VFX Sup Guide to Camera Tracking

Introduction

Camera tracking can sometimes be an afterthought when the fur is flying onset. This quick guide is to help a vfx supervisors ensure important information is recorded, laying out tracking markers correctly and identify problematic shots early on.
As tracking is at such an early stage of the pipeline it is an often an overlooked foundation for the rest of the facility. Getting this right, and with economy, helps keep projects on time and budget, saving dollars and headaches.

Software

There are three programs that seem to have become established in vfx facilities that are most noteworthy to my eyes being 3dequalizer, Boujou and Syntheyes. I've used all plus pftrack and a couple of others but for the purposes of this guide I'll be talking in Equalizer.
The reason 3de is my preference is that its one of those rare pieces of software that has been nurtured over its lifetime by the same group of people that are looking for excellence rather than flogging a shallow upgrade. Other software seems to push its auto tracking heavily, which they admittedly do well but where 3de shines is in its manual tracking and lens distortion models. This is important when tracks get difficult making it worth the extra dollars.

Processes in tracking

It may be helpful in identifying the processes in tracking to better understand why the information your recording will help the camera department. The processes are as follows.
Loading footage - a straight forward process but.... You want to provide virgin footage. Cropping, stabilizing or trying to give reconciled stereo footage will only hurt as the programs used are made to work with the unedited image structures. You can safely play with colour and contrasts as long as the data has good visibility. I've once seen a facility try to get an editor to apply lens distortion to footage before it was tracked (based on lens grids) - doing so will almost always end in tears.
2d tracking - this can be manual (tracking individual, manually placed markers), or auto (where the program throws a point cloud of tracking points at footage in order to get the result). Both methods have pros and cons. An experienced tracker should be able to decide the best method on a given piece of footage. This is pretty much a physical task and you can gauge roughly how long it will take based on length of footage, amount of data and spread of needed data. Often a combination of both manual and auto will give you the best result.

Manual 2d Tracking

pros

The tracker is able to gauge the validity of points in order to give the best spread of information.
The tracker can focus on extending vague points to get a better length of information.
Its a clean process helping to minimise bad data that would hurt the result

cons

It takes time to build for a result
unless you spend a lot of time you don't get a point cloud with a vast amount of points

Auto 2d Tracking

pros

- It can be fast on simple tracks
- Because there are large numbers of points involved it will 'average out' and give a good smooth result when it works.
- You end up with a large point cloud which can help with modelling and lineup

cons

- If you need to create a mask for actors and moving objects the time can blow out as you need to clean up the data.
- Difficult footage like motion blur, grain, blur, and poor contrast can leave you bad data you need to clean up

Lens and camera calculation

This is where things get tricky. A tracker needs three things to get a result; camera filmback, focal length and lens distortion.

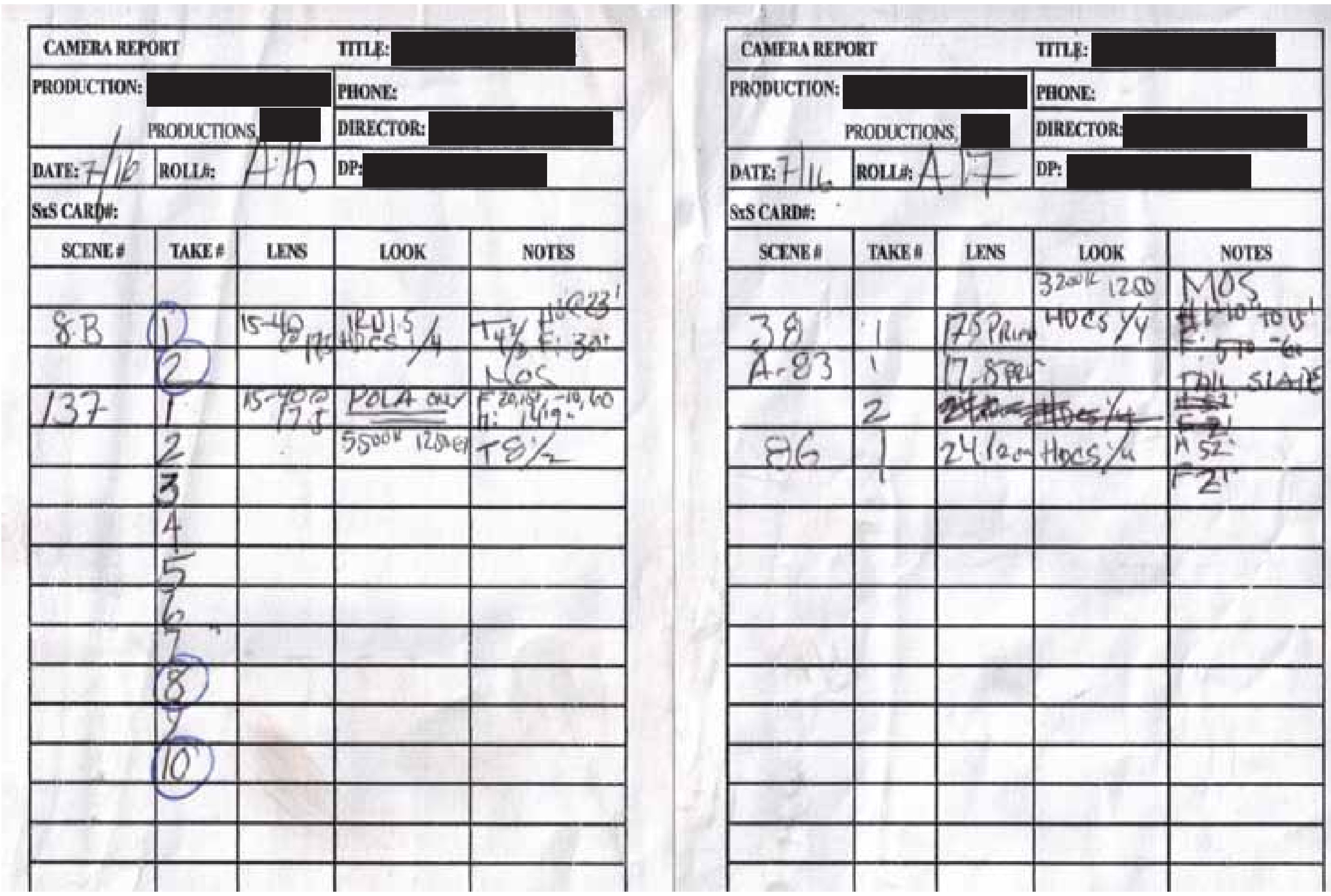
All of these items can be recorded on set and go a great way to getting an accurate result quickly.

It sounds easy as I write it here but the logistics of getting it together its not so straight forward.

Camera - if you can name the camera, say a red epic, we can find out the filmback, usually without too much problem. Its important to get this right as it sets up consistency for the project and will make focal length figures work correctly. It will also provide valuable information such as if the camera is using rolling shutter.

Focal Length - this is usually taken care of by the assistant filling in the camera sheets. It really needs to be better than a scrawl.

fig 1 is an example of a camera report that is actually fairly clear compared to some. Because the onset information is used by the editor and several other hands the linking of what roll, scene and take makes it way to what vfx shot number is rarely made and so it becomes detective work to get it right. By the time the footage gets to vfx we have lost the slate. Notes can sometimes be a clue and you can ballpark lens information. What is needed is the link to vfx number, a serial number on the lens (productions often carry more than one kit) and what camera it is filmed on (often more than one brand of camera can be used).


CAMERA REPORT TITLE: [redacted]
PRODUCTION: [redacted] PHONE:
PRODUCTIONS [redacted] DIRECTOR: [redacted]
DATE: 7/16 ROLL#: A16 DP: [redacted]
SxS CARD#:
SCENE # TAKE # LENS LOOK NOTES

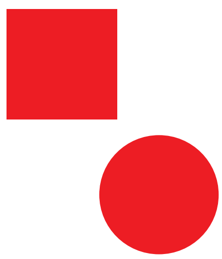
CAMERA REPORT TITLE: [redacted]
PRODUCTION: [redacted] PHONE:
PRODUCTIONS [redacted] DIRECTOR: [redacted]
DATE: 7/16 ROLL#: A17 DP: [redacted]
SxS CARD#:
SCENE # TAKE # LENS LOOK NOTES

fig 1. - camera report

Tracking Markers

The shape of tracking markers can be in a variety of different flavours. I find small squares best as you can track in two modes - pattern or marker.

Marker mode will track a shape - such as a circle so long as the shape does not change too much where as pattern will look for a pattern within the search area - such as a corner of a square. Squares are good because if your far away you can use them as a marker and if you get close you can still use them as a pattern.



When laying out markers on a green/blue screen its desirable to give patterns. Looking at fig2 if we were to go into a portrait shot with a long lens we will often lose our orientation of where on the blue screen we are looking. If the purpose of the vfx is to do a set extension this can be extremely important to make sure the orientation stays true between cuts. Patterns in the markers can help this. A grouping, different colours or a variety of shapes can be good indicators. On the below set we have too few markers, they used the same shape (a '+' sign) and colour barring a few yellow ones. The markers aren't laid out evenly but too sparse to easily identify a particular marker. Also the markers are loaded to where a person can conveniently reach them rather than giving good coverage.

fig 2. - bluescreen markers

Lidar and Survey

Not every production can afford or find time for lidar and survey, and this guide is for those that cannot or choose not to provide lidar. I felt it needed a mention however as it is incredibly useful and will push the tracking into a new level.

Good survey can help pinpoint camera position and greatly improve track accuracy. Not only this but it will provide consistency in scale and position in the tracks for lighting and animation artists. Without those benefits it should be created manually and when working with several people across a sequence it can sometimes get missed.

Lidar and survey however is not without its issues. You need to treat the set as hot once the survey is done.

Often a long lens cuts out distinctive pieces of the survey and so you end up spending time looking for what points in the footage match the survey.

If a set changes, such as a screen gets moved for lighting, then the survey needs to be done again if that screen is in shot. You then need to record what survey matches which shots. And remember it only needs to move a smidge before its considered moved.

Once you have the survey another benefit is that it can go through the modelling department and you get some great consistent geometry to use for placement and shadow catching. This is work that often needs to be done anyway and lidar can help with that process.

On the whole it is well worth the investment if you have a set that will require significant vfx across a great number of shots. Especially if points of contact for digital elements are important or direction of the action requires a special consistency. If however your talking one shot or the requirements allow for digital elements to be more ambiguous then survey can be overkill and you can save the dollars.

Natural Markers

Just because you don't have markers doesn't mean you cannot track. Fig 3 shows a shot that has an abundance of data. The best data here is on flat geometry such as the boxes or the corner of the door. 'Flat' means that there would be no background parallax to interfere with the track like you would get on the corners of objects. Other points to make are that there is good information in the depth, good contrast and spread.

Although this has all those benefits this isn't a great candidate for auto tracking. Auto tracking will pick up all the intersections of foreground and background patterns and so you would spend a bunch of time cleaning up all the bad points

fig 3. - good data

fig 4. - lack of depth

Lack of Depth

A lack of depth can be a major problem with getting good solves on translating cameras. You often get this with walls or screens.

Because there is a lack of depth the translates become ambiguous even when working with survey. Sometimes, to help, you can get away with putting in 'c' stands to introduce a foreground elements. If the translates are not big you might be able to put the camera on a tripod making it a simple nodal solve. Sometimes however, like with this shot, you cannot really do either an just have to work a solution.

Data Swipe

Here our two heros are taking tour of the warehouse. To get a feel for the warehouse the camera is on the far side of the shelving and tracks past the rows. This leads to a situation where the data is constantly changing or jumping in and out of the solve. At best this can lead to a time consuming management of the data but occasionally it can also lead to broken tracks where we get a solve for the start and a solve for the end. Imagine if the swipe was an actor walking past and blotting out all the data. Survey can help this but often it takes some manual cutting and pasting of animation curves.

fig 5. - data swipe

fig 6. - motion blur

Motion Blur

Motion Blur is just a necessary part of tracking that needs to be dealt with. Importantly most tracking software and renderers track to the centre of motion blur so they are in sync. However you can track and render at the beginning and end. If tracks are sliding at the blur you may be out of sync.

When thinking about settings matching 3d cameras are able to increase and decrease the shutter angle so you should think about how that is calibrated at lighting too.

Sub frame motion blur can also be an issue. An animation curve hits a precise point in time, but peaks in the motion on footage don't necessarily hit the centre of the motion blur so you may get a subtle motion blur mismatch. It can also occur when motion blur is slowing down or speeding up - what fun.

Another interesting effect people often don't identify occurs when a blur runs over a background blur. Because the background points exposure to camera is interfered with, that motion blur is clipped throwing out the data.

See the still - the girl is running across the background and each of those background points inside of her motion blur is clipped for that frame.

fig 7. - parallax

Parallax

Parallax is the difference in position a foreground element will make with a background element between frames due to the movement of camera or object.

A common example of parallax is seen when watching a landscape from a moving car. The foreground points whip by while the background moves slowly. Parallax is essential for tracking a moving camera. The shot to the right is awkward as much of the parallax used to track the camera is obscured by the car.

The car is a separate object track but even then it lacks good depth and so the parallax information is shallow. Tracking objects is a house of cards as often the accuracy of the camera track is important to calculating the object track accurately. If getting an accurate track on the car in this shot is important I'd suggest fixing an upright post with a marker on it on the far side of the car. This would improve parallax and give a more accurate result.

An interesting error can sometimes occur with parallax. As with a car, commonly the foreground moves faster than the background, however consider a hand held camera tracking around an object on a table. Here the object is holding its position in frame while the background swings past! This can lead us to seeing inverted results where foreground points register as background and vise versa. Survey will certainly help here - even artificial survey, but often it falls to tweaking and weighing tracking points.

It is here that infinitely distant points are gold (such as the farthest buildings here). These points are far enough away that little or no parallax is registering. These points represent pure rotational values and tracking software is able to identify and use them.

fig 8. - refraction

Refraction

Refraction should be avoided at all costs. You would be better off removing this window an putting it back in digitally than trying to track and render it. Old glass is especially nasty but so too water, car windows or heat distortion.

Also any glass that comes between the filmback and the environment should be recorded in a distortion grid included anything used in stereoscopic work such as mirrors etc.

Producing artificial refraction, even distorted such as this has been around a long time so you shouldn't feel shy about asking for it. Just remember if you were to put a digital gremlin in this shot your lining up for a headache.

Caustic Lighting

Probably not the best example but caustic lighting can be caused by firelight, gas light (like here), reflected pools, rain on a window. Its a really cool practical effect but tracking which relies on consistent patterns can struggle with it.

The best way to get around this is to use LED lights for the tracking markers as they generate their own light.

You will also want to appreciate that it may take longer to track and could be difficult to match at lighting.

fig 9. - caustic lighting

Unseen Points of Contact

This is often a blessing rather than a curse, but it can be. In this shot we don't really know where the floor is.

If we need to put a digital character in here we would be relying on the track we get from the background as we wouldn't be able to track the characters. Further to that if we needed to put the character in the foreground we would be pushing what we don't know and so the track starts to become how it feels rather than what we can see. Putting a marker on a c stand would help here.

Focus Pull
For those that don't know, pulling focus is a mechanical process. When we do so we are turning the lens on a thread to make an adjustment to the focal length bringing an element into focus. This effect is often called Barrelling but it effectively gives a subtle zoom.
Zoom lenses are another degree of difficulty to trackers and consideration should be given as we are often dealing with blurred footage which has a changing 'circle of confusion' as well as the zoom.

fig 10. - focus pull

fig 11. - facial tracking

Facial Tracking
Facial tracking often comes up in productions either due to a piece of digital prosthetics or blood work.
I will often look to the most stable parts of the face such as corner of the eyes, around nostrils and the ear.
There are two things that can help this work.
1. Getting some reference photos or scan so we can have a good base model to use
2. Having makeup place some markers on the face to aid the process (disguised or not).
Btw I never want to see a cats head again. You wouldn't believe how they can move.

That's it for a first edition guide - nice and short and hopefully will save some people some grief. I think I'll be elaborating on some topics and adding in some new ones, such as zoom lenses and distortion, so feel free to drop some suggestions.

If you ever need some help feel free to get in touch for a quote or some free advise.

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