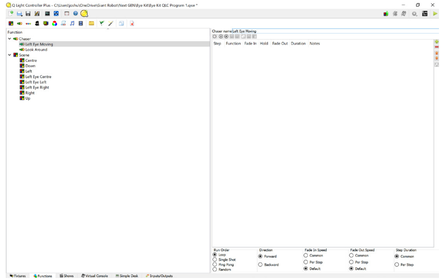
Clone this scene now and name our third and final scene ‘Left Eye Centre’. Set the slider to a value of 127. For ease, you can type the value into the top of the slider.



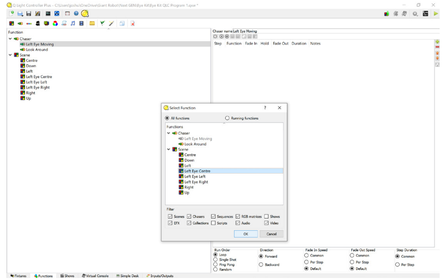
Next, ensure the options for ‘Fade In Speed’, ‘Fade Out Speed’ and ‘Step Duration’ are all set to ‘Per Step’. This means each scene can be assigned its own duration.



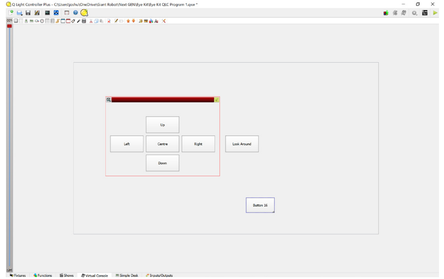
Next, adjust the ‘Fade in Speed’ and ‘Fade out Speed’ values to ‘1s’, (meaning one second) by typing them in the relevant boxes.



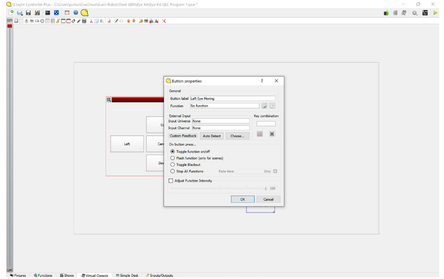
We will now make our chaser. Click on the new chaser button, and a chaser editor will open. Name the chaser ‘Left Eye Moving’.



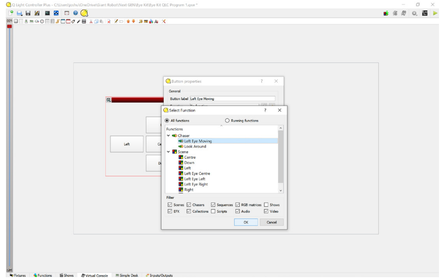
Click the add scene button and insert the ‘Left Eye Centre’ scene. Then repeat this to add ‘Left Eye Left’ and ‘Left Eye Right’



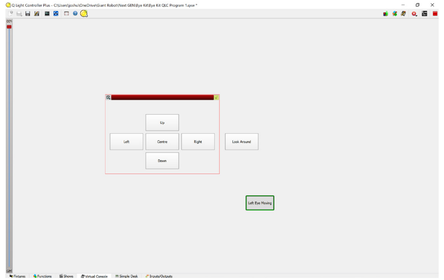
Heading back to the Virtual Console page, we can click the add button symbol to create a button. If you hold the corner of the new button it can be resized.



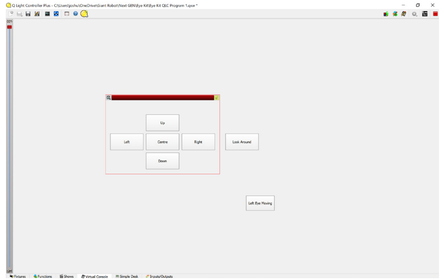
Double tap on this new button and a dialog box will open. Change the button label to ‘Left Eye Moving’. Click on the ‘Attach a function to this button’ symbol.



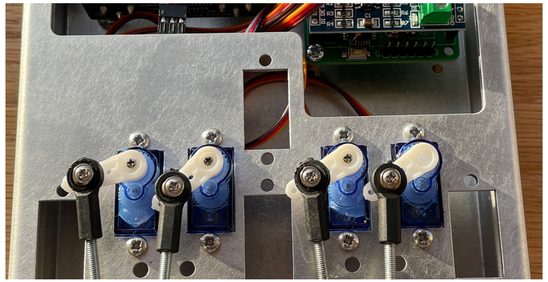
In the next dialog box that has opened, select the Left Eye Moving chaser, and click okay. Click okay again to be returned to the virtual console.



Click the green ‘play’ symbol in the top right of the window to start the show, and click our new button to see the chaser run on the eyes.



You can now build more scenes and chasers on QLC+, and then link them to buttons, sliders and more on the virtual console.



That concludes the main building and programming section of this project, take a look on the following pages to see what else NextGen can offer!

Looking Ahead

You have now completed the NextGen Head Kit. Throughout this pack you have assembled a robot head, including realistic human eyes, a functional neck and mouth, got to grips with a show control software and created your own functions and a mini show.

These are fundamental skills for designing interactive robots that cause people to say ‘Wow’ or ‘That’s crazy!’ Don’t see this as the end, you have just completed Chapter One of your journey.

So where to go now? Continue working with your NextGen Head Kit and continue to expand it’s capabilities. You could use it as the basis of a whole robot, or if you want to get one that has already been designed, take a look at our NextGen GREG.

NextGen is an extensive system with the following products:

> The NextGen Eye Kit, consisting of a set of eyes.
> The NextGen Head Kit, which you have just built.
> The NextGen Hand Kit, with a whole hand, wrist and forearm.
> NextGen Compact, an intelligent table top robot designed for Human Robot Interaction projects.
> NextGen GREG, the full sized humanoid robot, that has been talked about around the world.

More information about each of our products can be found on our website.

The full NextGen product line launches in January 2025.

Good luck with your future projects, and enjoy building!

GREG NextGen V1.0, interacting with people in the summer of 2023.