Quintic Hardware Tutorial
Camera Set-Up

All Quintic Live High-Speed cameras are specifically designed to meet a wide range of needs including coaching, performance analysis and research. Quintic LIVE streaming video cameras have full manual controls which ensure they can be used in many different disciplines. Quintic Live High-Speed cameras can be fully integrated with the Quintic Sports, Coaching and Biomechanics Software.

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Camera Alternatives

All Quintic software packages are compatible with a wide range of video cameras including the latest iPhones and iPads. Video files can be uploaded into the Quintic software and played back, provided the correct video codecs are used. Quintic software has increased 'Video Format Compatibility' with the latest digital cameras: the latest iPhone / iPad,*.avi, *.mov ,*.mpeg,*.wmv,*.mp4,*.vob,*.flv.

Video Capture Fundamentals

The average human eye can only separate around 12 images per second, therefore, although coaches are irreplaceable in analysing athletes' techniques, often the coach's eye cannot extract all the necessary details in a live sporting situation.

Video cameras create the illusion of motion by tricking the human eye by playing lots of still pictures per second. Video can very quickly help athletes to understand the fundamentals of a specific movement, providing both them and their coach with immediate performance feedback. The coach and athlete can then discuss their technique and plan strategy for improvement, providing the athlete with an extra dimension of feedback.

Many Quintic High-Speed Cameras allow video capture of up to 1000 still frames per second (fps) at certain image dimensions, capable of capturing even the fastest human movements. Quintic Software allows for up to six Quintic High Speed videos to be imported and analysed live.

Camera Settings

There are four basic operations which can significantly influence the output of cameras and the quality of the images produced:

- **Zoom** –The zoom function allows you to stand much further back from the action while keeping your athlete as large as possible in your camera view.
- **Focus** – Focus can be adjusted manually or automatically (iPad), typically manual focus is recommended (Quintic Live Camera). A good method of setting up focus is to zoom all the way in and focus the picture on some small detail such as a piece of text. The picture can then be zoomed out to the desired level and the image will stay focused, as zoom and focus are independent of each other.
- **Aperture** – The aperture is the opening through which light travels to the camera lens, controlled by the iris within your camera. A smaller iris number equates to more light being let in and therefore a brighter picture, whereas a higher iris number will make the picture darker.
- **Exposure/Shutter Speed** – Shutter speed adjustments are essential for a good quality video. If the shutter speed is too low, fast moving actions will appear blurred as movement will have occurred between the still frames (whilst the shutter remained open). An optimal shutter speed allows for sharp and clear images. It is important to remember that a higher shutter speed will result in a darker image as there is less time for light to enter the iris.

Initial Set-up

There are some important considerations before setting up your camera hardware to minimise the chances of error during recording:

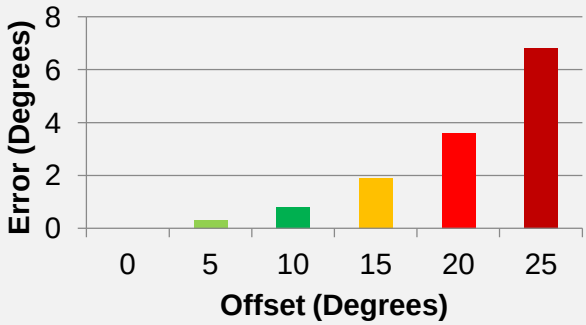
- **Space** – Ensure that there is enough space for your performer to carry out their usual gait or movement pattern.
- **Background** – Ensure that your background is clear so that the anatomical landmarks can be seen clearly on your performer.
- **Lighting** – Ensure that there is enough lighting surrounding the area of interest - this could also include adjusting the aperture on the camera. Additional lighting such as the Quintic High Performance LED Bar Light can also be used to increase the visibility of reflective markers and general anatomy.

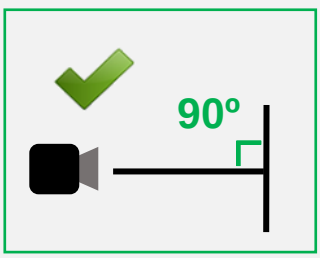
Camera positioning *is a very important part of initial set-up as it rules out two camera measurement errors.*

Parallax Error

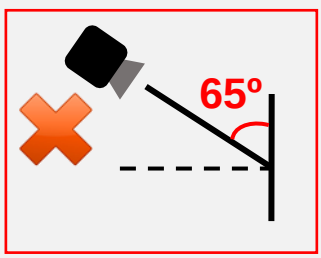
A parallax error is when the measurement of an angle or orientation is incorrect due to the object not being viewed directly side on (at 90º), relative to its plane of motion.

The larger the initial offset in the camera positioning, the greater the angular error in the image will be. An offset of less than 20º is recommended.





Camera is at 90º so there is a 0º offset.

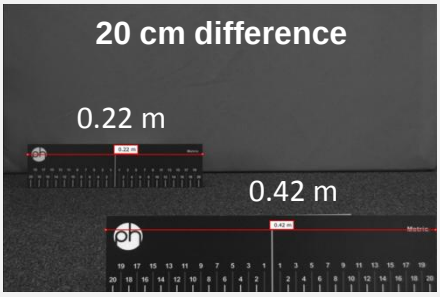


Camera is at 65º so there is an offset of **25º**.

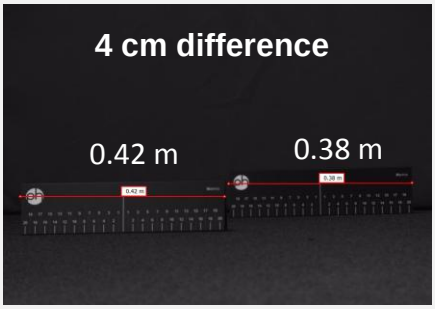
Perspective Error

A perspective error is when there are apparent discrepancies in lengths between two objects of equal length, which are at different depths within the scene.

When the Camera is 1m from the subject:



When the Camera is 10m from the subject:

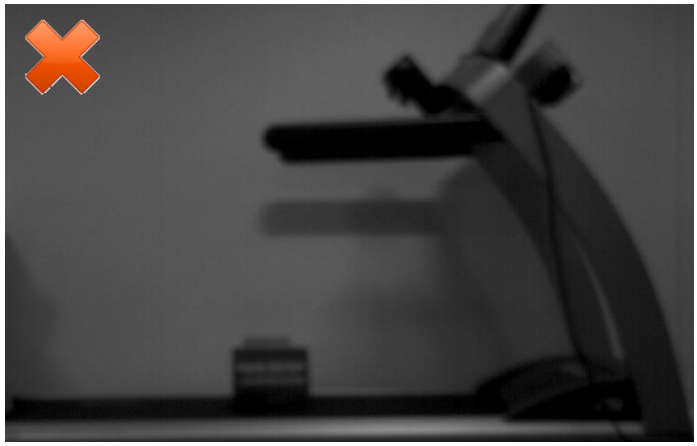


As illustrated above, moving the camera as far away from the subject as viable then ZOOMING IN will minimise the influence of depth on apparent size.

Focus

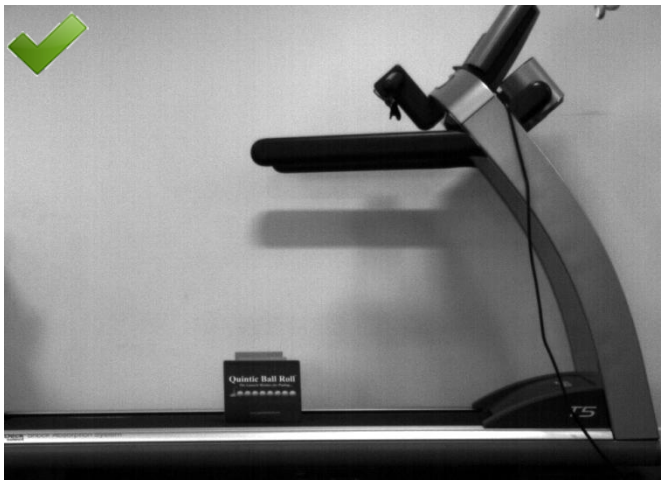
As previously mentioned it is recommended that manual focus is used when using a camera (if this function is available). When you are recording in a fixed plane there is no need for the focus to change throughout the movement, therefore the focus should be fixed.

- With the incorrect focus on your camera lens the image will appear blurry and undefined. This will then cause difficulty when identifying smaller details and landmarks.



- It is recommended to place an object that contains fine detail (such as text) at the appropriate depth in the scene (movement area). This object can then be zoomed in on via the lens and the focus can be adjusted manually so that the text is defined and easily readable.

- You can then zoom out to your desired level, so that all movements of interest are within the field of view. The image will remain focused and even the smallest details will remain in focus.



Camera Settings

Exposure/Shutter Speed

The shutter speed controls the amount of time, and therefore light, that each individual frame is exposed to. If the shutter speed is too low, fast body movements may become blurred.

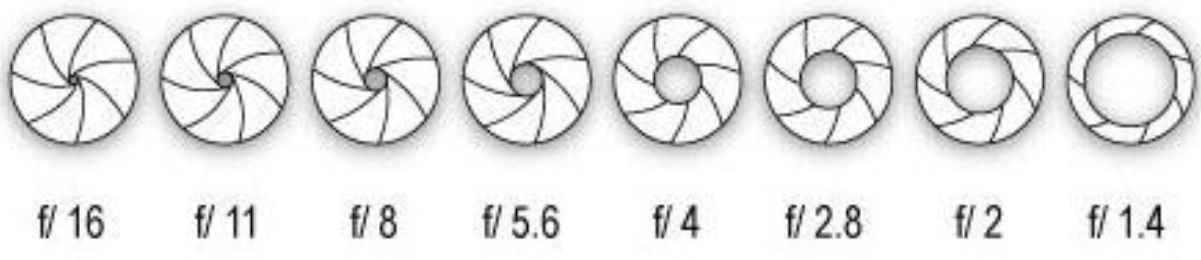
- Increasing the shutter speed during fast movements will reduce the likelihood of blurred images, however it may reduce the brightness of the video recording.
- Careful consideration of the shutter speed is therefore essential and the decision is dependent on both the scenario and the speed of the movement that is being recorded and the lighting conditions. Additional lighting may be required when filming fast movements indoors.
- It is therefore recommended that a few trial recordings are performed to determine the optimal shutter speed for that movement.
- The general rule is that fast movements require faster shutter speeds to ensure the image is crisp for frame by frame analysis.

Shutter Speed	Exposure Time (ms)
1/503	1.985
1/672	1.487
1/800	1.249
1/1010	0.99
1/1257	0.795
1/1457	0.686
1/1555	0.643
1/1666	0.6
1/1869	0.535
1/2032	0.492
1/2232	0.448
1/2469	0.405
1/2941	0.34
1/3367	0.297
1/3952	0.253
1/5319	0.188
1/6896	0.145
1/9803	0.102
1/12500	0.08

Aperture

The aperture is the amount the lens is ‘open’ which therefore dictates the amount of light that reaches the camera image sensor. This can be adjusted to produce optimal exposure and focus, the higher the f-stop the darker the image.

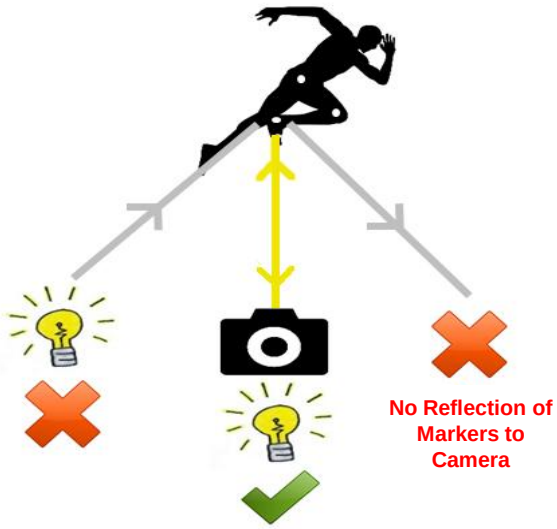
- Normally stated as the f-stop on the lens, the lower the number, the more the aperture is open, resulting in a brighter image. However, having the aperture open fully will reduce the clarity of the image.
- We would always recommend using the middle f-stop, this gives you the best depth of field and sharpest focus of the image.



Lighting

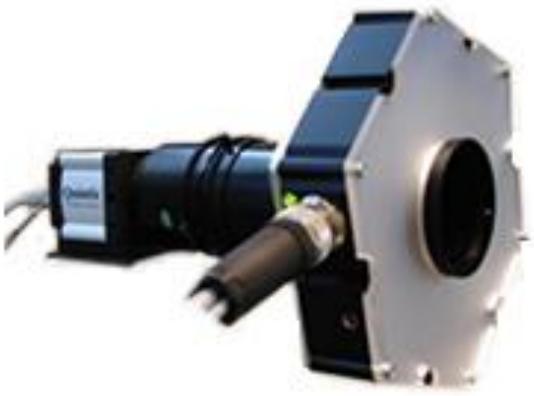
The main use of additional lighting when recording for automatic or intelligent digitisation within Quintic Biomechanics / Coaching / Sports is to ensure the markers are easily visible in the video image. This enables the digitisation process to be performed quickly and accurately.

The most important factor when setting up the additional lighting is to ensure that the light is reflecting directly off the markers and **back** into the camera lens. This requires the lighting to be directly behind the camera lens (perpendicular to the motion). If the lighting is being directed to the markers at an angle, then the reflection will not be directed towards the camera lens and the markers will appear dull.



By placing the lighting on a separate tripod you **MUST** position the light source directly behind the camera. Quintic High Speed Cameras and lighting options can be attached directly to the same plate, ensuring that the light source is being emitted in the same direction that the camera lens is pointing.

Quintic IR Ring Lights produce infrared light, which is not visible to the human eye and so will not have any detrimental effects on the performer. The reflection of the infrared light is still picked up by the Quintic High-Speed Camera, producing clear marker identification from a distance of up to 20m. The light slides directly on to the front of the camera lens ensuring that all the light is reflected straight back into the lens. This light is best used indoors.



Joint Markers

Reflective joint markers are used to indicate an anatomical position of interest on a performer so that the cameras are able to pick these up easily, allowing the analysis of movements to occur.

- The location for marker placement is often identified through palpation of the anatomical position, with the overall aim being to place the marker on the underlying anatomy, giving a true indication of joint position.

The reflective markers allow both linear and angular analysis of the movement:

- Linear outputs such as the distance/displacement, speed/velocity and acceleration of a single point, such as the knee, can be easily calculated using simple calculations:

$$Speed\ (ms^{-1}) = \frac{Distance\ (m)}{Time\ (s)} \qquad Acceleration\ (ms^{-2}) = \frac{Velocity\ (ms^{-1})}{Time\ (s)}$$

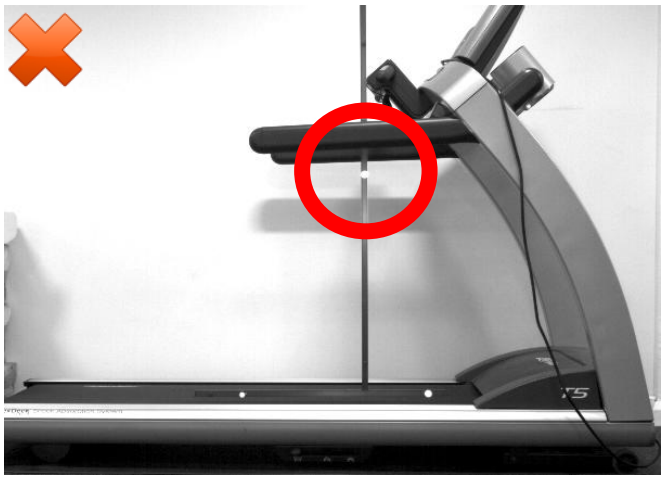
- Angular outputs such as angular displacement, angular velocity and angular acceleration can be calculated using trigonometry if two or more markers are present. For example, the angular position of the thigh relative to the horizontal could be calculated.

Reflective markers can be automatically digitised within Quintic Software using its Automatic or Intelligent Tracking. Quintic then calculates the linear and angular outputs, averages and 95% confidence intervals.

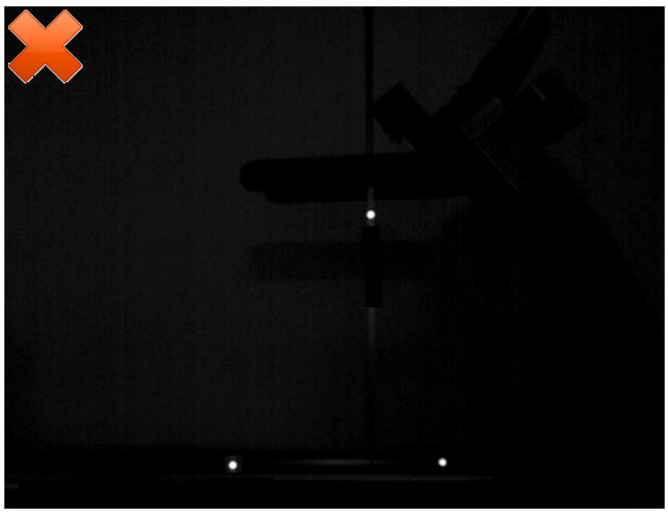
Contrasting Markers

For your video footage to be automatically or intelligently digitised within the Quintic Software, there needs to be a level of contrast between the white markers and the rest of the image. This is to ensure the markers can be easily identified. If this is done correctly it makes digitisation and therefore data collection quicker, easier and more accurate.

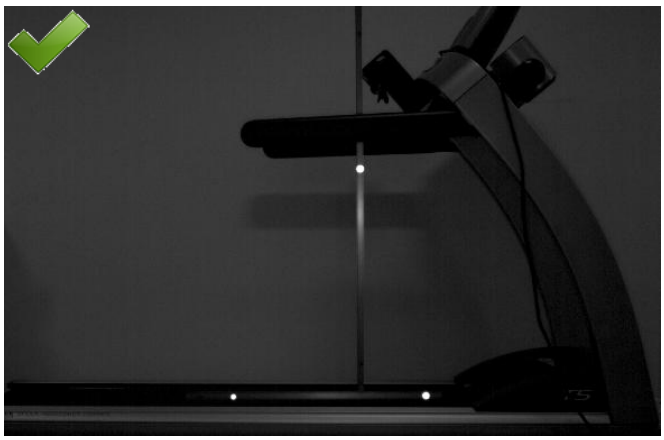
If your image is too bright, although the markers are visible, there may not be enough contrast between the markers and the rest of the background image. The Quintic software may struggle to distinguish the moving markers from the rest of the image and thus digitisation would have to be performed manually rather than automatic or intelligent tracking.



In this case the image is too dark. There is, however, a large contrast between the markers and the rest of the image and so it could be automatically digitised very easily. However, you will not be able to see the performer and will have no reference as to what the movement looks like. This is important when it comes to applying movement to the analysis / results.



This image has the right balance between clear and contrasting markers to allow for automatic digitisation and visibility of the movement. Therefore, you will be able to quickly collect data to analyse, while also applying these results to the physical movements of the performer.



Calibration

Calibration of the videos is necessary so that it is known what a given length within the footage equates to in the real world (e.g. 20cm on the monitor equalling 1m in the real world).

- This calibration is most effectively performed by taking a short recording of an item of known length. However, this video must have been taken with the camera in the exact position and set-up as it will be when recording the subject, otherwise the calibration will not be accurate.

- The use of a calibration wand or a ruler could be used to provide a known length in both the horizontal (x-axis) and vertical (y-axis) directions. It is important to remember that this calibration tool must be held at the exact same depth and position in the scene that the subject will be performing in (e.g. on the treadmill)

The calibration tool should be large enough to reduce the effect of errors when digitising points. You can imagine if you were trying to calibrate using a tool only a few cm's long, the slightest inaccuracy when calibrating these points would be scaled up to cause large inaccuracies over longer distances.

- Correct calibration of the video is crucial for accurate data collection, as the lengths provided are used in the calculations of the linear and angular outputs.

Quintic Software allows you to load external calibration files onto multiple videos, therefore if you are recording multiple videos with the camera and subject in the same position, the calibration process does not need to be completed each time (providing the camera remains stationary).