

Choosing a camera for ANY-maze

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1 Introduction

ANY-maze supports a range of different camera types, but some of these are now considered to be *legacy* devices and if you're planning to buy a new camera then you'll essentially be choosing between:

- A USB webcam
- An industrial USB camera
- An analogue camera

1.1 USB webcams

USB webcams are inexpensive and provide good quality images in most conditions. They do, however, have a couple of drawbacks. They have *fixed* lenses (you can't change the lens) which usually have a lens angle of around 40°; this might be a problem if you have a large piece of apparatus, as the only way to get the apparatus into the camera's field of view will be to move it further away. Also, they usually have quite short *captive* cables, which means you can't unplug the provided cable and plug in a longer one. That said, you can purchase extension cables.

Key points:

- Low cost - typically around \$50
- Can't change the lens
- Short, captive cable (but can be extended by 4.8m)
- Good for use in normal lighting conditions
- Some cameras are infrared sensitive and can be used with infrared lights to track in the dark
- Recommended for apparatus which is not very large and which is not used in low light, for example Plusmaze, Y-maze, open-field, etc.

1.2 Industrial USB cameras

Generally speaking, *industrial* USB cameras are the best choice for ANY-maze. They provide good quality images in most lighting conditions, have interchangeable lenses and are always infrared sensitive, which means you can use them to track in darkness using infrared lights. They don't have *captive* cables, although their cable length is still limited to maximum USB cable length of 15 feet (4.8m), although this can be extended by an additional 15 feet using a USB active extension cable.

Key points:

- Extremely flexible
- Interchangeable lens
- Maximum 4.8m cable (can be extended by an additional 4.8m)
- Good for use in all lighting conditions (except very low light)
- Infrared sensitive - can be used with infrared lights to track in the dark

- Recommended for all apparatus
- Cost around \$350 with a lens

1.3 Analogue cameras

Analogue cameras are designed for security applications and generally work very well in even extremely low light. They also have interchangeable lenses and an essentially unlimited cable length. However, to connect them to a PC requires a digitiser card which fits in a PCIe slot, something only found on desktop computers. They also need to be connected to power, whereas USB cameras are powered by the USB cable.

Key points:

- Extremely flexible
- Interchangeable lens
- Unlimited cable length
- Good for use in all lighting conditions, including very low light
- Infrared sensitive - can be used with infrared lights to track in the dark
- Recommended for all apparatus
- Require a digitiser card (which can only be fitted to a desktop computer)
- Cost around \$250 with a lens, plus \$200 for the digitiser (although the digitiser can connect to 4 cameras)

1.4 Using multiple cameras

If you want to track in multiple apparatus simultaneously then you may need multiple cameras (remember you *can* place multiple apparatus under a single camera, if they'll all fit). The issues relating to connecting multiple cameras to a PC are discussed fully in the Connecting multiple cameras topic, but the key points are:

- Connecting up to 3 USB cameras to a notebook is straightforward
- Connecting up to 6 USB cameras to a notebook can usually be achieved but depends on the computer
- Connecting up to 15 USB cameras to a desktop is achievable, although usually it's cheaper and simpler to use analogue cameras
- A single digitisers can be connected to up to 4 analogue cameras. It's usually possible to install up to 4 digitisers in a desktop computer, for a total of 16 cameras.

2 USB cameras

2.1 Introduction

USB cameras are usually the best choice for ANY-maze. USB webcams are inexpensive and work well in many situations, while Industrial USB cameras are flexible and work very well in almost all apparatus. That said, there are still some circumstances where analogue cameras can provide better performance and/or a cheaper option - for more details about the pros and cons of the different camera types refer to Choosing a camera.

- Webcams - recommended specifications
- Industrial cameras - recommended specifications
- Extending a USB cable
- Mounting a USB camera

2.2 Webcams - recommended specifications

Most modern USB web-cams are suitable for use with ANY-maze although we'd advise against very cheap devices as these can provide poor quality images. We recommend devices from manufacturers such as Microsoft and Logitech.

The only significant choice you'll need to make when selecting a webcam is the resolution. Although it might seem that higher resolution will be better, this isn't usually the case as high resolution images just require more processing without adding much additional information (from a tracking point of view). That said, if you only plan to use a single camera then (unless you have an old computer) any resolution should be fine, but if you want to connect multiple cameras, using devices with lower resolutions would be better.

2.3 Industrial cameras - recommended specifications

We recommend the industrial USB cameras from The Imaging Source, specifically their USB 2.0 Monochrome Industrial Cameras. That said, devices from other manufactures should work fine, as long as they are provided with a *DirectShow driver* (most will be).

A few points to note:

- There is no benefit in using a colour camera with ANY-maze as it only processes and displays black and white images.
- As is the case for USB webcams, choosing a high resolution Industrial camera is usually not beneficial and, if you plan to connect multiple cameras, can actually be detrimental. A resolution of 640x480 is usually perfectly adequate.
- Industrial cameras are available with two types of image sensor, CMOS and CCD. Both are good and it make no difference in ANY-maze which you use. These sensors also come in different sizes, typically 1/4 inch, 1/3 inch and 1/2 inch. Large sizes are more expensive, but 1/4 and 1/3 inch sensors are perfectly adequate for ANY-maze.
- The latest USB version is 3.0 and USB 3.0 cameras are now (in 2016) becoming available.

There are no significant benefits to using USB 3.0 cameras with ANY-maze and, as these devices are usually significantly more expensive than USB 2.0 cameras, we don't recommend them, although they should work fine.

Choosing a lens

Industrial cameras are not supplied with a lens, so you will need to purchase one separately. Choosing a lens is relatively simple once you've calculated the minimum lens angle you need - see Lens calculations. However, you still need to consider the following points:

- Make sure you buy a lens that matches the sensor size of your camera. As mentioned above cameras are available with different sized sensors and you **must** use a lens which matches the camera's sensor size.
- Make sure you buy a lens that's compatible with your camera's lens mount, either C or CS. Some cameras can accept either type of lens but some will only work with one or the other.
- Some lenses have fixed irises, some have manual irises and some have automatic irises. Most industrial cameras do not support automatic irises so, you should use avoid this type of lens. We recommend a manual iris lens.
- If you expect your target animals to be close to the lens (for example, if you'll be tracking *inside* a place-preference box) then check that the lens will be able to focus at that distance.
- Generally speaking the best type of lens to buy is a vari-focal lens as these allow you to zoom in and out so that your apparatus nicely fits the camera's field of view. This is particularly beneficial if you want to work with different sized pieces of apparatus - a rat plusmaze and a mouse Y-maze, for example.

2.4 Extending a USB cable

USB webcams are usually supplied with *captive* cables (you can't unplug the cable) of about 2 or 3 metres length. As the camera has to be mounted over the apparatus and the computer will ideally be positioned out of the animal's view, these short cables can be a problem.

Industrial USB cameras don't have a captive cable so you can purchase a long USB cable and use that, but be careful - the USB specification mandates that cables are no longer than 15 feet (4.8m), some manufacturers do make longer cables but these can be unreliable and we'd strongly advise against using them.

If you need to extend a USB cable then you should use what's called an *Active* extension cable. These include electronics which "repeats" the USB signal, thus allowing it to travel another 15 feet. Again, some manufacturers exceed the distance specification, but you should avoid cables which are longer than 15 feet as they may prove to be unreliable. You should also avoid any extension cable which is not *active*, unless the total length of all the cables from the camera to the computer will be no more than 15 feet.

We don't recommend connecting multiple extension cables together - so using a standard 15 foot cable with a single 15 foot active extension, giving 30 foot (around 10m) in total, is the maximum distance you can achieve.

We don't recommend a specific product, but a search of Google for "Active USB extension cable" will usually turn up a wide range of options.

Finally, there are USB extension cables available which convert the USB signal to a network signal, which

can then be transmitted through a long (50m or more) network cable, before being converted back to USB again. In theory these should allow you to extend a USB cable well beyond the 10m limit, but we have never tried them and so can't provide any sort of recommendation.

2.5 Mounting a USB camera

While it might seem an obvious thing to mention, don't forget that you'll have to mount your camera above your apparatus. Industrial cameras come with a standard fitting in their base which allows them to be screwed onto a camera mount, however USB web-cams don't include this feature.

As web-cams are usually very light the easiest way to mount them is simply to stick them to the ceiling with duct tape - not too elegant but it works. Alternatively, if you have a suspended ceiling, cut a hole the size of the lens in a ceiling panel and stick the lens through the hole - the panel will easily be strong enough to support the camera's weight.

3 Analogue cameras and digitisers

3.1 Introduction

ANY-maze will work with almost any analogue video camera you might encounter. There are a few specialist cameras you can't use but any standard CCTV (closed circuit TV) camera, such as a security camera will work fine (subject to the considerations described below).

Before going into the details, it's important that you understand that to use an analogue camera with ANY-maze you'll need a *digitiser* (sometimes called a frame grabber or a capture card). These devices convert the analogue video signal from the camera into digital data which ANY-maze can process. This, by the way, is the key difference between analogue and USB cameras - USB cameras don't need a digitiser, the video signal already being digital. For more details see [Choosing a camera](#).

- Choosing an analogue camera
- Choosing a lens
- Choosing a digitiser
- Video cables, connectors and camera mounts

3.2 Choosing an analogue camera

As I already mentioned, ANY-maze will work with almost any analogue camera. However, if you plan to work in low light you should pay particular attention to the camera's sensitivity. Here are the *recommended* specifications.

| | |
|-----------------------|--|
| <i>Camera type</i> | Use a black and white camera. ANY-maze <i>will</i> work with colour cameras but it doesn't use the colour information so buying a colour camera is a waste of money. Indeed, even if you use a colour camera the video pictures in ANY-maze will still be black and white. |
| <i>CCD size</i> | Modern analogue cameras use devices called CCDs to capture the video picture. These come in various sizes but the most common are half inch and third inch. If you're going to buy a camera for ANY-maze, buy one with a third inch CCD - they're cheaper and perfectly good enough for ANY-maze. You may also encounter quarter inch CCDs - they're not as good as third inch devices but should work OK. |
| <i>Sensitivity</i> | If you plan to work in low light conditions then make sure your camera has a sensitivity of 0.1 lux or below. If low light work is not relevant then you don't need to concern yourself about the camera's sensitivity. Note that colour cameras generally have a much lower sensitivity than black and white cameras. |
| <i>IR sensitivity</i> | All black and white cameras are sensitive to infrared light, but some include an IR block filter. Make sure you choose a camera without a filter as you'll then be able to use infrared lights to track in darkness. |
| <i>Resolution</i> | Unless you plan to track very small targets (in relation to the apparatus size) then the camera resolution is not likely to be important. If you do want to track small targets then a horizontal resolution of 500 lines or greater is best. |
| <i>Video output</i> | 1.0Vp-p 75ohms. |

As I said almost all cameras will meet this specification so, apart from sensitivity in low light, how do you choose one? Well, there are some considerations.

- There are two common types of lens mount: C and CS. Some cameras use one type and some use both. Be careful that your lens and your camera use the same type otherwise the lens won't fit - in fact you can irreparably damage a camera by trying to attach the wrong type of lens.
- Some lenses (see below) include an automatic irises so they can adjust to changing light levels. This can be very useful if you plan to track in various lighting conditions - perhaps with different apparatus. However, for auto irises to work the lens must connect to the camera, so if you want to use an auto iris you need to make sure your camera will support this feature - ask your supplier to confirm this.
- Different cameras use different power supplies. Some connect directly to the mains power (120VAC or 240VAC), some connect to 24VAC power supplies and some to 12VDC supplies. If you use a camera that uses 24VAC or 12VDC you will need to buy a separate power supply too. For this reason we recommend you try to use a mains powered camera.
- If you plan to mount the camera inside a box (for example inside a light-dark box) or close over an animal's home cage, then a *board camera* is probably the best solution. These are very small cameras (typically 2-3 cm cubes) which usually use have a pre-installed (although interchangeable) lens. They're cheap and their image quality is not fantastic, but if the target animal is close to the camera they work well and take up almost no space.
- Although you might find some very cheap cameras on the market, the image quality is likely to be poor. Although ANY-maze doesn't demand perfect quality, these cameras probably won't be good enough. Expect to pay around \$150 for a good camera.

3.3 Choosing a lens

Choosing a lens is relatively simple once you've calculated the minimum lens angle you need - see Lens calculations. However, you still need to consider the following points:

- Make sure you buy a lens that matches the CCD size of your camera. As mentioned above cameras are available with third inch and half inch CCDs (we recommend third inch), and you **must** use a lens which matches the camera's CCD size.
- Make sure you buy a lens that's compatible with your camera's lens mount, either C or CS. Some cameras can accept either type of lens but some will only work with one or the other.
- Some lenses have fixed irises, some have manual irises and some have automatic irises. Using a fixed iris lens is not recommended with ANY-maze because you're likely to want to track in various lighting conditions and a fixed iris will be restrictive. An auto iris is nice, but costs more and must be supported by your camera - see above.
- If you expect your target animals to be close to the lens (for example, if you'll be tracking *inside* a place-preference box) then check that the lens will be able to focus at that distance.
- Generally speaking the best type of lens to buy is a vari-focal lens as these allow you to zoom in and out so that your apparatus nicely fits the camera's field of view. This is particularly beneficial if you want to work with different sized pieces of apparatus - a rat

plumaze and a mouse Y-maze, for example.

3.4 Choosing a digitiser

A digitiser is a device which converts the video signal from an analogue video camera into digital data which a computer can process. You may sometimes hear digitisers referred to as *frame grabbers*, *capture cards* or *video acquisition cards*.

Unfortunately, there are no standards in the world of digitisers, with the result that each manufacturer has its own proprietary system for capturing video images and making them available to application software such as ANY-maze. This means that it's difficult for ANY-maze to support a broad spectrum of devices because we need to develop specific software for each one.

That said, ANY-maze supports around 10 digitisers from various manufacturers, but today, all but one are considered to be legacy devices. The one, non-legacy digitizer is the RTV-24 from Adlink Technology Inc. This device is inexpensive, good quality and can connect to up to four cameras and capture images from them all simultaneously - it is the digitiser we recommend if you plan to use analogue cameras.



Figure 1. The RTV-24 digitiser, which we recommend for use with ANY-maze.

The legacy devices, which will work with ANY-maze, but which we no longer recommend for new systems are:

- The Pico series of digitiser from Euresys s.a.
- The DT3120 and DT3153 from Data Translation Inc.
- The PCI1407, PCI1409, PCI1410 and PCI1411 from National Instruments Inc.
- The DFG/1394-1 and the DFG/USB2PRO from The imaging source.
- Any other DirectShow compatible digitiser - that's a digitiser that is supplied with WDM drivers for DirectShow.

How a digitiser connects to your computer

The RTV-24 is a *PCIe expansion card* which fit into a slot *inside* a desktop computer. This means that your computer must have a free PCIe slot for the card, something which modern 'compact' desktops sometimes lack.

All the legacy digitisers also fit into PCIe (or in some cases older PCI) slots, except for the DFG/1394-1 and DFG/USB2PRO which are FireWire and USB devices, respectively.

3.5 Video cables, connectors and camera mounts

Analogue cameras are rarely supplied with a video cable so you'll need to buy one. This isn't actually such a bad thing as you can then buy a cable that's just the right length to reach from your camera to your computer. However, be careful with connectors. There are two types of connectors in common use with cameras, BNC and RCA. You need to check the type of connector on your camera **and** on the digitiser - which is what the camera is going to connect to. You may well find that the camera has a BNC connector and the digitiser has an RCA connector. Don't worry - the company that supplies the camera can probably make a suitable length cable for you with the correct connectors on it. You can also buy adaptors to convert from BNC to RCA or vice versa.

Don't forget you'll need a mount for your camera. Although these are simple to find you need to make sure that you buy one which will allow the camera to be mounted pointing straight down when the cable's attached - see figure 2.

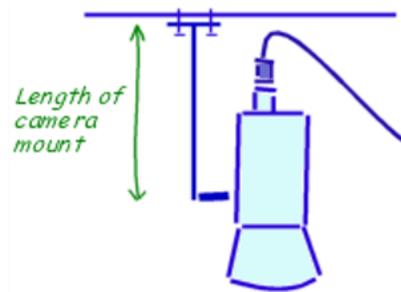


Figure 2. Make sure your camera mount is big enough to allow the camera to point straight down when the cable is connected.

4 Connecting multiple cameras

4.1 Introduction

There are a number of situations when you may want to use more than one camera in ANY-maze:

1. When you want to be able to switch between different apparatus for different experiments.
2. When you want to track in more than one piece of apparatus at the same time.
3. When you need more than one camera to see an entire piece of apparatus.

As ANY-maze can be used with USB or analogue cameras there are three possible situations to consider:

- Connecting multiple USB cameras
- Connecting multiple analogue cameras
- Connecting a mix of USB and analogue cameras

4.2 Connecting multiple USB cameras

There are three different scenarios to consider depending on what you're trying to achieve:

Scenario 1. Switching between different apparatus

In this scenario you don't intend to use more than one camera at the same time, rather you just want to switch to different cameras depending on the apparatus you intend to use.

This is the simplest scenario and there are no special considerations. You can simply plug your cameras into any available ports on your computer (or on a hub) and then switch between them from within ANY-maze. For example, you might install one camera over a plusmaze and another over a water-maze - you could then simply select the appropriate camera depending on the experiment you wish to perform.

Scenario 2. Tracking in more than one piece of apparatus at the same time

This scenario is a little complicated because of issues with USB *bandwidth*. The USB bandwidth defines how much data can be transferred across a USB connection in a set period of time. Suffice to say that as you connect more cameras so the amount of data that need to be transferred increases and eventually you'll reach the bandwidth limit. Now, you might be thinking that this shouldn't really be a problem if you simply connect one camera to one USB port and another camera to another port and so on. However, things aren't that simple because the bandwidth limitation doesn't apply to the USB port, it applies to the USB *controller*, which is built into your computer. So, for example, you might have 3 USB ports on your notebook but they may all connect to the same USB controller - this means they'll all have to share the same USB bandwidth.

Trying to quantify the exact bandwidth limitation gets technical, but usually you can connect 3 USB cameras to a single *controller* before you'll have any problems. So, if you want to connect, for example, 5 cameras, you'll need two USB controllers. Fortunately, most computers have multiple controllers in them and you'll often find that the some of the computer's USB ports connect to one controller and some to

another. So, in our example, you could connect 3 cameras to ports that connect to one controller (using a USB hub, if necessary) and 2 cameras to ports that connect to the other controller.

Clearly this requires that you know the relationship between the USB ports and the USB controllers in your computer and this is something that you can find out using the USB viewer built into ANY-maze.

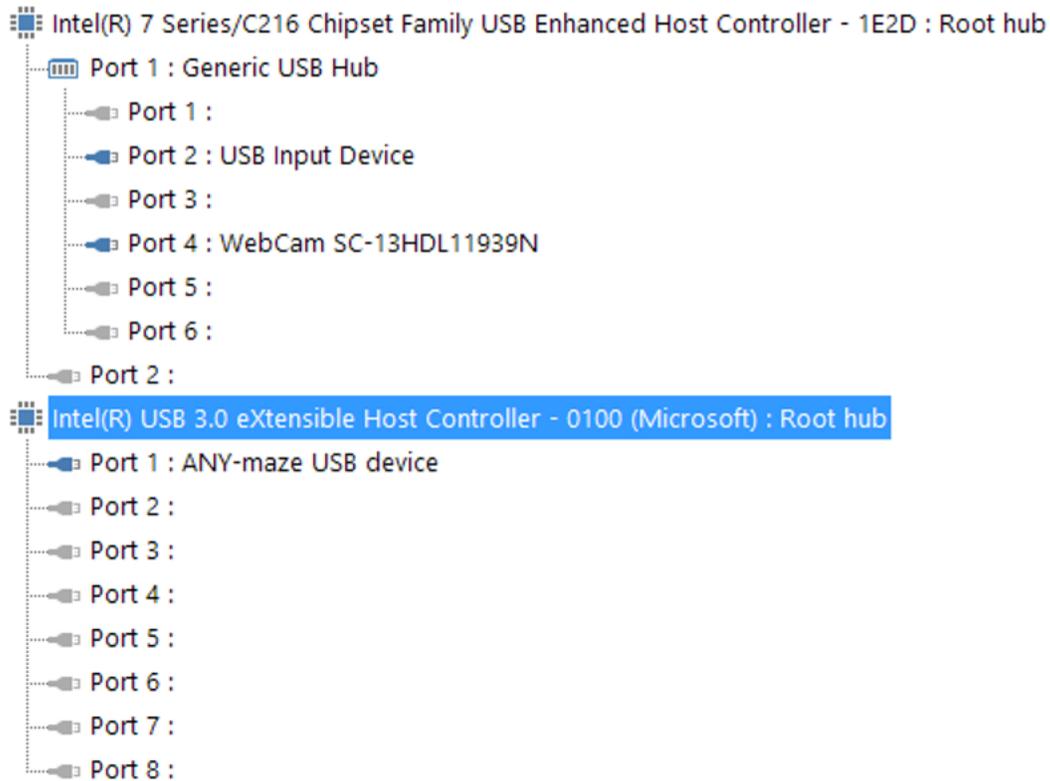


Figure 3. The ANY-maze USB viewer shows the USB controllers in your computer and the ports connected to each one.

As mentioned above, some computers have USB ports which connect to different USB controllers, but in some machines all the ports connect to one controller and in any case it's unlikely that there'll be more than two controllers with external ports. This raises the question, how do you connect more cameras if you've exhausted all the ports/controllers that are available? There are a couple of things you can do:

- You can reduce the frame rate of the cameras, which means they'll send fewer images per second which in turn means they'll use less bandwidth. Note that this doesn't always work, because not all cameras can have their frame rate adjusted.
- You can add another USB controller to your computer. USB controllers can be purchased on expansion cards which plug into a PCIe slot in your computer. Each card usually has a single USB controller, so this means you can connect up to 3 more cameras to each card. Only desktop computers have PCIe slots (and even then you should check, because so-called *compact* desktops sometimes exclude them). This means you can't add more controllers to a notebook PC.

Scenario 3. You need more than one camera to see the entire apparatus

This scenario is very similar to the previous one, in that you will need to connect more than one camera and capture images from all of them and the considerations are identical.

4.3 Connecting multiple analogue cameras

As you would expect, if you want to connect more than one analogue camera to your computer then each one will need to connect to a digitiser. As for USB cameras, the exact requirements will depend on what you're trying to do.

Scenario 1. Switching between different apparatus

The simplest solution in this case is to just use a single digitiser and physically plug in the correct camera for your experiment. However some digitisers, including the recommended RTV-24 device, have connections for more than one camera, allowing you to connect multiple cameras and simply switch between them from within ANY-maze.

Scenario 2. Tracking in more than one piece of apparatus at the same time

In this scenario you will obviously need to have multiple cameras connected to your computer at the same time. In this using the recommended RTV-24 digitiser is the best solution as it includes four camera inputs all of which can capture images simultaneously. (Some other digitisers include multiple connections which can only capture an image from one camera at a time - with 4 cameras connected this will typically reduce frame rates to around 6 frames per second.)

Of course, there's nothing to stop you using more than one digitiser so, for example, by using 4 RTV-24s you could capture on 16 inputs simultaneously, although this would require that you are using a desktop computer with 4 available PCIe slots.

Scenario 3. You need more than one camera to see the entire apparatus

This scenario is very similar to the previous one, in that you will need to connect more than one camera and capture images from all of them.

4.4 Connecting a mix of USB and analogue cameras

There's no reason why you shouldn't use a mixture of USB and analogue cameras with ANY-maze - indeed if you want to automate a range of apparatus this may offer the best solution.

For example let's imagine we want to automate the following equipment:

- A plusmaze
- Two place preference boxes
- A water-maze in which you want to track in low light

A good solution might be:

- A USB webcam, to automate the plusmaze.
- Four industrial USB cameras (one on either side of each box) to automate the place preference boxes.
- A good quality analogue camera (which will be very sensitive in low light) connected to an RTV-24 digitiser to automate the water-maze.

With this set up you'd be able to choose whether to perform an experiment in the plusmazes, in the two place-preference boxes simultaneously or in the water-maze, without having to move or reconnect any cameras.

5 Lens calculations

5.1 Introduction

To ensure that your apparatus will fit in your camera's field of view you need to perform a simple calculation. This will tell you the minimum *lens angle* that you need.

5.2 Lens angles

Any lens has a value called its *lens angle* (sometime also called its *angular field of view*) which essentially tells you how wide the camera's view is - see figure 4.

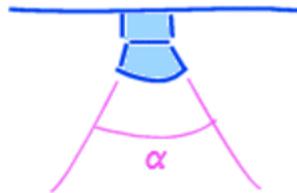


Figure 4. The lens angle alpha determines how wide the camera's field of view is.

As you may realise, a lens might have a different lens angle in the horizontal and vertical planes and, in fact, there are *three* lens angles you might encounter - horizontal, vertical and diagonal, but the horizontal angle is the most commonly quoted. What's more if you know one you can make an approximate calculation of the others:

```
Horizontal = Vertical / 0.75  
Horizontal = Diagonal x 0.80
```

These won't give exact answers but should be close enough for our purposes. Nevertheless, if at all possible, I'd suggest you try to find out the horizontal angle of any lens you want to use.

5.3 Calculating the required horizontal lens angle

Generally speaking you'll be constrained to a minimum lens angle by the size of your apparatus and the height of the ceiling in the room you want to use. As you'd expect the bigger your apparatus is, the further away from it the camera will have to be in order to see it all. However if the camera reaches the ceiling and still can't see all the apparatus then you'll need a wider angle lens - see figure 5.

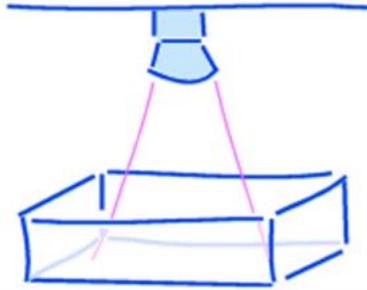


Figure 5. With this lens the camera can't see the entire open field. You'd need to move the camera up (which is likely to be difficult) or use a lens with a wider angle.

To calculate the lens angle, the first thing you need to do is to measure: the distance from the camera lens to the surface of the apparatus, the width of the apparatus and the depth of the apparatus - we'll call these measurements *a*, *b* and *c* respectively and they should be in centimetres - see figure 6.

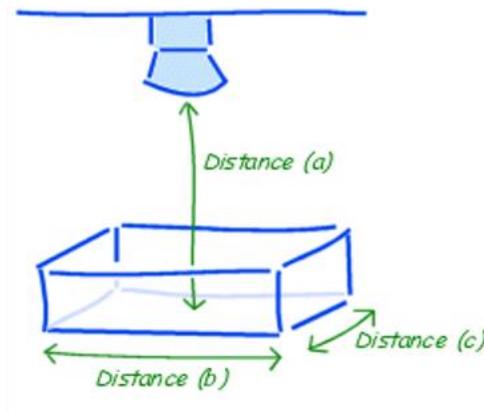


Figure 6. The three dimensions you need to measure to calculate the required lens angle for a piece of apparatus.

Next follow these steps:

1. If *c* is greater than *b* then swap *b* and *c*
2. If $c \div 0.75$ is greater than *b* then make $b = c \div 0.75$
3. Multiply *b* by 1.1
4. Divide *b* by 2
5. Subtract the approximate height of the animal (when rearing) from *a*. For a rat a value of 15cm is OK.
6. The required horizontal lens angle = $\text{arc tan } (b \div a) \times 2$.

 You can use the calculator that's part of Windows to calculate the arc tan. Open the calculator,

which can usually be found on the Start menu under Programs - Accessories. Select the View menu and if Scientific isn't selected then select it. Calculate $b \div a$. Next ensure that the Degrees option is selected, then check the Inv box and finally click the tan button. Don't forget that the final lens angle is this value multiplied by 2.

Here's a worked example for a typical plusmaze, where: $a = 200$ $b = 110$ $c = 110$

1. b and c are the same so nothing to do
2. $c \div 0.75 = 147$ 147 is greater than 110 therefore $b = 147$
3. $b = 147 \times 1.1 = 162$
4. $b = 162 \div 2 = 81$
5. $a = 200 - 15 = 185$
6. Lens angle = $(\text{arc tan } (81 \div 185)) \times 2 = \text{arc tan}(.438) \times 2 = 23.5 \times 2 = 47^\circ$

We need a lens with a **horizontal** lens angle of at least 47° . In fact, in the 3rd step we added 10% to the value of b giving us a little leeway in the minimum acceptable value for the lens angle - for example, a 45° lens would be fine.

Of course, if you're planning to use ANY-maze with different pieces of apparatus, a plus-maze and a Y-maze perhaps, then you should calculate the required lens angle for each of them and use a lens with at least the largest angle reported, although in this situation you'd probably do better to use a *vari-focal lens*.

5.4 Vari-focal lenses

If your budget will run to it then, without doubt, the best type of lens to use with ANY-maze is a vari-focal lens. With these lenses you can alter the lens angle and thus *zoom* in and out so your apparatus nicely fits the camera's field of view. This can be particularly important if you plan to use different apparatus, especially if they're dramatically different sizes. For example, if you have a fixed angle lens suitable for a rat water-maze then, if you put a mouse plus-maze under it, the apparatus will only fill a small part of the picture and the mouse itself will be tiny. Of course, even a vari-focal lens only has a range of lens angles (perhaps 35° - 75°) so you should still check that your apparatus will fit it.

6 Working in low light or darkness

6.1 Introduction

Many behavioural experiments are performed in either low light or complete darkness, but clearly you'll still want to track your animals; this topic explains how you can do this.

6.2 Tracking in low light

Some black and white *analogue* cameras are extremely *sensitive* and can produce surprisingly clear images even in very low light conditions. For example, cameras with sensitivity of 0.01 lux are not uncommon (or very expensive) and these will work well in even extremely dim conditions. Note that colour cameras don't share this high sensitivity.

Black and white industrial USB cameras are also quite sensitive, although not to the same extent as analogue cameras. Nevertheless, they can often create usable images in low light. USB webcams, on the other hand, are usually even less sensitive and while they may produce an image in low light, it will typically be low contrast and quite *noisy*.

Having said all that, if you have high contrast between your animal and the background of the apparatus (for example, a white rat on a black maze), ANY-maze will usually track satisfactorily even if the image quality is quite poor. However, if you want to detect the full area of the animal, for example to determine precisely when the animal enters a zone, or you want to detect freezing, then low-contrast, noisy images will not suffice. In these cases you should use a very sensitive camera and/or use the techniques for tracking in darkness - see the next section.

6.3 Tracking in darkness

Most of the cameras you can use with ANY-maze are infrared sensitive. This means you can illuminate your apparatus with infrared light, which the animal won't be able to see, but which will allow the camera to produce an image as if the apparatus were brightly lit.

To use this technique you will need two things:

- An infrared sensitive camera. Almost all analogue and industrial USB cameras are infrared sensitive and many USB webcams are too. Any easy way to check is to view an image from the camera (for example, in the ANY-maze Video page), then point a television remote control at the camera and press a button. If you see a bright spot appear at the end of the remote control then the camera can see infrared. By the way, here we are talking about *near infrared*, there are also thermal imaging cameras available which are sensitive to *long-wavelength infrared*, but these are very expensive.
- infrared lights to illuminate the apparatus. Infrared lights are quite inexpensive and usually take the form of a bank of infrared emitting LEDs - see figure 7. These can be found quite easily by searching Google for "Infrared illuminator". One thing to be careful about is the beam angle, if it is narrow then you'll be lighting the apparatus with something like a flash-light, which will tend to make the centre very bright and the edges dim. One way to address this is to point the device upwards so the light reflects off the ceiling, which usually helps to disperse it.



Figure 7. Infrared illuminators are inexpensive and can be used "light" the apparatus so ANY-maze can track in darkness.

7 Installing and configuring cameras & digitisers

7.1 Introduction

All cameras and digitisers are provided with instructions so installing them is normally a fairly simple task. However, after installation some devices still need to be configured to work with ANY-maze and, of course, you will always want to test everything is working OK.

- Installing USB digital cameras
- Installing and configuring an RTV-24 digitiser
- Testing your equipment with ANY-maze

7.2 Installing USB cameras

Installing USB cameras is usually very simple and we recommend you follow the instructions supplied with your device. However, we do have a few comments:

- Generally it's best to install the software which came with the camera *before* you plug the camera in.
- If possible plug the camera into a USB port that connects to a *USB controller* that doesn't have any other high bandwidth devices attached to it. This won't be an issue if you don't have any other USB devices (or you just have a USB mouse), otherwise you might want to read the Connecting multiple cameras topic which goes into this issue in more detail.

Once you've installed your camera you're ready to test it with ANY-maze.

7.3 Installing and configuring an RTV-24 digitiser

It's important, when installing an RTV-24 digitiser, that you install the driver software *before* physically installing the digitiser in your computer - here are full instructions:

- **First** install the driver software that came with your device. The procedure is described in section 3.2 of the RTV-24 manual and is quite straightforward. Note that you only need to install the driver in order to use the digitiser with ANY-maze; you don't need to install the software package.
- Next, you should physically install the digitiser card in your computer - details on how to do this are in section 3.1 of the RTV-24 manual.
- When you restart your computer after installing the card you will probably see *eight* messages from Windows about new hardware devices being found - this is normal, just ask Windows to automatically install the hardware (although, if relevant, you can tell it to skip checking on the Internet for a newer driver).

By default, ANY-maze will assume you'll be using the digitiser with an NTSC camera - this is the standard in the US and many other countries outside Europe. If, however, you will be using the digitiser with a PAL camera (the European standard) then you need to configure it before it will work correctly:

1. Start ANY-maze.
2. Switch to the Video page
3. Click the  *Setup video devices* button in the ribbon bar.
4. A window will open listing the video capture devices installed in your computer. This should include four entries for your RTV-24 digitiser (because it contains four separate capture *ports*). Click on any of the entries for the card you just installed.
5. Now click the *Configure* button just below and to the right of the list.
6. The RTV-24 digitiser configuration window will open. Here you can specify the default camera type you will be using with the device and also specify any RTV-E4 video extension cards you have installed.
7. After selecting the camera type (and specifying any installed RTV-E4 cards), simply click OK on all the open windows.

You're now ready to test the device with ANY-maze.

7.4 Testing your equipment with ANY-maze

Once you've completed the installation of your camera or digitiser you should test it's working with ANY-maze.

1. If it's not already installed, install ANY-maze.
2. If you're using an analogue camera then connect it to your digitiser. Make sure the camera is connected to the power and, if necessary, is switched on. If you're using a digital camera then make sure it's connected to the computer.
3. If your camera has a lens cap remove it!
4. Run ANY-maze.
5. Switch to the Video page.
6. Your device should be listed on the left side of the page.
7. Click on the item in the list. The image from the camera should appear in the main area of the window.

If your device is not listed, or it is listed but you can't get your video picture to appear, don't panic - there are a number of perfectly benign reasons why this might occur. Refer to the Problems with cameras topic for further assistance.

And don't forget, if you get stuck we're here to help, just contact ANY-maze technical support (techsupport@anymaze.com).