LENS METADATA: A KEY LINK IN THE PRODUCTION CHAIN AND HOW TO CAPTURE IT

L Zellan

Cooke Optics, UK

ABSTRACT

Metadata will be most useful when it has become trivial to collect and, therefore, becomes ubiquitous. Logically, this should happen right from the start of the acquisition process - at the lens. The tools have been there for more than a decade, however even now there are vast quantities of valuable information that could be obtained during acquisition but aren't. This metadata can save significant time and money during production and post production, but only a small percentage of productions take advantage of this.

This paper seeks to address the development of /i Technology, a semi-open metadata protocol developed by Cooke Optics that is made available to the industry in an effort to create a standard protocol for gathering and sharing lens data. It will also look at the barriers to adoption and implementation, and efforts to achieve greater standardisation.

INTRODUCTION

The value of metadata is now completely accepted for archiving and in many areas of production, particularly news, where it is crucial to enabling people to search, find and manage content quickly and easily. However, it is still largely overlooked at the acquisition stage. Although some metadata from the lens is being used on set for monitoring levels, there is so much more it could do that could save significant time and money during production and post production.

While lens/camera communication is taken for granted in the B4 broadcast environment it is still in development in the PL world. On set, smart PL-mount lenses (such as those in figure 1) can communicate with other camera equipment in order to automatically and instantly calibrate controls for that lens when you plug it in, thus saving preparation time. In post production, lens metadata can provide crucial information for complex VFX work, particularly working with tracking software to solve scenes that would otherwise have to be solved manually. Lens metadata detailing how footage was shot could also be useful for future reconstruction work.

Figure 1 - The S4i PL-mount range of smart lenses can all produce metadata

APPROACHES TO LENS METADATA

The /i project was started in 1998, not because there was any real demand for this lens metadata then, but because we could see the potential for it. We started it with just the idea of delivering basic information (as a continuous remote readout), such as: iris; focus; depth of field; hyperfocal distance; and circles of confusion (which is related to the film or camera sensor format - and can be user selectable or potentially could be set by the camera). The information can be digitally recorded for every frame and stored as metadata, accessible via cable connector near the lens mount and/or contacts in the PL mount that sync with /i compatible cameras and other equipment.

As lens manufacturers, all of this had to be carried out in the lens. We couldn't farm it out to the camera, because we didn't make them. The lens contains various encoders and sensors, as well as the computational power to calculate what is happening, and deliver meaningful results.

As we were giving people something they didn't even know they wanted, at the time, we had to keep the cost down and make it reasonably simple and transparent. At the very minimum, /i is a simple serial data stream, communicated using ASCII via 9600-baud RS232 (higher speeds are also provided and more usually used). This means you can hook up a computer into the lens, query it and get the information you need. It is about as universal as it can be.

At the same time, unbeknownst to us, Arri was developing its Lens Data System (LDS), and approached us to put LDS in our lenses, which we did, informing them that we were in turn working on /i.

Because Arri made both lenses and cameras, it was able to do the computation in the camera (where there was more space for extra processing power), and created a more sophisticated encoder system within the lens. Whereas our encoders were simple, proven carbon tracks with a head, measuring the resistance, Arri's LDS lenses use a flying head technology over magnetic track, which is less sensitive to temperature fluctuations, but requires more calibration - including each time it is powered up. Carbon tracks, however, don't need calibration when the lens is switched on, and while they can be temperature sensitive, in practice variations are insignificant over the working temperature range of the lens. Ultimately, both systems work.

When we agreed to support LDS, we put development of /i on hold, as we believed the industry only needed one lens metadata format. However, LDS was an added cost option, and take up was minimal, as people didn't want to pay for something they didn't have a use for. So, in 2001, we resumed our development work, and Arri agreed to also support /i. Initially it was only available as an option on our S4 lenses (which in 1998 were the first modern prime lenses from a non-Panavision company since the mid 1960s), but within a couple of years we realised that if lens metadata was going to gain traction, it had to be in every lens. So, since then every Cooke lens has had the electronics in it, whether it was used or not.

Because the licence for /i technology is just £1 per year, other companies have licensed it (1), including many of the main lens and camera manufacturers (Canon, Fujifilm, Zeiss, Angénieux, Arri, Panavision, Red).

Digital cameras that are /i compatible can talk to /i lenses directly via four contacts in the lens mount (see figure 2) as well as an external communication connector. The /i Technology provides the framework; the extent of camera data made available is the choice of each camera manufacturer via its software and hardware.

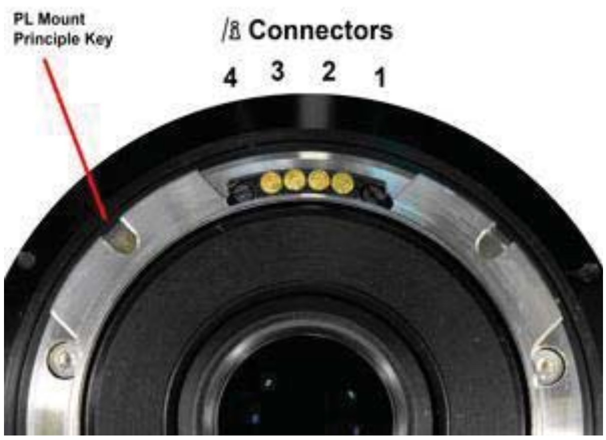

Figure 2: Viewed from rear of lens - Pin 1: Data from Lens; Pin 2: Data to Lens; Pin 3: 0 volts Data and Power; Pin 4: +V Power in

By feeding this lens data to post-production teams, they can not only save time and cost but also ensure a better quality product because the digital data provided takes the guess work out of many processes – the VFX artists can therefore create effects and 3D models that are more accurate, with much greater speed.

Importantly, capturing lens metadata does not affect normal operations on set at all. Metadata recording takes place without having to monitor or manipulate anything. Data records to the digital or film recording medium, or to an SD card; there are no specialists required on set and the DP needn't worry about fussing with complicated accessories.

Being able to do the computation in the lens was a real advantage for /i when the first new digital cameras were developed, as it meant there was less for camera manufacturers like Red to have to do.

ADDING FUNCTIONALITY

From the very beginning we've been working with tracking software companies, particularly Pixel Farm. A decade or more ago, its software was only completing about 60-70% of tracks, the rest having to be completed manually. We worked with them on experiments in lens tracking, but without a complete lens system, including zooms, it wasn't suitable at the time for a real production.

With $/i^2$ (launched in 2013) we added inertial components into the lens, to track the camera movement. In practice, inertial components drift, and get less accurate over longer periods of time, which is why we originally wanted to go for GPS. However, it doesn't really work indoors, and has problems with reflections, which is why $/i^2$ uses inertial tracking. Fortunately, over the intervening years, tracking software has improved greatly, and can now solve 95-97% of the tracks they do. Unfortunately, the 2-3% of the tracks they can't solve are the really difficult ones. If there is no tracking data from the time the camera is switched on until the end of the shot, inertial tracking probably won't help, but if the camera can't see the tracking markers from, say, ten seconds in to the shot, for three or four seconds, then you have an exit point where you can re-zero the inertial data and map it correctly to the entry point a few seconds later. Then you can create an error table for the chip (for the inertial data), to see where it is drifting, and create pixel accurate tracking data. The position and orientation data, along with the lens data, also make it easier for VFX teams to deal with common issues like occlusions or fast camera motion (motion blur).

Figure 3 - Inner workings that show the /i boards in a lens housing

What we can realistically offer has changed considerably over the years, as the technology has developed. When we originally looked at having an accelerometer, for example, it would have required an external box on the lens, now they are in the lens (see figure 3).

The components are continually getting smaller, faster and better, which improves the accuracy and speed, although /i^2 had to be delayed for a year because the first inertial sensor we used was too noisy.

The next version of the technology, /i^3, which is being launched here at IBC, is aimed at introducing non-dynamic data, such as lens distortion. This is something that effects houses have been asking for, as they spend a lot of time mapping lens distortion.

We will put into the lens a mathematical model of both distortion and illumination (mapping the light fall off) for each unique lens, rather than just a theoretical measurement of all lenses of a particular focal length. This will be created at the factory using new equipment we've just installed. The resulting information will also be made available online - allowing users to input the lens serial number. Any /i lens can be updated with that mapping, if they are returned to the factory. Earlier /i lenses can also be upgraded to the latest /i components.

MAKING USE OF METADATA

Although all of this metadata will be created in the lens, ensuring it can be made available across the production is not easy. Cameras may record all or just some of the metadata, and not all handle it in the same way. This is why we have worked with Codex Digital and Transvideo to ensure all the data can be recorded and made available on set, to ensure customers get all the lens data they want, and not just what a camera manufacturer decides.

The Codex Data Logger One can record /i lens metadata from any /i Technology lenses, while Transvideo's CineMonitorHD can display /i Technology lens data on the monitor, giving a graphic representation of iris, focus and depth-of-field.

There are many uses for this information in acquisition as well as post production. Think of the efficiency gains on the set if you can plug a Preston zoom motor into the lens and instead of having to calibrate the lens, record that information, then save it by serial number in the zoom control you are using, you could just plug the control into the lens and it will immediately load up all the marks and distances, and they will each exchange all the information they need to work together.

With Transvideo's monitors, you simply plug the cable from the external connector on the /i lens into the monitor, and it displays all the crucial information the Director of Photography might need.

CASE STUDY - STORYLINE STUDIOS

To get an idea of how /i Technology is being used to connect acquisition and post production on VFX-heavy shoots, we talked to Andreas Herzog Grimsø, Camera Manager at Storyline Studios, Norway, which is currently using /i Technology on an upcoming new TV show, *Valkyrien*, and has been a /i user since the S4/i was released.

/i Technology is "fairly easy when you know the approach. Usually the challenge is when new cameras do not yet support the /i protocol. We never use output from the lens, but Arri and Red both support /i lenses in the PL mount," he said. Storyline always uses in-camera recording, and uses Arri Meta Extract software to compile the metadata, outputting a CSV file for reference. Nuke can read this data directly from the Raw files.

To ensure it gets the /i data it needs, it co-ordinates this with the DIT on set. “The DP also is aware of how we use it and how it’s captured. The DP then can do VFX shots without always having a VFX supervisor on set,” he added.

He sees it as “a huge timesaver for compositing. It saves time when there are shots not supervised by a VFX supervisor. Time is saved when the artist[s] don’t have to guess all values and try out different values in the composite. When the DoF and focal length values are read by Nuke directly, they can start working with the composite the right way and use time on the composite and not guessing values. It can save a whole day’s work on some shots.”

It was used a lot on *Valkyrien*, which had “a very active two-man splinter unit that did a lot of tunnel shoots where we have inserted digital trains. There is a one shot that shoots down an empty tunnel with a huge focal pull to track the train. The lens data made it possible to place the digital train correctly down the tunnel and composite the train’s focus correctly based on the lens data.”

A NEW LANGUAGE

The /i technology language is split - into CORE commands and EXTENDED commands. The first is the public part, a published document that contains enough information about the lens query language for anyone to implement it. It gives the configuration, the command structure, the information protocol, and all available metadata that is in this public part.

Some EXTENDED commands are associated with calibrating a lens, another set are associated with lens program updates. These are dealt with in Appendix D, a confidential section that handles proprietary commands (particularly to do with lens control), such as those for B4 lenses. This is only available to /i Technology partners (of which there are currently 28).

Typical CORE commands include: N - Retrieve Fixed Data (the required first command); K3 and K4 - Retrieve the name of the lens manufacturer and lens type, respectively; Kbn - Set Baud Rate to n (where n = 1-7) default = 115k or 9.6k; and Wnn - Set Film Size to nn (where nn = 00 - 09 referring to a specified film size/circle of confusion).

An /i lens accepts specific commands that control the data output, including a continuous mode that can send a constantly updated data stream at up to 285 frames per second.

Commands to a lens are in the ASCII format and terminate with a carriage return character. Responses from a lens are in either an ASCII format, a packed binary or a pre-defined binary data packet format and terminate with the character pair, linefeed carriage-return: [l/f][c/r]. See figure 4, below, for some of the values that are delivered.

Tag	Value	Definition
D	s s s s s s s	Actual focus distance – units*
T	a a a a	Actual Aperture setting
t	b b b b b	Actual Aperture setting – conventional notation**
Z	f f f f	Zoom – EFL (mm) [0000 for Prime lenses]
H	a a a a a a a	HYPERFOCAL Setting –units*
N	b b b b b b b	NEAR FOCUS distance – units*
F	c c c c c c c	FAR FOCUS distance – units*
V	v v v . v	Horizontal Field of view - degrees
E	s e e e	Entrance Pupil Position – units* [Tag: s is a + or - sign]
z	mmmm	Normalized Zoom Setting
S	xxxxxxxxx	Lens Serial Number

All distances are actual distances measured from the focal plane.

Figure 4 - from section 5 of the /i Technology User Guide & Technical Manual (2)

BARRIERS TO IMPLEMENTATION

Cooke created the /i system as an open protocol in an effort to unify lens and camera manufacturers and create an industry standard. While /i Technology has been adopted by many of these leading camera and lens manufacturers, it has not yet been implemented into many products, and therefore very little data has made its way to VFX houses. It is something of a chicken and egg situation – once VFX teams see how the lens data can help them in the post-production process, they will ask for projects to be shot with /i compatible systems; but until the metadata becomes available they won't know what it can do.

IN SEARCH OF A STANDARD

There is beginning to be a critical mass of /i Technology partners, Panavision, for example, recently joined, and on an industry level we want to come up with a common language for lens metadata, regardless of whether it is an LDS lens that works totally differently to an /i lens. Indeed, Cooke's /i lenses work differently to how Angénieux has decided to implement /i Technology in its /i lenses. But, if we can come up with a common language, with all the possible questions you could ask, and all the responses, regardless of who made the lens, then all of this equipment will be able to talk to each other.

Having invested heavily in /i Technology, as Arri has in LDS, it is frustrating that this lens metadata isn't more easily accessible, more readily exchangeable and more widely used. We don't need common hardware, just a minimum specification for basic functions (iris, focus, depth of field, etc. - basically the original /i information from the lens), and anything beyond that will be a bonus. For instance, not everyone needs to implement inertial data.

We are now trying to agree on a minimum requirement and a common query language, so that all the cameras and lenses can talk to each other, and hopefully those discussions will prove fruitful.

CONCLUSION

The industry only needs one lens metadata standard, be it ours, LDS, or something else, because if you need different software for each lens, it could end up with no one using it because it is too complicated.

With the support of the /i Technology partner manufacturers the industry can promote the uses and benefits of an acquisition-to-post production workflow and also add more valuable metadata information that can benefit content further down the production chain.

REFERENCES

1. A full list of /i Technology partners is available at http://www.cookeoptics.com/i/itechpartners.html

2. Cooke /i User Guide & Technical Manual V4.0 - available at http://www.cookeoptics.com/s/