



**THE  
CORE  
SKILLS  
OF**

**VFX  
REPOSITORY**

**12 TOPICS  
FOR FUTURE VFX TALENT**

# WELCOME TO THE NEW CORE SKILLS OF VFX REPOSITORY

## Update to the new edition

**Some of you will be familiar with Creative Skillset's 2011 *Core Skills of VFX Handbook*, upon which this new edition is built. Much of the information presented here isn't new to this edition; however, the format is.**

In March 2015 we started to consult industry and friends in education about whether the original Handbook was still 'roadworthy'. In our discussions we concluded two things. Firstly, the content was generally still very useful and although it could be split into different divisions or smaller or larger chunks, or written up as a real credited curriculum, essentially the content was still valid.

The second finding was that while a faux-academic 'modular' layout had been useful in 2011 to provide a kick-start for new VFX course designers and teachers, such a 'serving suggestion' or incentive was no longer needed. The landscape has changed – partly due to the impact of the original Handbook. So, we now shift emphasis from seeding new courses (as we did in 2011) to supporting a more knowledgeable and established group of HE and FE educators in 2016.

Thus the biggest change is the old style modules (which were only ever a conceit to get everyone thinking), which are transformed into topics or discipline headings and are now designated as useful components of an emerging, updateable and accessible online repository. This points to an eventual transition online, where dynamic media and commentary can be added as practices change over time. The notion of a VFX repository can be likened to a postbox where the industry can drop advisory notes for receptive educators to initiate within their lectures and where educators can share tips and be collegiate across the sector (don't tell their competitive university management this though).

As before it needs to be stated that there is no monolithic voice of industry and no consensus on what constitutes an advanced – as opposed to an intermediate – level of achievement. No one should feel non-plussed if we've framed something as beginner's level when it's in your postgraduate curriculum, or feel our advanced level description is not advanced enough. As always, educators should take what they need and adapt as they see fit, but hopefully now some educators can get a better sense of what beginner or advanced skills might look like.

None of these 12 topics represent the whole territory, but they're a good start if you are learning or teaching. Everyone consulted thought it was important that educators had the space to interpret and mix as they saw pedagogically appropriate.

This Handbook shares the same ethos as the original, but we have disengaged the Student Primer – which now has a life of its own – as a way to encourage different readerships. There were some reports that students were finding it easier to look at the module suite for guidance and ignore the (more difficult to internalise?) Primer, so we wanted to bring the original marriage of convenience of the two conjoined documents to an end, signalling to students that they should shift attention away from judging (often erroneously) their own institution's modules against the Creative Skillset suite, to examining and improving their own aptitudes and behaviours against what the Student Primer advocates.

As before we are aware that most of the voices in this document are from the larger and more populous VFX companies in London rather than the small or sole trader operator, but it's important to realise this was self-selecting and, as we had a shorter time scale, it follows that smaller companies found it harder to let someone go to a Creative Skillset roundtable panel for half a day. However, we don't think there is a significant weighting towards larger SMEs and if companies disagree, we hope they will help re-balance this with content and advice as the Repository moves online.

My last words on behalf of Creative Skillset must be to those without whom this would not be possible. Firstly MPC's Ian Murphy, original co-author with me on the 2011 edition, and still an eminence grise in this version. Also the VFX academics and VFX professionals (*who are often no longer mutually exclusive groups*), who gave up time to come to Creative Skillset's advisory groups to ensure we kept content and format relevant. Thanks for giving your time to our meetings across the UK. Readers should know that new ideas and developments in the Repository are down to the combined voices of both industry and education.

**We believe that attention to the competencies and skills within the Repository can increase the quality of our home-grown graduates when blended with inventive teaching methods and intensive new courses from the UK's dedicated tutors.**

Saint John Walker  
Consultant



*Artifice*

Courtesy of Felix Bauer-Schlichtegroll / Mohrag Taylor / Gordon Marshall / Nikolay Zorov / NNCA.

# THE CORE SKILLS OF VFX REPOSITORY

## Preliminary notes for tutors

### **First steps and teams**

We recommend that in the first part of any course it is advisable for students to concentrate on a single topic or area at a time and so tutors should provide supporting assets or pre-built scene files, etc. to enable this to happen. If you are teaching modelling then don't dilute the students' time by expecting them to texture, shade and light the model as well. Provide assets so they focus on just one issue at hand or, if timetables/structures allow, enable them to be fed assets from others studying related topics like texturing or lighting, so they can concentrate solely on the modelling. Likewise, if the subject is animation, provision of a model, rig and render will be needed for them at first. Once the fundamentals are covered in this way then team-based projects can increasingly be introduced with each student in charge of an aspect of any project.

### **Cutting cloth to suit**

A vast array of choice can sometimes be deadening for creativity. Ensuring students learn through invention based on a small number of variables and 'make do' in the face of limitation is a useful tactic, rather than emphasising what each menu heading does and the sheer number of options available.

We all know that endless slider controls or pulldown menu options can divert the student from focusing on the task at hand, so introducing deadlines early on that restrict students from being distracted and ensure they get things done is very useful.

### **Dailies and presentation**

Get your students to regularly present their work to their peer group and others and be questioned by someone in a client/line manager role. Get them to justify their approach and articulate the thinking behind it. You might want to consider videoing this, since it's a great way to encourage feedback. While no one wants smooth-talking salesmen, you DO want concise narratives effectively communicated in the right idiom. It's important that your students know their role is not to persuade but to explain clearly. Actually, the most shy and retiring students might prefer this, because they can be still be soft spoken and succeed in this task.

### **Lights, camera, action**

Students must at some time be given use of a camera – video or stills. This provides immediate feedback on framing, composition and balance. It speedily gets them used to thinking about lens properties (why focus is more crucial in telephoto for instance), aspect ratio (why is everything stretched?), aperture and a host of issues they will eventually need to mimic in their VFX work. They can also see what lens flare really looks like!

It will also help train the eye so the student can accurately recreate the visual cues that give an object or a scene an aura of realism.

There is a widespread consensus that you can't really understand the camera by theory alone, the student needs to experience it. Also, cameras should be accessible for the students throughout their VFX study rather than contained in a single workshop or session. However this doesn't mean students have to generate their own plates, unless proper tuition and time is available.



Courtesy of Hollie Pearce / NCCA.

### **Different pipelines and roles**

If universities and colleges are prioritising what is generally called film VFX, they need to give their students experience of creating and experimenting with a range of different pipelines and production processes to successfully provide students to the larger companies. This is what makes some of our European schools such honeypots for recruitment: they teach through demarcation of roles as per industry. However, the depth of this tuition may vary if students are more likely to take their skills to smaller companies, into motion graphics or, for instance, into medical or architectural visualisation fields as the demand for VFX skills increasingly diversifies.



Courtesy of University of York

### **It's broken, so mend it**

Students need to start problem solving – diagnosing why an image doesn't work. A quick way is to present them with deliberately broken scenes, images or scripts.

Anything that involves detective work and analysis – going back through stages to find why a shot is dysfunctional – will speed up learning. There's a phrase 'fail faster' and, as you'll know, one of the hardest things is to get students to document their failures as springboards for future success. There needs to be an attempt at least to enable students to see that past failures – if correctly analysed – are a rapid route to improvement. Also when documented in reflective journals, such mistakes lead to potentially better work and maybe higher marks.

### **Schools, colleges and universities**

Generally in the UK, higher education (HE) focuses on a different level of critical thinking and analytical skills than further education (FE). We have taken the view at the time of compiling that most new entrants still come from university rather than FE, so that is where we concentrate advice, but we hope FE tutors feel they can also use this document to align their offer, either towards progression into HE, or direct entry to industry.

# THE CORE SKILLS OF VFX REPOSITORY

## The current suite

**Here are 12 topics or disciplines that span VFX. They are rough subject headings that educators can use to help create talent that industry wants. They are a powerful aid to starting new courses or modules, but also a reality check and – we hope – an inspiration to others. They are full of ideas and snippets from many industry sources and voices.**

Institutions can choose to take as much as they like and create a curriculum. We've tried to give indications about whether material is introductory, intermediate or advanced, but we leave levelling and credit-bearing to our more experienced friends in education. These topics are a means to empower universities and colleges, not dictate to them.

We have made no attempt to standardise the length or word count of these topics. That's because they have different authors and different voices, being products of roundtables held with specific professionals. Word count could be seen to reflect the attention given by our industry advisors – a sign that these areas might be currently lacking prominence in the teaching that occurs at colleges and universities. However, this doesn't mean these areas are more popular regarding industry recruitment and you should ignore others. Each university or college should play to its strengths and resources. We suspect as this work transitions to an online setting the word count will increase with new donations.

Let's look at the topics. Through the dissemination of these topics and the building of the repository we hope to accelerate and initiate more quality courses to feed the UK's VFX industry.

## HERE ARE THE **TOPICS** IN THE CORE SKILLS OF VFX REPOSITORY:

<b>001:</b> Acquisition for VFX	<b>6</b>	<b>007:</b> Matte Painting and Environments for VFX	<b>40</b>
<b>002:</b> Introduction to CGI for VFX	<b>14</b>	<b>008:</b> Rigging and Creature Effects for VFX	<b>46</b>
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Paddington

Courtesy of Heyday Films / Framestore.

# TOPIC 001: ACQUISITION FOR VFX

## 1. THEME AND SCOPE

**A VFX student shouldn't have to work on generating imagery. As a starter, give them images of a quality that is realistic.**

Certainly students should be exposed to cameras and engage with filming, but to do this to generate their own plates can mean certain challenges and issues might be overlooked or unintentional errors could get in the way of learning. It's far better to disengage and separate the two activities.

Securing a supply of qualitative shots from a neighbouring film faculty will be doubly useful if students can shadow the shoot – but only if the people shooting have the requisite experience. This will hold for motion capture or performance capture activities too, although be aware students can often favour mo-cap over film sets in their studies since it seems more seductive.

Students should know where the imagery and data they will be working with in VFX originates and how the VFX professional might be involved at early stages in ensuring that data and imagery is captured and formatted correctly, ready for later use.

By understanding about the mechanisms and technologies involved in image and data origination students can gain an appreciation of how such processes can give imagery certain qualities or even distortions that the VFX professional will need to address later.

### **There are four main sources of imagery and data:**

- Principal photography (the lens and the physical properties of the particular camera used on set).
- CGI and data (computer generated imagery and data).
- The motion/performance capture process.
- Editorial (the sequences and their construction parameters as dictated by the client).

## 2. WHY TEACH THIS?

There can be considerable student resistance to moving away from the comfort of a screen and image processing software (visiting a film set can be seen as interesting but superfluous), unless students can experience actively collecting data or references.

However, if students have an ahistorical ignorance of where the imagery and information that they need to process comes from, they often are incapable of achieving the levels of nuance and mimicry that their work needs in order to be great.

Also, it is important to know that it is not necessary that students know how to operate a mo-cap or performance capture system. Although such interaction can enrich their learning – and when working with actors help their teamwork and communication skills – the appropriate processing and implementation of the output is the central skill that industry is interested in. Few graduates get a job because of capture experience, but rather because it has given them organisational, teamwork, or even directorial qualities.

You may also want to note Source Four: Editorial is the most ignored of all these sources that the VFX artist has to deal with, but it can be simulated through exercises and you could consider asking a VFX editor to ‘front’ an exercise you have devised – around colour space for instance.



*Guardians of the Galaxy*  
Courtesy of Marvel Studios / Walt Disney  
Pictures / Framestore.

## 3. RELATED JOB ROLES

SHOOT SUPERVISOR

MATCHMOVE OR PREP ARTIST

VFX SUPERVISOR

DATA WRANGLER

PIPELINE TD

VFX EDITOR

VFX PRODUCER

ANIMATORS\*

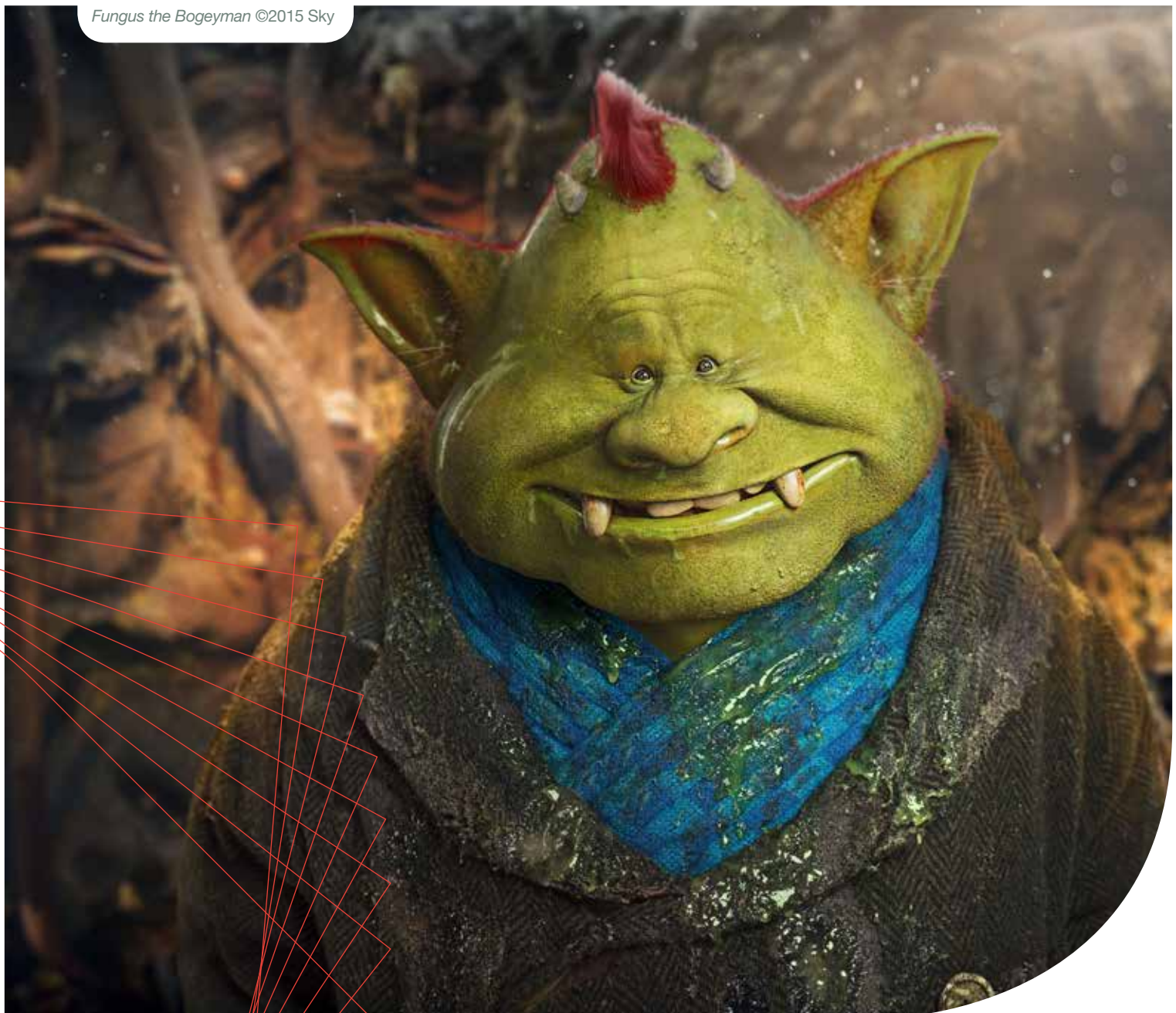
\*who may use mo-cap data or on-set footage for reference

## 4. WHAT STUDENTS NEED TO KNOW AND DO

### Intro level descending to advanced level

- Gain a broad awareness of the origination of different imagery the VFX artist uses and how it gets to their computer.
- Understand how assets they are given have certain properties that define or limit what can be done to them.
- That VFX is not the same as post-production, or something you layer on top of your edit.
- Take time to look at received plates and recognise what the lens has contributed to the image, which might be subtle.
- Engage with techniques for shooting a correctly exposed screen.
- Show first-hand experience of a shoot, a mo-cap exercise and/or file transfers and naming protocols.
- Show how to modify, 'clean up' or package imagery or data professionally.
- A detailed understanding of the origination of different information and how it is gathered, stored and modified and strategies of what to do if there are errors.
- Recognise key issues regarding creating images and data and how a VFX supervisor might be involved in the early stages of such creation.

*Fungus the Bogeyman* ©2015 Sky





## 5. OUTLINE CONTENT

Students should examine four areas where most of the images and data we deal with in VFX originate.

### SOURCE ONE: PRINCIPAL PHOTOGRAPHY (LOOKING AT THE LENS AND THE PHYSICAL CHARACTERISTICS OF THE PARTICULAR CAMERA USED ON SET).

While VFX personnel increasingly get involved earlier in the production process, it is important to realise that the camera department rightly dictates and leads during principal photography. VFX has very little or no influence here; it mainly needs to react and accommodate this.

The particular characteristics of the camera used will often need to be recorded, replicated and applied to CGI later. This may involve much observation and creativity on the part of an individual artist or even software tools being written by a pipeline TD (Technical Director), for production-wide application.

#### Consider the following:

- How to light a screen, how to judge the exposure of the screen through the use of spot meters and digital SLRs. When to choose blue v green. Dealing with creases, joins, shadows, light fall-off, etc.
- What does the lens contribute? Exposure, aberration, motion artefacts, depth of field, flare, blooming, veiling, distortion, etc.
- The concept of persistence of vision and motion blur.
- What does the camera format lend to the image? How would you replicate such characteristics and apply to other CGI elements later in post?
- How is the camera position moving in the shot and how might you record its position so you can apply it to a 3D CGI scene later?
- The different impacts of nodal, non-nodal and mixed positioning.
- The curve, Cineon (log) data, colour space as it applies to different cameras.
- Getting a noise reference (lens cap on).
- The need and use for a colour reference for the plate – the Macbeth chart – shot for each plate, allowing colour ranges to be matched.
- The need and use for a lens grid for each lens used in order to gather distortion info.

- Metadata from lenses made by certain manufacturers (eg Cooke). Position, gimbal, focal length and how it is recorded, read and later used.
- New possibilities with zoom and focus encoders – camera bolt-ons.
- Understanding set etiquette: students should be given a Who's Who of a large contemporary film set. Who are your points of contact on set, particularly for camera?
- Chains of command on film shoots – protocols and responsibilities.
- What you can reasonably ask the camera department to do and the right time to suggest it. The importance of etiquette and hierarchy. VFX is not important to anyone else, so how do you get the material you need? How can you be pro active and helpful (rather than just demanding) on set? Communicating useful suggestions can save time for both them and you (eg "We don't need to do this shot with a large green screen, because we can do a garbage mask in post").

### SOURCE TWO: CGI AND DATA (GENERATED IMAGERY AND DATA)

Various real phenomena and natural processes inform the eventual creation of CGI imagery. This topic section concentrates on those related to gaining a) lighting references, b) geometry references and c) motion or positional data for a virtual camera which will eventually 'film' CGI elements.

#### Consider how you might explore the following:

- The role of witness cameras and how they create an accurate virtual camera (especially as a solution to real camera occlusion). While you probably can't set this up yourself, show online video clips to illustrate this.
- Motion reference cameras (eg cheap DSLRs) should be explained or used on a shoot.
- How to mark and measure the set, for instance theodolite surveys for 3D, especially with the intention of students completing CGI extension work later.
- Capturing references for later CGI lighting. It is important students understand and later replicate the DoP's lighting scheme.
- Capturing light reference typified by the grey (for diffuse light) and chrome (for direct light) balls, which are shot in situ.
- Look at image-based lighting for HDRI: capturing via chrome balls shot at different f-stops, or maybe talk through a Spheron camera shooting a panorama from a single point as opposed to stitching stills taken at 10 degree intervals to make a panorama.



Courtesy of MPC

- Collect texture and other visual references from the set, for use by texture and environment artists.
- The importance of capturing using the wider range of the digital camera RAW image format for HDRI and textures.
- Explain/demonstrate how tracking markers are used for creating an accurate virtual camera or are applied to objects in frame in order to attach CGI elements. Examples may be talking animal 'muzzles' or vehicle embellishments. Describe the tracking markers' size, position, type and how they are used on green screen shoots with c-stands or other objects. Have enough on set to allow for sufficient depth analysis for a 3D matchmoving application.

**Advanced operation: under this section students should be exposed to three levels of engagement with the recording of data:**

- 1) DIY and guerrilla: using photos and hand measurements.

The bare information you need without any automation or gadgets: lens type, chip size/camera back, height, distance and other measurements or references (eg a physical yardstick). 'Witness camera' style stills for 3D matchmoving applications (depending on the application available) can be used to improve the 'camera solve'. The student should understand how collected data/measurements are input into 3D matchmoving software and shown that geometry can be constructed from point clouds generated within software. These should 'fit onto' (and move with) the image when overlaid – if the measurements were accurate!

- 2) Semi-automatic means:

Demonstrate how stills shot for image-based modelling/photogrammetry software (eg PFTrack, Nuke) will generate geometry/mesh or a point cloud. This is good for modelling buildings or extracting depth from relatively simple objects.

- 3) Automatic means:

An explanation of LIDAR (used for large sets, buildings and large areas which would take too long to collect by other means) and how LIDAR generates geometry based on laser scanning technology. You might want to show online video clips of this.

## SOURCE THREE: MOTION AND PERFORMANCE CAPTURE

This is essentially a way of measuring moving things and applying that movement to drive CGI objects, characters and 'digital doubles'.

The history and uses of motion-capture data should be outlined, but it helps to focus on optical processes, while referring to other mo-cap systems that are available. It is not necessary for the student to have operated a system, but it is essential they understand the process and the types of data they might be given and how to process it. A visit to a facility off-campus might be instructive.

### Consider the following:

- What can be captured and what can't (eyes, cloth)? Types of mo-cap system.
- Roles in mo-cap work – including health and safety.
- The process of planning a shotlist from a script – coming up with scenarios.
- Working with actors and how a mo-cap shoot is directed. Getting a good performance. Physical props and measurement.
- Marker placement.
- Tracking and solving.
- Different types of solver.
- Dealing with occlusion, missing data.
- The role of the lens and calibration.
- Understanding the relationship of data captured to a rig.
- How to remove noise.
- 'Range of motion' and its purpose. Degrees of freedom re: joints.
- File nomenclature.
- FACS (Facial Action Coding System) sessions, facial capture and rigging.
- Blend shapes and deformers.
- Motion edits and the importance of clean curves.
- Real time mo-cap applied to a rig for a director to view.
- Camera and motion capture techniques in the future (eg Cameron's 'simulcam').
- How to capture unconventional anthropomorphic movements (eg big feet/over-extended arms).

## SOURCE FOUR: UNDERSTANDING THE ROLE OF EDITORIAL

This needn't be as foregrounded to the student as the other sources, but it does give useful context to how they may eventually work in larger VFX houses and also open their eyes to how fluid editing decisions can be relatively late in the day.

The VFX editor or editorial department apportion out the shots and their constituent plates, providing a template or scaffold structure that many people build on and supply elements to create the finished shot. As such they are another originator of imagery that the VFX student should be aware of.

Students should know in bigger companies you will be distant from editorial, the clips are already timed and set, but in smaller companies you are expected to input and be more flexible – you may even chose back plates.

Students should note that from editorial the images sometimes can be pre-graded in order to standardise the colour match across a range of shots. Thus, knowledge of colour space is important, along with a basic knowledge of grading terms.

### Consider the following:

- Anatomy of film production – the VFX vendor's relationship to the production.
- The repercussions of marketing schedules and deliverables on the VFX schedule.
- Closed/locked reels.
- The nature of handles. You need to concentrate on the middle portion!
- Talking to your supervisor or production assistants, predicting task completion.
- Understanding editorial hierarchy and the relationship of VFX editors both on the client side and internally.
- How editorial impacts on your work decisions; length of plates.
- Using photographic elements – 'temping' things up in the absence of final elements.
- The temp and the final – and how you might be involved in working on either.
- Accommodating and preparing for unexpected changes and understanding why they happen.
- Colour grading terms explained.
- Colour space: what you see isn't what you necessarily get (and that's a good thing for VFX – something that others in production don't understand!). Other people in the film process will want to see the look and stylistic veneer of the film, but the VFX artist needs a neutral plate that they can later push and modify. So there's a 'translation'

needed. Conceptually the look should be thought of as separate to the image, so the image is uncompromised and yet others can see the intention. This can be difficult for students to grasp!

- Colour space basics: video linear (Rec. 709 and 601), true linear, Cineon PDlog685 and newer flavours of log colour space.
- How colour is captured or rendered. Look-up tables (LUTs) as a means of translating imagery to be visually useful or to transform an image from one colour space to another.
- All VFX operations are achieved through linear colour space, since linear leads to predictable colour transforms.
- Editorial sometimes supplies a neutral grade (also referred to as a tech grade) that is termed a 'linear mult' (this may also be based around skin tone).

**Note:** the new entrant needs to understand how to implement that grade (depending on the VFX company) either in log or lin. If it's log it's an Add or Offset, if lin, a Mult or Gain.

- How an exposure node works and how and why it is applied.
- The processes by which log becomes linear.

This paradigm is also present in the notion of the colour decision list. The look that the DoP saw and chose on set travels with the material but isn't 'baked in'.

The colour decision list is the DoP's choice and how it travels as metadata through the pipeline needs to be appreciated.

Students should experience different formats in this topic and learn when they might encounter them within the VFX process. Shooting formats are different from posting formats.

- Is the image cropped in camera or in post?
- Understanding hard masking (in camera) 2 perf, 3 perf and open gate, super 35mm versus Cinemascope, Vistavision, IMAX, Academy aspect ratios versus 185, 165, 177, 133, 235.
- Soft masking (in post) and open gate.
- Scanning and resolution: 2k, 4k and the use of proxies in compositing.
- Bit depth: 8, 10, 16 bit and float/half float.
- Major file formats: .dpx, .cin, .tga, .tif, .jpg, .exr.

Whereas large companies might have conversion built within their pipelines, smaller companies may employ a more hands-on approach where they will be responsible for re-formatting (for instance, downresing film to fit video).

### Optional addendum: stereo 3D

It needs to be noted that most VFX aspects of stereo 3D are explored in other topics, since it has no unique bearing within this topic. However, explanations that deal with the following may be judged useful.

- The impact of stereo 3D on principal photography.
- Stereo 3D acquisition – split beam operation, convergence and parallax.
- Precision on set – for many mistakes there's no fix in post.
- Post dimensionalising. 2D conversion should be seen as qualitatively different, not inferior. It's useful to know different conversion methods and their implications. See also: the Pulfrich effect.
- Positive/negative screen space (world space, personal space).
- What are the problems likely to be encountered? Look at ghosting, edge violation, keystoneing, etc.
- Get students to compile a glossary of terminology: accommodation, depth budget, hyper/hypo, etc.

Stereo 3D's relationship with virtual reality (VR) is interesting from cultural and technical perspectives. At the time of writing it was considered that VR development is still fluid and so shouldn't yet be included in this repository.





## 6. KEY TEXTS/LITERATURE

Alton, J. (1995) *Painting with Light*, University of California Press

Mascelli, J. V. (1998) *The Five C's of Cinematography: Motion Picture Filming Techniques*, Silman-James Press, U.S

Okun J A., Zwerman, S. (Eds). (2010) *The VES Handbook of Visual Effects*, Focal Press

CVMP 2015 – 10th European Conference on Visual Media Production

Brinkmann, R. (2008) *The Art and Science of Digital Compositing*, Second Edition: Techniques for Visual Effects, Animation and Motion Graphics, Morgan Kaufmann Series

Wright, S. (2010) *Digital Compositing for Film and Video*, Focal Press

Guy, NK (2012) *The Lens: A Practical Guide for the Creative Photographer*, Rocky Nook

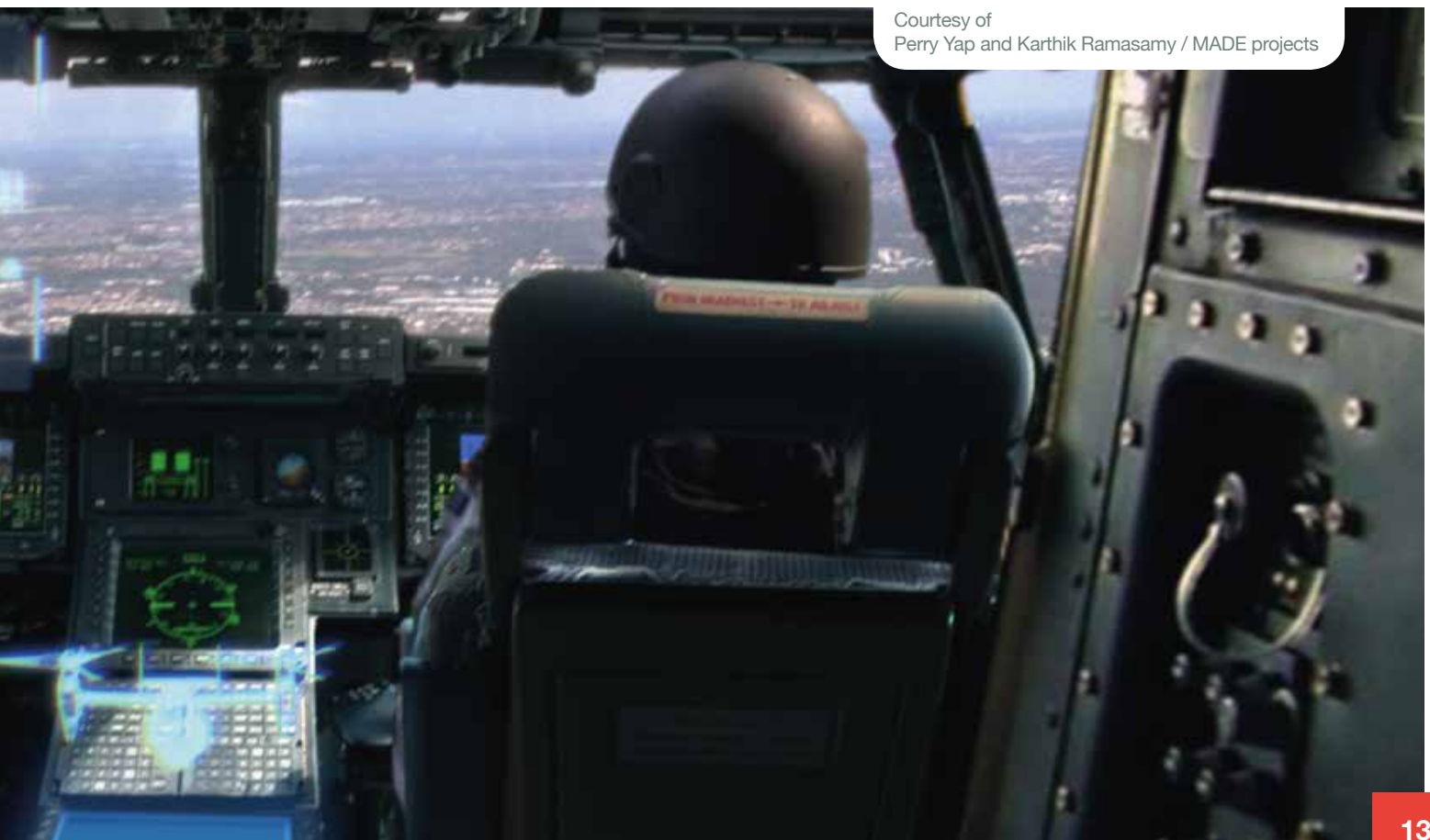
## 7. SUGGESTED LEARNING ACTIVITIES

We recommend that students be exposed to a real film shoot. This might be at a neighbouring studio, department or even university. Obviously some kind of interaction with such a shoot would be useful, although not compulsory. Observing and understanding the roles of those participating are the main purpose.

Attending a mo-cap session would also bring to life the curriculum, although it is not necessary for a student to work on a mo-cap session if this is beyond the resources of the course. However, students need to work with a variety of files and exercises that highlight and maybe problematise issues brought up in the curriculum.

Student project idea: How would you gather useful measurements from a set without the help of technology? Smaller VFX outfits don't have access to LIDAR and technology – and neither do many universities – so how would you collect this information from a film set yourself?

It might be useful to expose students to pre-viz and its interpretation on a real set. This means giving them some knowledge of cameras (focal length, lenses) and lights.



Courtesy of Perry Yap and Karthik Ramasamy / MADE projects



Courtesy of  
Derek Doritis / MADE projects

# TOPIC 002: INTRODUCTION TO CGI FOR VFX

## 1. THEME AND SCOPE

Here we introduce students to the main principles of hard surface modelling in 3D space and the preparatory placing of those objects into a (static) composite. It deals with the challenge of creating 3D objects that will need to integrate with a background that will be from another source (typically a digital film camera) and how to make the 3D object conform or 'fit into' that environment.

In order to keep focused on this integration this topic excludes animation or rigging (which come in later topics), as we suggest it's good to build students' knowledge and abilities in a way where they are not distracted or attention is diffused.

This topic is not just about modelling – it also introduces the important notion of the virtual camera and how this 3D software camera needs to match and parallel real film camera movement and qualities.

The student will learn to analyse and to efficiently build forms using professional techniques, creating 3D assets in shot that may or may not be interacted with by real filmed actors.



Courtesy of Causeway Pictures/Compositing Coach

## 2. WHY TEACH THIS?

There will be an emphasis throughout this topic on the importance of the minimum use of data needed to achieve the required quality when producing assets, to focus learning. Students with a propensity towards 3D CGI need to gain a proficiency with hard surface modelling in 3D at a level that allows for further independent learning and gain the ability to develop a range of different models placed in different and challenging environments.

Efficiency as a concept features in the Student Primer, so you could make a connection there.

This efficiency aspect also needs to be communicated to students concerning the influence topology has on texturing and rendering further down the pipeline.

Clearly the concept of aligning and orienting 3D objects within the notional space of a film plate is axiomatic to building a coherent image. By ensuring students focus on this before engaging in a headlong rush into rigging, motion and animation skills, there'll be more time for this important skill to be perfected.

You may want to note we recommend the teaching of basic 'look dev' is increased incrementally as the topic continues rather than in a block. Students need to understand the relevant number of passes needed to achieve believability within the context of the shot. They should create the look dev on one shot to explore how the workflow of texturing > lighting > shading > compositing – can be tweaked (focusing more time and resources at one stage than the others) so the process (or pipeline) can be applied to several shots efficiently.



Courtesy of MPC

## 3. RELATED JOB ROLES

LAYOUT TD

DIGITAL MATTE PAINTER

MATCH MOVER

PREVIS ARTIST

ASSISTANT TD

CONCEPT ARTIST

3D MODELLER

GENERALIST TD



## 4. WHAT STUDENTS NEED TO KNOW AND DO

### Intro level descending to advanced level

- How to build simple 3D models and engage with ideas of space and form.
- How the way they work in 3D may have implications later on regarding subsequent texturing and rendering further down the pipeline.
- An awareness of professional practice in industry-standard 3D software.
- How to build models with the most efficient use of data needed to achieve the required quality.
- The ability to place 3D models into static composites, conforming to background image positional cues.
- Appreciation of the influence topology has on subsequent texturing and rendering further down the pipeline.
- Attain recognised professional practice in industry-standard 3D software.
- A technical working knowledge of the art of polygonal modelling, NURBS and subdivision surface modelling techniques, the pros and cons of each and an understanding of which technique is best suited to the task at hand.
- Methodologies regarding analysis of the form and efficient dissection, breaking everyday objects into individual shapes.
- Give context concerning when texturing can usefully replace time-consuming modelling operations and how imitating lighting or reflections can sometimes be more efficient than processor-intensive operations.

## 5. OUTLINE CONTENT

The student will learn how to model basic assets to fit and composite into a locked-off back plate. However, before modelling objects, the curriculum suggests examining how footage can be measured and interpreted so that the virtual camera within the 3D software can match the real camera used to originally shoot the footage.

### Matching a backplate

The student needs to understand that the lens, focal length, camera film back and other positional data are critical as starting points for accurate matching of models. Everything springs from that starting point.

- Importance of camera film back, format, clipping planes, resolution, aspect ratio, focal length, camera height/angle/inclination, lens distortion.

*Note: the important thing for match move in regards to the 'film back' or sensor is its physical size in cm, mm or inches. A typical camera used for 35mm film is 0.968 inches wide by 0.735 inches high. This value is different depending on the camera. As an example, consumer HD cameras generally have a sensor that is much smaller. Getting this value correct is important as it has an effect on the focal length when solving a camera match move! You can usually find the size of the film back (camera sensor) in the manual or specification documents online.*

- How to measure the set and apply this within the 3D environment.
- Discussion of lighting characteristics of the back plate/photograph, outlining key or direct light (such as the sun) and ambient bounce or fill light (such as the sky).
- Shadow characteristics, highlights and materials (such as how wood looks compared to metal, plastics, etc.).

Fungus the Bogeyman ©2015 Sky





## Modelling

- How to model everyday (ie photo-realistic not fantasy) hard surface objects using cross-section line drawings or photographs.
- Using references – photographs or line drawings scanned into 3D software, then modelled.
- Understanding and conforming to photogrammetry.
- Use of established modelling techniques within 3D software, including but not limited to: an understanding of quad modelling with efficient edge loops, cartesian co-ordinates, NURBs versus polys, etc., primitives, topology, extruding, mirroring, lofting, translate, rotate and an understanding of UV mapping.
- Assessing the best technique for the task in hand while ensuring the level of detail needed.
- Turntabling 3D models.

## Basic texturing

- Understand how CGI creates the look of real world objects by combinations of texture mapping techniques, shaders (how the surface and the surface beneath reacts to light), lighting and how LUTs are used (this will lead usefully on to CGI multi-pass compositing).
- Photographing/sourcing textures: what makes a good texture? Remember: no reflections or shadows! Introduce the idea that you can paint them off.
- Cleaning up or editing texture via paint techniques (eg Photoshop/BodyPaint/Mari), pointing out the pitfalls of 'Google image sourcing'. Painting out highlights.
- UV (or Ptex) mapping: laying out UVs/pelting compared to projection techniques.
- Texture projection method – the method used to project or 'stamp' a photo (or other image) onto a model in 3D. This is a good starting point for a texture, which the student can then clean up or fix.
- Once the projected texture looks good then the student can 'bake' out the texture, making sure the UVs of the polygons are correct.

Note: lighting and texturing 'cheats' may be outlined, such as when/how to fake reflections rather than using expensive ray-tracing techniques and when/how to bake elements such as shadows, highlights and ambient occlusion to be reused later, or even when/how to paint them into texture files.

## The asset pipeline

- Explaining that UV layout techniques should be a common language between modelling and texturing and the influence that modelling techniques should have on texturing (avoiding stretching).
- Strategic placement of 'seams' in UVs to reduce any visible seams in the texture.
- Techniques in dealing with texture seams and making them invisible.
- Deciding on where to concentrate to create the look (this will be a useful lead-in to the concept of look development later).
- How diffuse, colour, bump, displacement, luminance or transparency maps can be used with shaders (using only software presets – no shader development).
- Shader designation (understanding that shader and 'material' can be used interchangeably).
- Specularity maps, material designation and basic (key/fill) type lighting.
- Working with multi-pass rendered layers and grading in compositing.
- Extracting all maps from a colour map. Understanding where its specular points are (good Photoshop skills are needed here).
- Students need to be given practical experience of how to generate relevant passes (beauty, etc.).
- Patching with photo images where appropriate rather than painting.
- When to use procedural textures.
- Awareness of multi-tiling for UVs.
- Resolution issues and the usage of proxies for large textures.

## Rendering and compositing

- Rendering beauty RGBA: render gamma settings, premultiplication.
- Rebuilding the beauty from colour, specular and shadow passes.
- The over, mult and add layer functions.
- Matching focus, grain and grade (emphasis on techniques for matching black points).
- Using ID passes to further control selective grading.

## Post camera effects

How to add effects in post. This should be divided into two sections:

- Matching the look of a real camera, depth of field, lens distortion, chromatic aberration, lens flare and bloom.
- Simple transforms, stabilisation, pans and tilts.



Courtesy of National Film  
and Television School /  
Compositing Coach

## 6. KEY TEXTS/LITERATURE

Brinkmann, R. (2008) *The Art and Science of Digital Compositing: Techniques for Visual Effects, Animation and Motion Graphics*, Morgan Kaufmann

Birn, J. (2013) *Digital Lighting and Rendering*, New Riders

Zwerman S., Okun J. A. (2010) *The VES Handbook of Visual Effects*, Focal Press

[www.textures.com](http://www.textures.com)

<http://lesterbanks.com/2010/11/maya-texture-projection-mapping-tutorial/>

Texture projection in ZBrush: [www.youtube.com/watch?v=vTh0wSjF71U](https://www.youtube.com/watch?v=vTh0wSjF71U)

Yot R. (2011) *Understanding & Using Light in Art & Design*, Laurence King

## 7. SUGGESTED LEARNING ACTIVITIES

Critical analysis – getting students to reconstruct efficiently something ‘everyday’ that they may take for granted (a postbox, street furniture). Ensure students critically compare their CGI version against the real thing (via split screen).

Picking a real object in the back plate and building it in CGI.

Placing a built model into a well-known film shot (‘borrowed’ from a Blu-ray disc for instance).

**Show students how to bake out a projected texture:** There are variants to this procedure, but this is the basic method).

1. Make sure the UVs of the polygons are correct. Look for a tutorial on unwrapping polygons. This isn't a problem if you are using NURBs.
2. Find the texture that is being projected and in the hypershade, select its SHADING GROUP NODE, (find the material and choose SHOW UP AND DOWNSTREAM CONNECTIONS).
3. Select the polygonal object it is being projected onto.
4. Then, in the hypershade go to the EDIT pulldown menu and select CONVERT TO FILE TEXTURE.
5. You should now see a new material node in the hypershade, showing your new file texture.

We recommend a ‘dailies process’ throughout this topic, with students sharing work progress and engaging in presentation and peer critique.







*The Martian*

Courtesy of 20th Century Fox / Framestore.

# TOPIC 003: VFX COMPOSITING FOUNDATION

## 1. THEME AND SCOPE

**Compositing is where a variety of disparate elements are brought together into a visually cohesive whole. The composite is the destination of a range of assets and great precision is needed to enable the viewer to suspend disbelief. Even when the result is not intended to be photoreal, it is vital that the final image is cohesive and seamless and evidence of its construction does not detract from the story or meaning.**

Whilst composited images do not need to be photoreal, this topic focuses on the student's ability to combine elements into a seamless 'photographic' image.

We introduce students to 2D image basics, including layering, masking, simple keying, notions of colour space, '2.5D space' and complement this with tuition on perceptual skills and the underpinning apparatus that can fool the eye and brain.

It is important to have an appreciation of the history of compositing and its roots in early photographic spectacles, a chronological thread that informs today's practice.

The student progresses through this topic accumulating techniques, being introduced to the efficient design of project set-ups and flexible re-usable templates, building flow graphs to anticipate changes as they might be guided by a compositing supervisor or sequence lead and developing the knack of actively second-guessing what might later need changing. The student will learn that since shots can move from artist to artist they need to be built to be readable by others and be logically laid out.

*Note: introducing the notion of the template or 'hero script' here at the compositing foundation stage is valuable. Students could wire in similar input images to their attempted scripts and be challenged to talk through what is happening at each operation. Although we aren't recommending students conform to a particular orthodoxy or standardised approach, students need to understand and evaluate in a systematic way the nodal process that creates their composite.*



## 2. WHY TEACH THIS?

If nothing else, compositing is what glues together all VFX creations and finalises the image. To students, it's often revelatory and gratifying when elements come together, but also eminently frustrating when it goes wrong. It can be deceptively hard to get that last 20% or 10% right and that's what really deserves attention. It's that last 10% of meticulous attention to detail that recruiters notice and appreciate in an era when everyone has comps on their reels.

Compositing is also enriched by an understanding of pixel math, which allows artistic students to start to get a fix on a useful strategic approach to solving a key or strengthening a matte, as opposed to flailing at Primatte sliders hoping for a lucky break.

It is that final finishing of a great comp that needs to be instilled in the student – a pertinent case of quality over quantity.



Courtesy of  
University of York

## 4. WHAT STUDENTS NEED TO KNOW AND DO

### Intro level descending to advanced level

- A basic proficiency in layering and combining disparately created elements into a perceptually cohesive whole.
- Match elements to a background using common compositing techniques such as edge quality, focus, colour, grain/noise structure, etc.
- Utilise different approaches to creating masks and isolating groups of pixels.
- A practical understanding of the building blocks of 2D VFX and simple operations.
- Be able to dissect and communicate what makes a shot look 'right' and visually coherent.
- Identify and choose optimum processes to create seemingly photoreal images and recognise the importance of efficient ordering of image elements.
- Explain clearly different approaches to manipulating colour and light.
- A grounding in 2D pixel math operations, allowing 'under the bonnet' manipulation of images.
- Thorough exploration of both 2D and 2.5D methodologies and having created composites for both, understanding the differences between the two approaches.
- Combine different CGI passes appropriately (at least diffuse, colour, specular and shadow should be covered).
- Explain pre-multiplication to the peer group via pixel math and visuals.
- Full understanding of compositing in different pipelines.
- Usage of LUTs and moving images successfully through different colour spaces.

## 3. RELATED JOB ROLES

COMPOSITOR

VISUAL EFFECTS EDITOR

VFX ARTIST

## 5. OUTLINE CONTENT

Here is a list of the main points this topic should cover, divided into sections:

### History of compositing

- Rewinding in camera, matte, stop motion, optical printing.
- Why things today are done in a certain way and the photochemical roots of some of the terminology.
- Simple pixel math operations (at least: over, multiply, add, subtract and screen).
- A demonstration of a composite built entirely with maths (using Nuke nodes like ShuffleCopy and ChannelMerge, for instance). How a key can be pulled with an expression or how an over node is built through maths.

### The colour pipeline: from acquisition to delivery

- Using pre-graded plates via offset or gain RGB changed values.
- The colour decision list.
- Checking VFX comp grading over a wide gamut – pushing the comp application's viewer via exposure or gamma controls and/or checking the comp in log as well as linear with a viewer LUT applied.

### Colour space and the use of LUTs

- Input, compositing in linear light space, implications in DI and for cinema delivery.
- Gamma, sRGB, CIE 1931 standard observer, Cineon PDlog685, other log implementations, dpx and exr formats, rendering the output.

### Premultiplication

- The concept of r,g,b,a as separate channels, how the pixel math operations affect channels and eventually the image; premultiplication artefacts, un-premultiplying and its uses.

### Project organisation

- Order of node grouping in the script should reflect the order of layers in the comp. Use labels, colour and thumbnails to organise your script. (Nuke – dots, Backdrop, StickyNote).
- Building flow graphs to anticipate changes with the logical grouping of operators – for instance clustering colour corrections, transforms, etc. together (avoiding concatenation) for filtering.
- Ensuring flow graph legibility, so a shot can move from artist to artist.

### Establishing depth cues

- Colour, tone, depth of field, scale and position, layering (putting part of the background back on top of the CGI), relative motion and fog. These may also be discussed in relation to 2D to stereo 3D work.

### Building up layers from simple sources

- Creating cutouts via masking, comparing Bezier with natural splines, editing masks, feathering and edge blur.
- Work with a minimum of three layers.

### Luminance keying

- Garbage masking/keying, core masking/keying, Union and Inside operations, grain reduction techniques, tonal and/or colour correction, using a single RGB channel to key from.

### Post processing the matte

- Filtering, erode/blur/edge detect, averaging single frame mattes together, tracking single frame mattes on to moving edges, painting onto mattes and use of stroke interpolation for fine detail.

### The lens, colour and the camera

- Matching edge quality, focus, tone/colour and image texture (grain).

### Understanding the concept of multipass CGI compositing

- Using the correct compositing math to build combinations of (at least) colour, diffuse, specular and shadow passes together to form the beauty pass. Which pass should you change and when?

### Layering in 2.5D space

- 2.5D basics and system setup. Cards, displacement, distortion, arrangement in space, camera animation to give false parallax, combination of 2.5D system with 2D layering.

### Grid warping tools

- Compare 2D warping with 2.5D card distortion operations (for example, to adjust horizon lines and correct exaggerated perspective).

### Intro to stereo compositing

- Dimensionalising the shot using masking cards and card displacement.

### Finessing

- The final touches such as dust hits on footfalls, warping clothing on interaction, particulates in the air, manipulating the all-too-perfect CG into a photographic image.

## 6. KEY TEXTS/LITERATURE

Brinkmann, R. (2008) *The Art and Science of Digital Compositing: Techniques for Visual Effects, Animation and Motion Graphics*, Morgan Kaufmann Series in Computer Graphics

Wright, S. (2010) *Digital Compositing for Film and Video*, Focal Press

Lanier, L. (2013) *Digital Compositing with Nuke*, Focal Press

Drate, S. Salavetz, J. (2009) *VFX Artistry: A Visual Tour of How the Studios Create Their Magic*, Focal Press

Zwerman, Okun (2010) *The VES Handbook of Visual Effects*, Focal Press



*Guardians of the Galaxy*  
Courtesy of Marvel Studios  
/ Walt Disney Pictures / Framestore.

## 7. SUGGESTED LEARNING ACTIVITIES

Exercises can be based on re-visiting the integration of assets from the CGI Foundation topic: like a sky replacement or multi-pass photographic exposure. For instance, one pass could feature an area of blown-out exposure (eg a window in a room) and one pass being exposed for the interior. Both passes can be integrated into one rendered comp, which could then progress from being a locked-off shot to a moving camera shot.

Simple photographed elements on green screen (or created In CGI) could be used to teach grading. The ability to 'tie' elements together through match grading so tone, colour, edges and direction of light are all matched.

A teaching pack of back plates could be prepared. For example, a field containing reference objects such as a fence or farm building or vehicles is shot at different times (could be time lapse photography) as the sun comes up and changes through time.

Students could observe and describe through colour temperature changes how diffuse or direct the light is, what angle the direct (sun) light is at, shadow quality, haze, etc. in the image.

Additional foreground elements such as another fence, the farmer or some flowers/crops could be then photographed against green screen and supplied pre-multiplied (there is another topic about this) or created as CGI. There are then options in matching these elements through studio lighting techniques (another option if available is to texture and light – backlight/front light/side light the CGI models to try to replicate the sun's effects as on the background). The student then has to match elements in purely by comp techniques such as match grading, edge grading and edge blending.

As an exercise, make students unexpectedly swap complex comps halfway through a brief to ensure they learn the need to lay out work rationally, thinking about how best others might interpret and utilise. Getting accustomed to 'dailies', revisions and working efficiently. Building node networks/flow graphs/scripts that are tidy and easy for others to understand. The concept of building tweak/change controls into a script should be clearly understood and demonstrated. These ideas should be introduced slowly, but reinforced throughout all compositing exercises.



Courtesy of MPC

# TOPIC 004: THE MATTE FOR VFX

## 1. THEME AND SCOPE

**This topic examines different methods by which mattes can be created and how they might be manipulated and used in VFX compositing.**

The integrity of the matte is vital in VFX and mattes need to be rigorously examined and tested throughout creation and implementation. Precision is called for and there are a number of tools and methods by which a matte can be extracted from an image. The student needs to appreciate the most appropriate and efficient way to create a matte under the circumstances.

This topic examines rotoscoping (mattes created by hand), keying (mattes made by colour or pixel range) and several variants such as mattes created by math operations.

It instils best practice by referring to the matte independent of the image and being attentive to issues regarding edge and core. Students are exposed to different tools and gain a practical understanding of their relative strengths and weaknesses.

## 2. WHY TEACH THIS?

**Being able to build a robust matte will always enable students to get out of trouble in VFX! Being able to demonstrate you can build and combine mattes inventively through a variety of techniques means the student is not limited to green screen scenarios, but can release their imagination towards a wider range of creative rich visuals, as well as 'rescue' and repair shots, which is highly prized.**



### 3. RELATED JOB ROLES

ROTO ARTIST

COMPOSITOR

R+D DEVELOPER

### 4. WHAT STUDENTS NEED TO KNOW AND DO

#### Intro level descending to advanced level

- An awareness of how mattes work and can be created and what they can do.
- How to make informed choices about which method of matte creation is the most appropriate.
- The main working practices of rotoscoping and its context for matte extraction.
- Analyse and plan shots, estimating time and resources, and communicating this effectively.
- Combine edge and body mattes in order to make seamless images out of multiple elements.
- Examine images and present a range of keying strategies and processes for consideration.
- Analytical and observation skills at work in the quality and integrity of edges and the core body of the image, supported by the matte.
- Display effective and efficient use of rotoscoping practice and keying within a showreel to gain employment.



Courtesy of National Film and Television School / Compositing Coach

### 5. OUTLINE CONTENT

The topic will cover the points under these headings

#### Rotoscoping as 'hand matting' for VFX work

- A demonstration of how mattes are used in a composite.
- Analysing and planning your shot, estimating time and resources.
- The pipeline: planning your own roto or taking a brief, initiating and completing.
- Recognising which elements should be rotoscoped and where other mattes are preferable.
- Extraction through other methods and how mattes might be combined.
- Breaking the shot down into shapes; natural splines for organic shapes, beziers for regular shapes.
- Finding the frame with the most detail and working backwards.
- Edges: finding the hard edge and drawing a spline to it. Outside or on top?
- Making motion blur within the matte and accurately matching the fall off on edges of rapidly moving elements within the plate.
- Edge quality: hard or soft edged matte? Why not ask the compositor!
- Animation: thinking like an animator, looking for natural keyframes – making the computer do the work.
- Why consistency over time is more important than following every nook and cranny.
- Using rotate and scale on an entire shape or on groups of points.

- Dealing with organic articulated forms: one point and two point stabilisation of the plate and the use of the same data to de-stabilise the roto shapes before rendering them as mattes.
- Boolean operations: Union, Plus, Inside, Minus, Outside, XOR.
- Inorganic or static forms: point and area/planar/corner-pin tracking approaches to the rotoscoping of static geometry.
- Understanding how to use appropriately positioned cards and 3D camera tracking to project roto shapes onto edges of static objects within the software's 2.5D system.  
*Note: this saves a lot of effort keyframing various splines to fit, as the virtual camera used to view the scene has already been tracked.*
- Rendering different roto-mattes to separate channels.
- Rendering and naming (eg renaming parts of body to distinguish different actors in shot).
- Making garbage mattes and assisting the compositor with matting solutions as required.

### Blue/green screen keying as 'procedural matting' for VFX work

- Types of key, their differences and properties.
- Chroma.
- Colour separation and channel keying.
- Luma.
- Difference matting.
- Motion keying.
- Image-based keying.
- Proprietary keyers; Ultimatte, Keylight, Primatte.
- Techniques for pre-processing the plate.
- The process of screen 'evening out' or levelling.
- Creating a spill map and de-spilling techniques.
- De-graining techniques.
- Creating your own clean green screen plate.
- Matte density. Using over- and under-exposure (in the viewer) to test matte density.
- Common matte combining operators (add, mult, subtract, etc.).
- Methodologies:
  - a) Pulling mattes with inside, outside and edge keyers.
  - b) Edge matte/body matte approach.
  - c) Split keying; different keys for different portions of the plate.

- How colour dilation can affect the matte (sometimes referred to as edge extrusion).
- The maths of keying. Building your own keyer.
- Tracking in static mattes to avoid boiling on very fine detail, if all else fails.
- Working with soft focus, semi-transparency and motion-blur issues.
- Using painting techniques for restoring very soft/motion-blurred edges.
- The challenges of integrating edges to look natural. How to approach colour bleed and other problems.
- Post-processing the matte.
- Match grading tools and techniques in order to get coherent elements: offset, gain, gamma, lift, cross-talk, black point, white point, curve tools and exposure tools.
- Log versus lin grading.

*Note to tutors: all channels use greyscale to represent tone in exactly the same way, so mattes can be stored in any channel (r, g and b, as well a).*

Complete transparency in the matte is at value 0 and complete opacity is at value 1, so values inbetween represent a level of semi transparency. Matte values should always be clamped at 0 and 1, otherwise the pre-multiplication (matting) math with the foreground colour image may be incorrect.

### General project organisation

Order of node grouping in the script should reflect the order of layers in the comp. Using labels, colour and thumbnails to organise your script.



Courtesy of  
National Film and Television School /  
Compositing Coach

## 6. KEY TEXTS/LITERATURE

Wright, S. (2010) *Digital Compositing for Film and Video*, Focal Press;

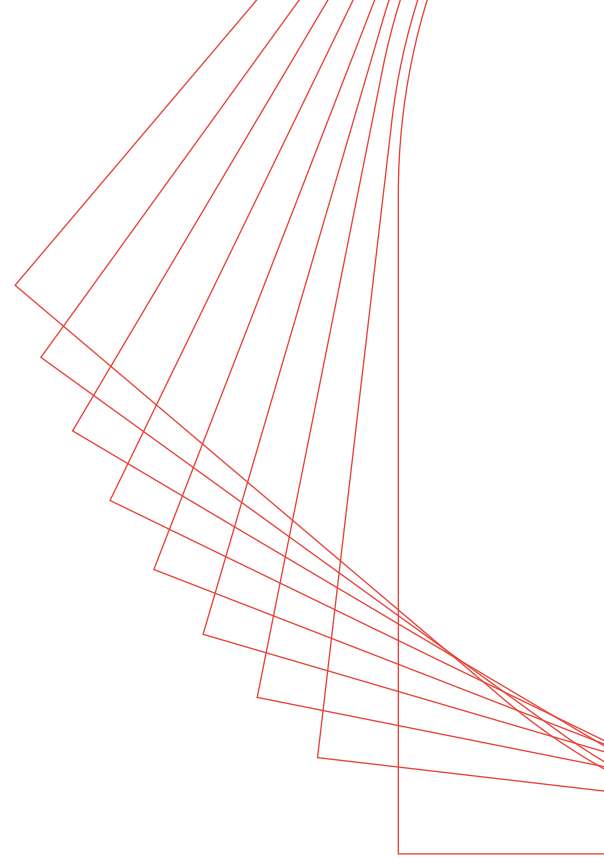
Brinkmann, R. (2008) *The Art and Science of Digital Compositing*, Morgan Kaufmann

Okun, J.A (Editor), Zwerman, S. (Editor) (2010) *The VES Handbook of Visual Effects: Industry Standard VFX Practices and Procedures*, Focal Press

Foster, J. (2010) *The Green Screen Handbook: Real-World Production Techniques*, Sybex

Bratt, B. (2011) *Rotoscoping: Techniques and Tools for the Aspiring Artist*, Focal Press

Hanke, J., Yamazaki, M., (2009) *Greenscreen Made Easy: Keying and Compositing Techniques for Indie Filmmakers*, Michael Wiese Productions



## 7. SUGGESTED LEARNING ACTIVITIES

### Developing a critical eye for edge quality through looking at existing video and film material.

Scene photography of actors from existing productions (with as little compression as possible) will provide better examples than blue/green screen sources. How does motion blur, fine hair, organic versus geometric form, camera focus and the lighting in the environment affect the edges in the image? Are edges the right level and gradient of translucency? How are they described in terms of matte density and greyscale level in the matte (alpha channel) across specific areas? (The range of 0 to 1 should be used where possible, as opposed to 0 to 255.)

Some of these clips could then be roto-scoped. An affinity for edge quality will then be further enhanced through students literally having to recreate the look of the original by adding feathering, edge blurring and motion blur.

A and B comparisons should be viewed on the biggest screen available, with the original clip viewed against the pre-multiplied (matted) clip on mid grey. This gives a good comparison. A critique of technique should take place summarily. Do edges boil, jump or chatter? Is there too much original background texture/colour visible or too little foreground object texture/colour? In other words are the roto-scoped edges too loose or too tight? Can problems be fixed quickly or will shapes need to be re-animated?

Students need to get used to the high level of quality control needed where roto-mattes are made and how (although the process is relatively 'manual', as opposed to more automatic keying processes) the end product is the same – a coherent matte.

Simple photographed elements on green screen could be used to teach integration (pulling the key/de-spilling and match grading). Students need to gain the ability to 'tie' elements together through match grading so that tone, colour, edges and direction of light are all matched and an integrated image fools the eye.

A teaching pack of back plates could be prepared, for example a field containing reference objects such as a fence, farm building or vehicles could be shot at different times as the sun moves position.

Students can then analyse colour temperature changes and describe how diffuse or direct the light is, what angle the direct (sun) light is at, shadow quality, haze, etc. within the image.

Additional foreground elements such as another fence, farm machinery, hay bales, etc. could then be photographed against a green screen. Students could then explore different strategies towards pulling a key with appropriate edge detail and softness, matching these elements through studio lighting techniques or purely by compositing techniques such as match grading, edge grading and edge blending.



Paddington  
Courtesy of Heyday Films / Framestore.

# TOPIC 005: VFX PAINT AND RIG REMOVAL

## 1. THEME AND SCOPE

Wires, harnesses, markers and all kinds of film apparatus may need to be digitally removed from a shot. Having played a purpose in assisting the shot, they now need to be made invisible to the eye. In addition there are sometimes mistakes on the shoot, such as boom mics or crew shadows accidentally appearing in the frame and other incongruous elements that may disrupt the story, like pylons or wristwatches in a period drama.

The same digital tools may also be used for image restoration – removing dust, replacing and substituting dropped frames or cleaning up stereo 3D image pairs. Traditionally all these tasks belong to a prep artist (digital preparation artist) or paint artist and expertise in rotoscoping is considered the entry point into a compositing career. You can progress into paint/prep, starting at 'dustbusting', marker removal, scratch repair and rig removal – and all of these techniques are introduced in this topic.

Today, the term 'paint artist' is a catch-all term – it is certainly not all about the act of digital painting, although such skill with a Wacom pen is held in high regard. People who can 'paint their way out of trouble' in the absence of photography are highly prized.

In dealing with large resolution images, high-level quality control and a dispassionate and discerning eye for repair work is necessary. Such work needs to be invisible and unnoticed and students will need to prove it to themselves and others with the use of A/B comparisons.



## 2. WHY TEACH THIS?

In this topic the student will learn traditional prep techniques such as paint, patching, de-graining, tracking and retiming as well as contemporary 2.5D and image re-projection techniques. This topic allows the creative art student to connect drawing and painting skills they may have utilised outside of the digital realm with a practical digital application. For non-arts students, observational and analytical skills can compensate for lack of drawing or art skills and students can also learn much about the role of practical effects as they remove wires and harnesses.



Courtesy of BA undergrad

## 4. WHAT STUDENTS NEED TO KNOW AND DO

### Intro level descending to advanced level

- Recognise the importance of quality control and invisibility of repair.
- Awareness of a range of rig removal/image restoration techniques and examples of successful utilisation.
- Understand the industry imperative for the minimum amount of change to the source material to get the job done, using the least amount of time.
- Experience of both 2D and 2.5D modes of working and a good sense of when either is best deployed, or even combined.
- Display a good blend of art and technology skills in the areas of rig and tracker marker removal.
- Show accepted entry-level skills in paint, restoration and rig removal for VFX.
- A portfolio of practical solutions and repairs to images and shots using a mix of rig and tracker marker removal, dustbusting, de-graining and re-graining, patch fitting, painting, 2.5D, image restoration and repair, exhibited through A/B comparisons where appropriate.
- Painting skills through proficiency with a pen and tablet.

## 3. RELATED JOB ROLES

PAINT ARTIST

DUSTBUSTER

PREP ARTIST

TEXTURE ARTIST

## 5. OUTLINE CONTENT

Here is a list of the main points this topic should cover, divided into sections:

### The theory of rig removal, including image processing, vector maths and tracking data

- A clear understanding of the underlying principles of how optical flow and motion estimation tools and technologies work.
- What is spatial motion estimation – both local and global?
- What is temporal motion estimation?
- How are forward/backward motion vectors produced and how are they used?
- How masks can be used to help the optical flow analysis.
- Understanding the difference between area/planar/corner pin tracking and point tracking. Analysing the image for position (transformation) or scale and/or rotation (translation) changes. Search and target regions, fixed and roaming target updates.
- What makes good tracking regions (planar/area/corner pin tracking) or features (point tracking)?
- 2D versus 3D tracking – when should you track in 2D or 3D?
- How to convert 3D tracking to 2D cornerpins or 2D track points.
- How to examine tracking data animation curves, utilise jitter removal and how the tracking data may then be applied as match move or stabilisation data.

### The art of rig removal

- The student will experience a range of rig removal/image restoration problems and develop appropriate strategies for dealing with them. Small areas of image that need to be repaired/restored can usually be dealt with by masking or painting in sections of a clean plate.

Note: these may be provided by the tutor or 'accidental' clean sections from other frames may be found in the clip, or the student may 'paint up' a plate, by creating a collage of different frames together or by clone brushing. Large areas of image that need to be repaired or replaced may mean going down the route of complete image reconstruction, using either patching or 2.5D re-projection techniques.

- Developing art skills that make your fixes invisible!
- As an artist, the student needs to decide on the tipping point between not successfully removing an object and going too far so that your brush strokes or mask lines become visible (the characteristic 'boiling' that people talk about). It might be that a patched section has grain structure that doesn't match the plate, or the image detail has been softened too much in the process of completing the fix.

A good exercise in the quality control expected in rig removal for VFX is to A/B compare your finished repair or restoration (a greater challenge would be where a large part of the image has been restored – for example, taking out a person in the foreground of a shot) against the original plate. How much image detail/grain has been lost? Would you consider your work to be the same plate with just the object/person removed or have you gone too far and the image betrays evidence of a clean-up?

### Tracker marker removal on blue or green screens

- The student will be able to use dedicated tools for this task or use animated masks, filled with colour sampled from an area of blue or green backing. Animated or interpolated brush strokes of solid colour can also be used, but care needs to be taken to avoid paint strokes boiling and checks made that all edges where markers may have originally passed under actors or objects are correct.
- As with all tasks, the student should start with broad strokes and then refine until the result is seamless. The process should start with garbage masks filled with screen colour, through colour correction techniques to neutralise the markers that overlap the subject and then down to frame-by-frame painting.

### Dustbusting

- Students need to be able to use dedicated tools, or alternatively practice manually clone brushing frame-by-frame over the 'dust' or dropout from a copy of the clip that has been typically offset one frame forward or one frame backward. Cloned brush strokes need to be just large enough to cover the problem.

An explanation should be given regarding how technologies such as infrared scanning can be helpful, with advice on the pitfalls of automated techniques and how to minimise any errors.

## Image de-graining

- The student will examine images on a per-channel basis, assess grain or noise structure and learn a range of techniques for de-graining still and moving images, including the use of blur filters, frame averaging and optical flow.
- The default isn't always optimum – it depends on the image. The student needs to understand and employ ways of controlling the blur so they have minimum grain but maximum image detail. Examples include using edge-detection filters as 'protection' masks and blurring separate image channels by different amounts.
- The theory behind frame averaging (sometimes called 'compounding') should be expounded and how this may be used to produce a de-grained still, with reasonable image detail. The technique has a wider application in making single frame mattes of fine detail that can be tracked in when all else fails.
- The use of optical flow-based tools to de-grain single frames or clips could be covered, as well as modern complex de-noising filters and FFT (Fast Fourier Transform) techniques.

## Patch fitting

- Understanding how to align and matchmove a de-grained 'clean' still to the appropriate part of the plate. This can be compared with clone brushing or masking in areas of a stabilised, repositioned or time offset/looped section of plate, if appropriate.
- Students could explore and note the characteristics of different blur filters as they apply to an image. After the clean still has been moved to fit the plate, differences in (for instance) cubic, rifman or parzen can be understood from both the perspective of pixel math or from looking at the image for softness.

## Painting

- As well as feather masking in sections of a fitted plate, it is very often desirable to develop skills with a graphic tablet pen, as sensitive frame painting is very often the only way to 'reveal' back in small areas to the fitted patch, or to paint into areas where there is plenty of movement.
- Being able to paint with subtlety and accuracy is an essential skill for a prep artist. Students should pay attention to boiling and understand how brush size, type and opacity (together with dexterity and a steady hand) can improve paintwork.

Note: it is almost impossible to produce good paintwork using a computer mouse. Skill with a graphic tablet pen is essential.

## Re-graining

- Understand how to use appropriate tools to match the grain structure on your patch to the original plate. This will usually mean working and checking the image carefully on an individual channel basis. Sometimes difference keying the repaired image with the original is necessary in order to isolate an area to apply grain to.

## 2.5D

- Using 2.5D techniques for repair work, the student will need to be able to use and understand how a '3D camera tracker' works. They will then need to be able to use the 2.5D system in the software to re-project still or painted patches back onto some geometry or cards that have been arranged appropriately in front of the tracked, virtual camera. Understanding how images can be painted on (and then UV textured again) onto models can also be useful.
- Through exercise, students will experiment when 2.5D is an appropriate approach. If the image has already been camera tracked or has a fair amount of parallax in it, then 2.5D is a workable option – otherwise the traditional patch and paint techniques may be quicker. Playing the role of the prep artist, the student must be able to intelligently choose which route to go down. Complex image rebuilds may require a combination of traditional and 2.5D rig-removal techniques.

## Image restoration and repair

- Students learn and develop techniques and routines for image restoration and repair (and how to win the heart of the post supervisor when something has happened to the rushes, or to circumvent the need for a very slow CGI re-render).
- Students learn how dedicated tools, optical flow or channel maths may be used to repair scratches, tears, damaged film, digital dropout or dropped frames from CGI renders, missing colour channels, film scanning errors or rolling shutter artefacts.

## Stereo 3D specific issues

- Students should be able to align stereo 3D image pairs vertically and remove specular highlights, flares or other polarising artefacts from one of the stereo pairs. They will be taught how to fix image ghosting and use roto and paint correlation methods. It is suggested that monoscopic 3D projection filmed from a set of tracked virtual stereo cameras is useful for producing stereo clean plates.

Optional: students can use 2.5D techniques to complete 2D to 3D conversion work.

## 6. KEY TEXTS/LITERATURE

Brinkmann, R. (2008) *The Art and Science of Digital Compositing: Techniques for Visual Effects, Animation and Motion Graphics*, Morgan Kaufmann

Eismann, K. Palmer, W. (2005) *Photoshop Restoration and Retouching*, New Riders

Ctein (2010) *Digital Restoration from Start to Finish: How to Repair Old and Damaged Photographs*, Focal Press



*Artifice*

Courtesy of Felix Bauer-Schlichtegroll / Mohrag Taylor / Gordon Marshall / Nikolay Zorov / NNCA.

## 7. SUGGESTED LEARNING ACTIVITIES

### The art of rig removal

Exercises should be presented where students repair/restore small areas of image by masking or painting in sections of a clean plate. These may be provided by the tutor, or clean sections from other frames may be found, or the student may 'paint up' a plate. Large areas of image that need to be repaired or replaced may mean going down the route of complete image reconstruction, using either patching or 2.5D re-projection techniques.

The student should get used to A/B comparing their finished work against the original plate. How much image detail/grain has been lost?

### Tracker marker removal on blue and green screens

The student uses animated masks, filled with colour sampled from an area of blue or green backing. Animated or interpolated brush strokes of solid colour can also be used, but care needs to be taken to avoid paint strokes boiling and checks made that all the edges where markers may have originally passed under actors or objects are correct.

### Dustbusting

Students practise manually clone brushing frame-by-frame over the 'dust' or dropout from a copy of the clip that has been typically offset one frame forward or backward.

### Image de-graining

The student will examine images on a per-channel basis and assess grain or noise structure and utilise a range of techniques for de-graining still and moving images, including blur filters, frame averaging and optical flow.

The student needs to employ ways of controlling blur by using edge-detection filters as 'protection' masks and blurring separate image channels by different amounts.

### Painting

Skills with a graphic tablet pen need to be encouraged, as sensitive frame painting is often the only way to achieve invisible and subtle results. Students should pay attention to boiling and understand how brush size, type and opacity (together with dexterity and a steady hand) can improve paintwork.

### 2.5D

This could involve the re-projection of painted patches back onto some geometry or cards that have been arranged appropriately in front of the tracked, virtual camera. Students will experiment when 2.5D is most appropriate. Playing the role of the prep artist, the student must be able to intelligently choose which route to go down.

### Image restoration and repair

Students should use optical flow or channel maths to repair scratches, tears, damaged film, digital dropout or dropped frames from CGI renders, missing colour channels, film scanning errors or rolling shutter artefacts.

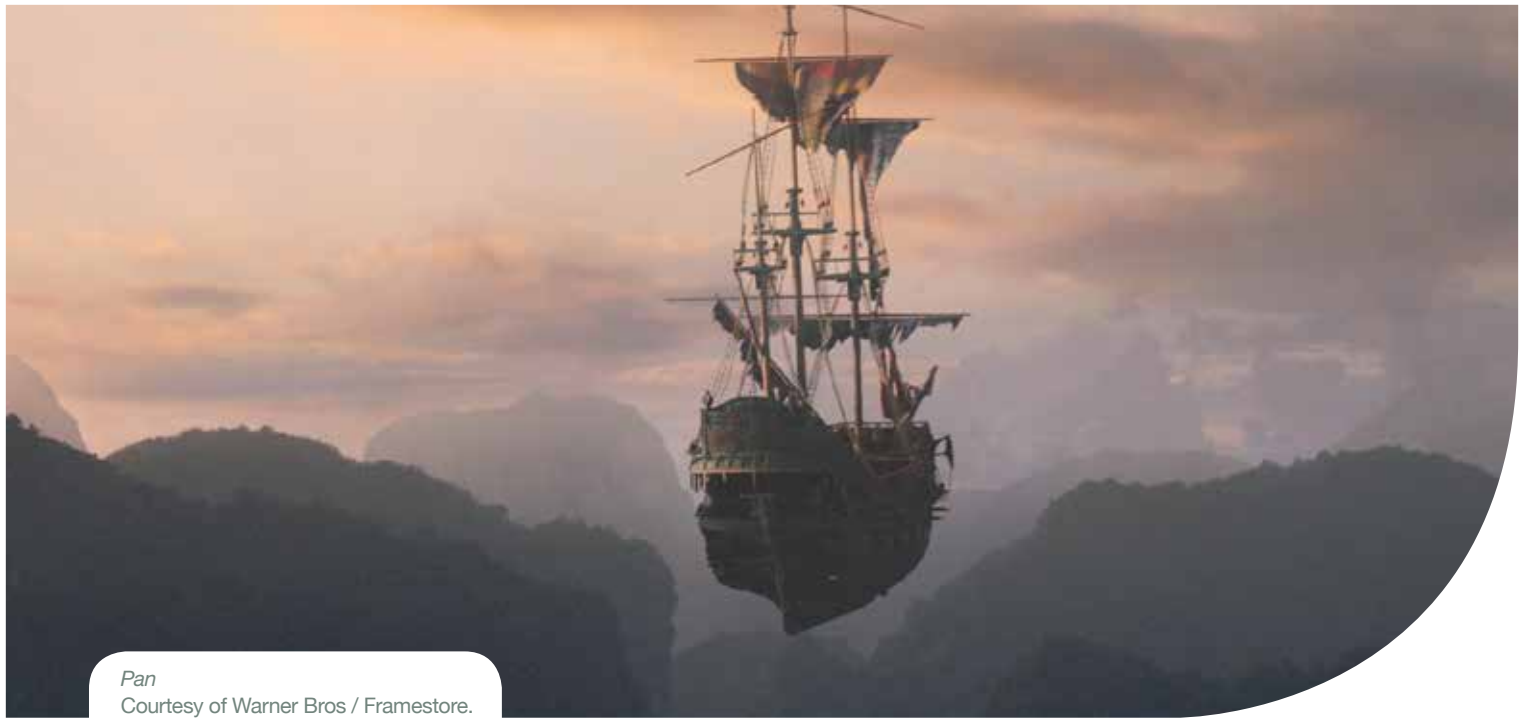
### Stereo 3D

Students align stereo 3D image pairs. They will be taught how to fix image ghosting.





*Pan*  
Courtesy of Warner Bros / Framestore.



*Pan*

Courtesy of Warner Bros / Framestore.

# TOPIC 006: 3D MATCHMOVING FOR VFX

## 1. THEME AND SCOPE

**This topic concentrates on the process of achieving an accurate ‘camera solve’ or matched object geometry from plates shot with moving film cameras.**

Emphasis is placed on how 3D matchmove has become the cornerstone of career progression within VFX (especially within 3D departments) and how accurate 3D matchmoving is crucial for the production of believable CGI.

There is an emphasis on the importance of the minimum use of data needed to achieve the required quality and in particular the influence that generated topology has on texturing and rendering further down the pipeline.

Whilst camera tracking and object tracking are taught within this topic, body tracking (roto-motion) is part of the Animation Foundation topic.

## 2. WHY TEACH THIS?

Replicating or reconstructing motion in 3D is a good discipline to have for progression within 3D-heavy departments. It gives the talented student an entry-level job at the right company.

It is important in this topic to encourage peer review and to develop in students a real critical eye for tracking accuracy and get students to understand that while the results (often tests) are not visually stimulating, they are passports to real work in the industry.

### 3. RELATED JOB ROLES

MATCH MOVER

CG SUPERVISOR

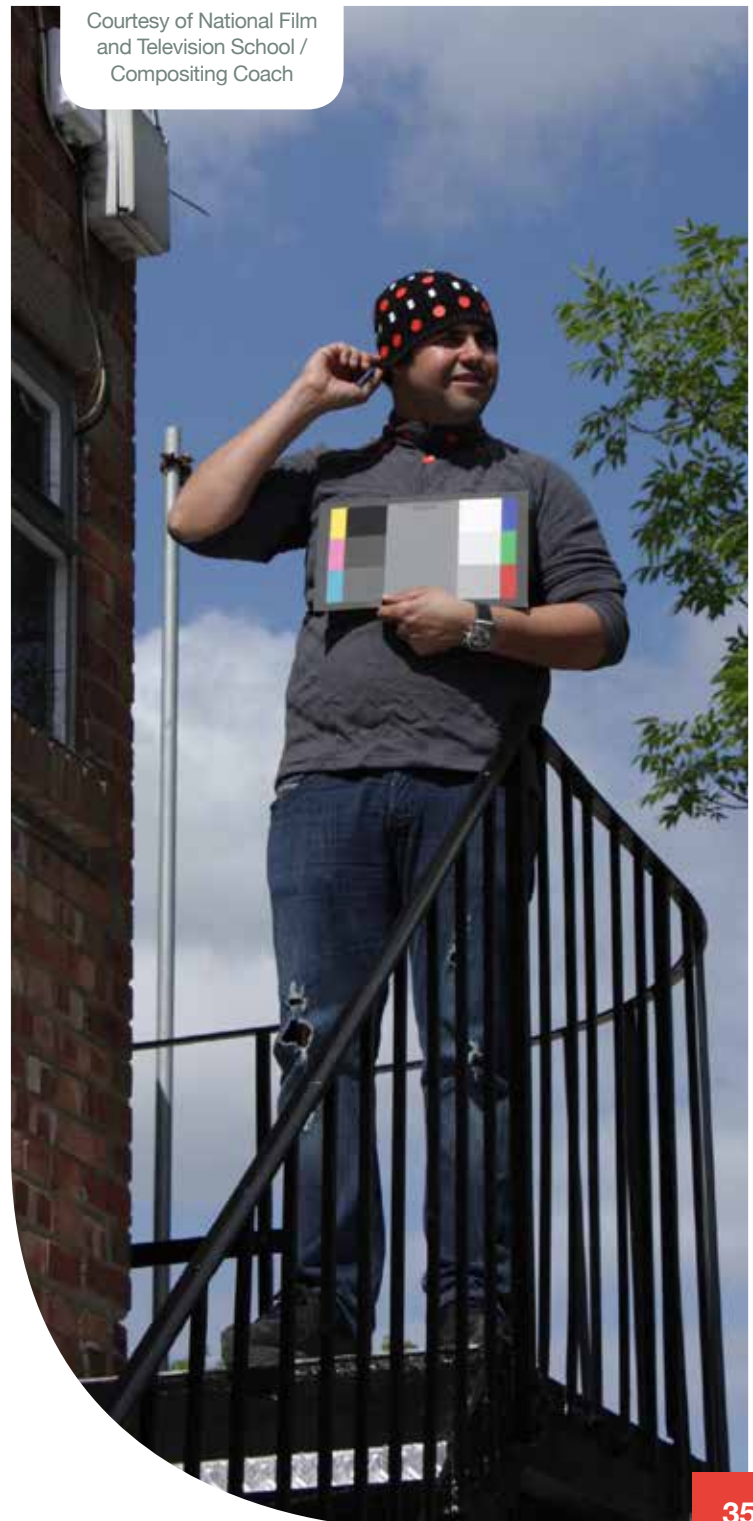
LAYOUT ARTIST

### 4. WHAT STUDENTS NEED TO KNOW AND DO

#### Intro level descending to advanced level

- They can extract motion data across a range of exercise plates.
- Show they understand the difference between object tracking and camera tracking.
- They can add the element of camera motion to an image, placing previously learnt VFX competencies within a more realistic and professional context.
- Generate successful renders of test geometry that conform to motion within a shot.
- Demonstrate the importance of creating efficient and minimum data for the project at hand, always mindful of the pipeline and deadline they are working within. They can value and gauge the prerequisites needed for an efficient pipeline.
- Provide practical tuition of the requisite depth to gain the successful student entry into a 3D department.
- Extract motion data professionally across a range of real film plates.

Courtesy of National Film  
and Television School /  
Compositing Coach



## 5. OUTLINE CONTENT

Having an accurate scene in 3D of the on-set environment will assist a matchmover in making their camera as accurate as possible. In the film industry a digital representation of the on-set environment is desired wherever possible.

Here is a list of the main points this topic should cover, divided into sections.

### The difference between object tracking and camera tracking

- Observing and deconstructing examples in film and commercials.

### How tracked CGI cameras (often referred to as shot or render cameras) can be used at various stages of the VFX production pipeline

- Attaching or 'sticking' assets to the perceived floor of the plate (as in the example of CGI motor vehicles).
- Being aware that you are creating tracked CGI camera data that may be used by others such as environment artists, 2D prep artists, roto artists and compositors.

### Image formats

- Understanding how anamorphic video images need to be pre-rendered flat and how cropping the plate before camera-tracking it can present problems.
- View examples of common image formats, with reference to their aspect ratio, resolution and crop.

### Techniques for undistorting (de-lensing) the plate

- Pin cushion and barrel distortion.
- De-lensing via image analysis, drawing vectors or lens grid analysis.
- Understanding the need to re-distort the plate after the CGI is composited.
- How STMap nodes can be used in compositing.

### Analysing camera movement

- Initial analysis via close inspection of the plate photography.
- The differences between parallax, nodal (eg tripod-based panning or tilting) as opposed to non-nodal (dolly or handheld camera motion) and camera movement with mixed motion all need to be clearly understood. The student needs a strong understanding of parallax and how it helps camera-tracking software calculate an accurate track.

- It is important the student understands the difference between a camera tracking in or out and zooming, how this looks (the effect on parallax, etc.) and how it affects the software's ability to generate a successful track.

Note: a discussion with a range of examples of images shot in different formats – with different lens distortion and camera movement (recorded material or commercially available DVDs can be used) – needs to widen student experience of the video formats they are likely to experience directly. Emphasis should be placed on students developing skills in analysing the image, so decisions are informed when it comes to the use of 3D matchmoving software applications.

### Camera tracking

#### a) Making use of on-set data (the Acquisition for VFX topic should be studied as a pre-requisite, as it is necessary to understand how on-set data is now used in a 3D matchmoving application).

- Importing media (the plate) and set-up of scene/project within 3D matchmoving software.
- Image format: flat or anamorphic. Pixel resolution.
- The camera film back (size in cm, mm or inches. For instance, a 35mm film camera is 0.968 inches wide by 0.735 inches high).
- The lens focal length.
- Use of other on-set notes such as camera height, angle and distance from set furniture.
- Operation of 3D matchmoving application to produce an initial track and camera solve.
- Operation for triangulating camera position.
- Understanding the principles of LIDAR.
- Understanding how a total station survey works. (It is not necessary to have used either LIDAR nor a total station survey).

#### b) Determine axis and ground plane

- Defining the co-ordinate system: drawing vectors to determine axis planes (at least x,y) within the plate.
- Setting the ground plane.



### c) Attempt to improve the solve

- Use test objects and/or test geometry and caching to quality check the work.
- Draw masks and/or deleting bad tracks.
- Make use of user features or 'golding'.

Golding refers to the user selecting what tracks he/she thinks are good (gold standard) tracks. If tracks are golded, the tracking software will take them into account to a greater degree than other tracks when doing the camera solve.

- Join tracks.
- Contrast grading and/or de-noising the plate.
- Checking there are no jumps/kicks/slips in the camera's movement by looking at the matchmoved camera from another camera – does it move like the real camera? Check the animation graph and see if there are any frames that look wrong (spikes in the graph). The CG camera should not have an unrealistic movement, which the real-world camera could not have done (for example move through a wall).
- Rendering the plate with test objects and/or geometry for approval in dailies.

Note: if a shot is tracking in on an area of detail, it can often be worth reversing the plate and tracking it 'backwards' since the software will prefer for additional detail to enter the shot as it progresses, rather than having it gradually lose tracking points and deteriorate as the camera moves in.

### d) Exporting

Students need to understand how certain exported data from camera tracking is of use elsewhere in VFX. As an example, how point clouds are useful to modellers and how a tracked camera can be used by roto and clean-up artists, or how data from motion control rigs can be imported into 3D software.

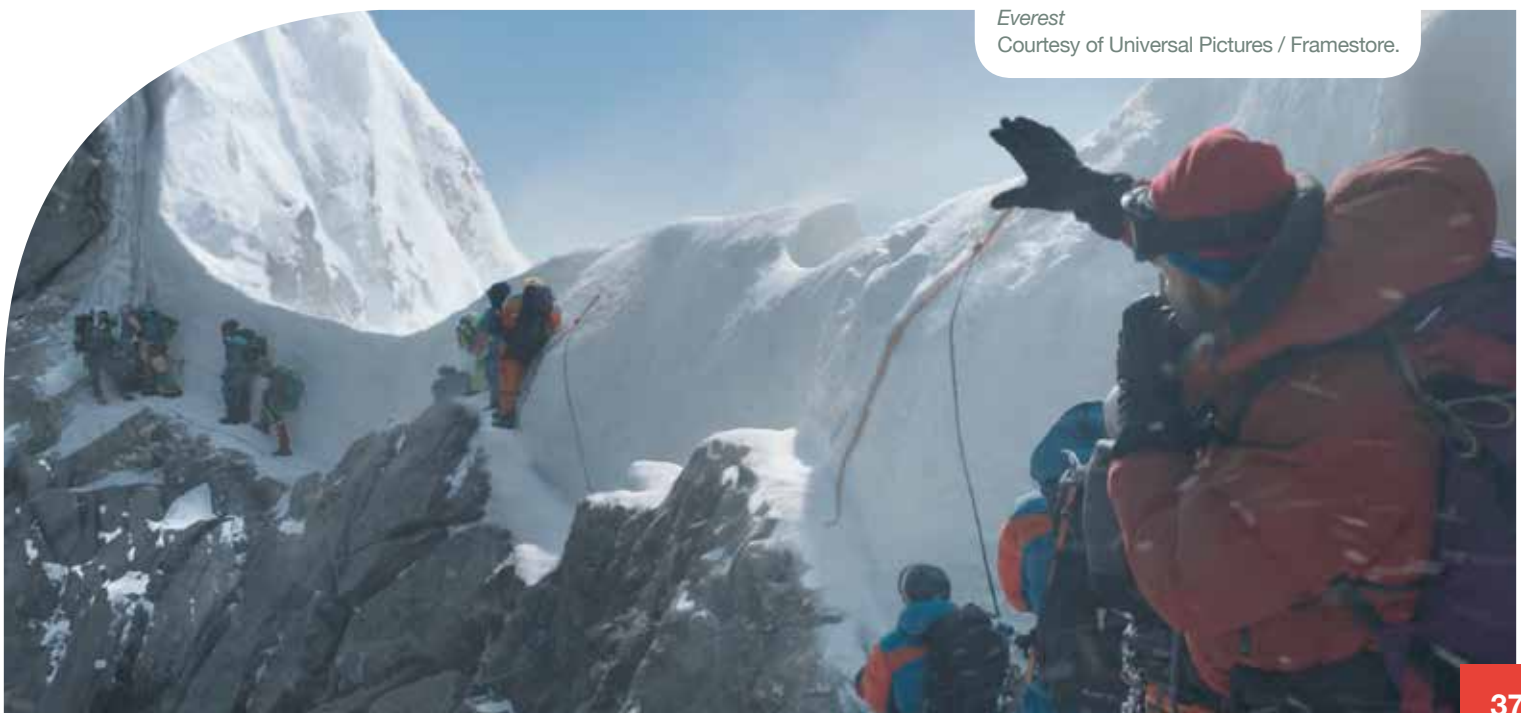
- Exporting the camera for use in other applications.
- Exporting the point cloud for use in modelling or other applications.
- Exporting individual tracks for use in compositing or other applications.
- Importing motion control data into 3D software.

### e) Object tracking

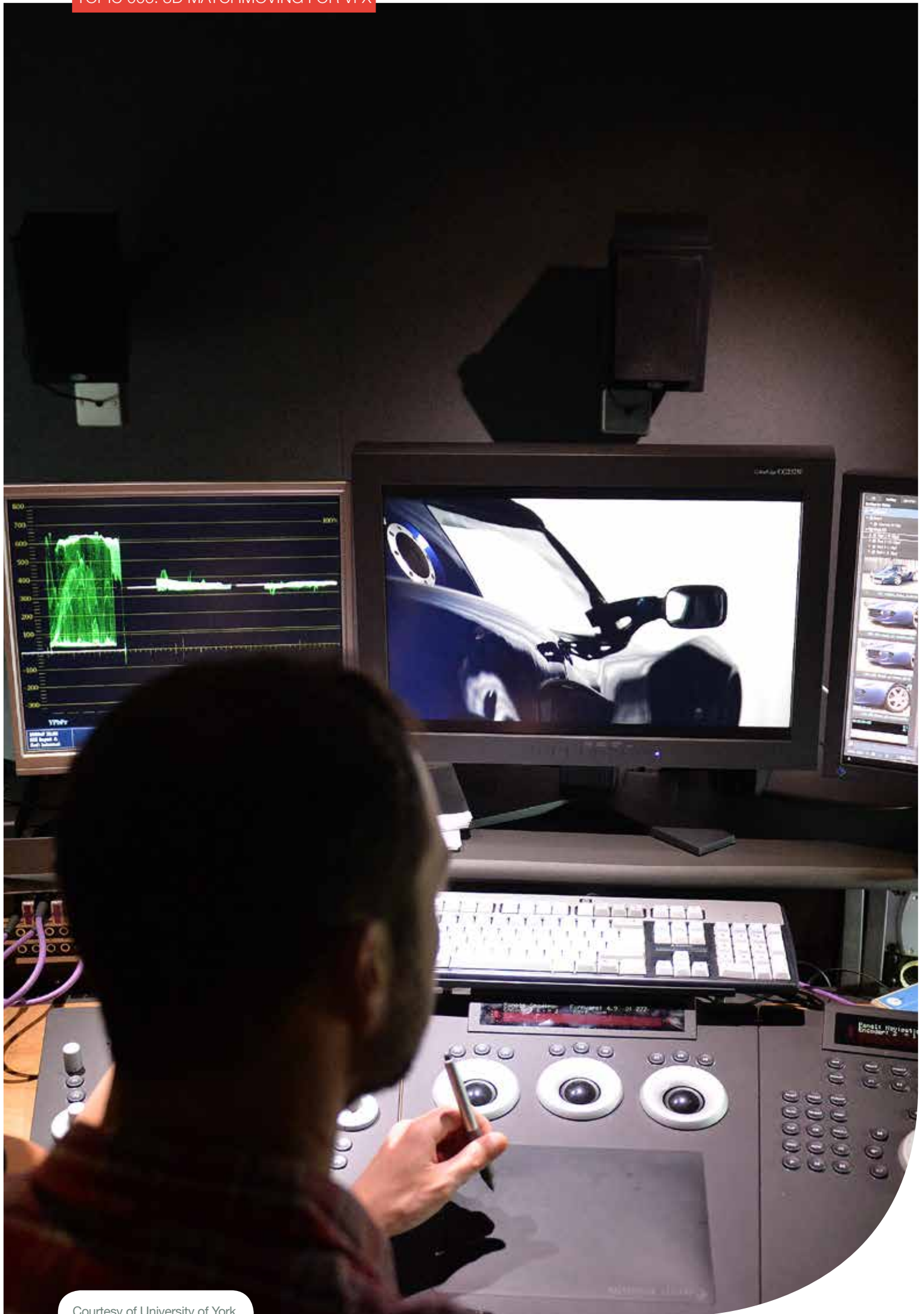
- Understand how to track a moving object within the plate, so that rigid body geometry may be applied at a later stage. Examples of this could be extending or remodelling cockpit controls in an aircraft (this would combine well with the paint/rig-removal, compositing foundation and CGI foundation topics).
- Another example might involve moving vehicles (body work can be added to, or be re-modelled). This may require a camera track first, before working on an object track. If the camera is moving significantly then it would more likely need a camera track before a good object track can be achieved.
- Object tracking items that flex, bend or warp can be very difficult. Tracking software as a whole is not so good at tracking things that deform. Cloth, for example. Usually you need to have a rig and controls in order to track deforming objects like a face or clothing.

### Body tracking (rotomation or matchamation) is included in the CGI Animation Foundation for VFX topic.

Note: the proof of an accurate camera track or object track is test geometry that remains firmly planted to the spot when overlaid onto the plate. 3D matchmove dailies allow for tracking work to be quality checked by a supervisor while looking at these overlaid renders. Students could be encouraged to take the 3D matchmove and complete modelling, texturing, lighting and compositing of a more fully fledged CGI asset into a plate shot with a moving camera.



Everest  
Courtesy of Universal Pictures / Framestore.



## 6. KEY TEXTS/LITERATURE

Dobbert, T. (2012) *Matchmoving: The Invisible Art of Camera Tracking*, John Wiley & Sons

Sawicki, M. (2007) *Filming the Fantastic: A Guide to Visual Effects*, Focal Press

Okun, J.A (Editor), Zwerman, S. (Editor) (2010) *The VES Handbook of Visual Effects: Industry Standard VFX Practices and Procedures*, Focal Press

## 7. SUGGESTED LEARNING ACTIVITIES

It may sound surprising that the outcome of this topic can be just a test render, with some geometry mesh overlaid onto the plate. This reflects industry practice though. It is important to encourage peer review and to develop in students a real critical eye for tracking accuracy. They need to be attentive to geometry that slips or slides over the length of the clip and to understand what tweaks can be tried in order to achieve a better track/solve.

We aren't suggesting that the 3D matchmoving exercise(s) shouldn't form part of a project that involves modelling, texturing, lighting and compositing as well. Indeed projects like this, already suggested in earlier 'examples', would give a clear understanding of the entire VFX production process as well as making good showreel clips. What we are keen to avoid here is the passing over of good accurate 3D matchmoving in favour of the more glamorous distractions of CGI production!

Students should understand the importance of accurate camera/object tracking as it forms the cornerstone of VFX, both in terms of production and career progression within 3D.

Although software vendors do provide basic test geometry (usually consisting of drawing pins, cones or company logos), better practice would be to use test geometry built for a plate. This could be fairly basic to begin with. Examples are wireframes of building elevations or street furniture. Once tracked, students could go on to produce finished shots with buildings or street furniture to suit a period (as in the period in which the narrative is set) or to suit a genre or style (war-torn landscape, futuristic or wild west, for example).

### Total station survey

A total station is a device to measure the distances of objects on set and the total station. It is commonly used in the surveying and construction industries. From the survey a point cloud of the environment is gathered, the data of which can be used to create geometry in a 3D application to position the matchmove camera in. It is like a LIDAR scanner but far cheaper and requires a lot more manual work.

The cheapest method is to manually measure the on-set environment by tape measure. This obviously is only a solution on-set and not necessarily in the field. The important thing is that students understand what data needs to be collected, by whatever means they have.

There is no way of avoiding the acquisition of industry reference standard software, such as PFTrack/Boujou/3DEqualizer/SynthEyes. Nuke has a camera-tracking operator and can be used to teach tracking to a high enough level.

In the absence of a client/film director/VFX supervisor, the tutor should highlight and demand high-level quality control and accurate work before anything is approved as 'signed off' from this matchmoving topic. Submission of a 'proof' render that shows the accuracy of camera track (for example there are no slips in geometry in the scene) is an industry standard method of signing off a good matchmove.

The student could also be required to submit a 3D scene with geometry and camera – (for example the Maya file that the render was created from). The assessor can check the scene and the quality of the work (for example, whether the shot has been de-lensed).

In the industry, once a matchmove has been signed off it will be picked up by animators, lighting TDs, etc. Any errors then would be apparent and costly.





Everest

Courtesy of Universal Pictures / Framestore.

# TOPIC 007: MATTE PAINTING AND ENVIRONMENTS FOR VFX

## 1. THEME AND SCOPE

This topic examines the art of matte painting and the role of the environment TD. With the advent of 3D CGI, the matte painter's job has moved away from creating 2D 'backdrops' of landscape and cityscape to include working with geometry in what is often phrased as '2.5D'.

In this topic the student explores painting techniques and their role in creating environments.

The technological and economic imperative for 2.5D often needs to be accompanied by photoreal paint artistry, informed by an understanding of 3D projection and the awareness of how the virtual camera might be placed.



Courtesy of University of York

## 2. WHY TEACH THIS?

Digital matte painting (DMP) is a good way to hook in fine artists who might not consider they have the chops for VFX. It's also good to expose 3D modellers to environment work, so they can see how 'cheats' can help them out and enable them to spend precious time on what needs to be in full 3D.

## 3. RELATED JOB ROLES

MATTE PAINTER

COMPOSITOR

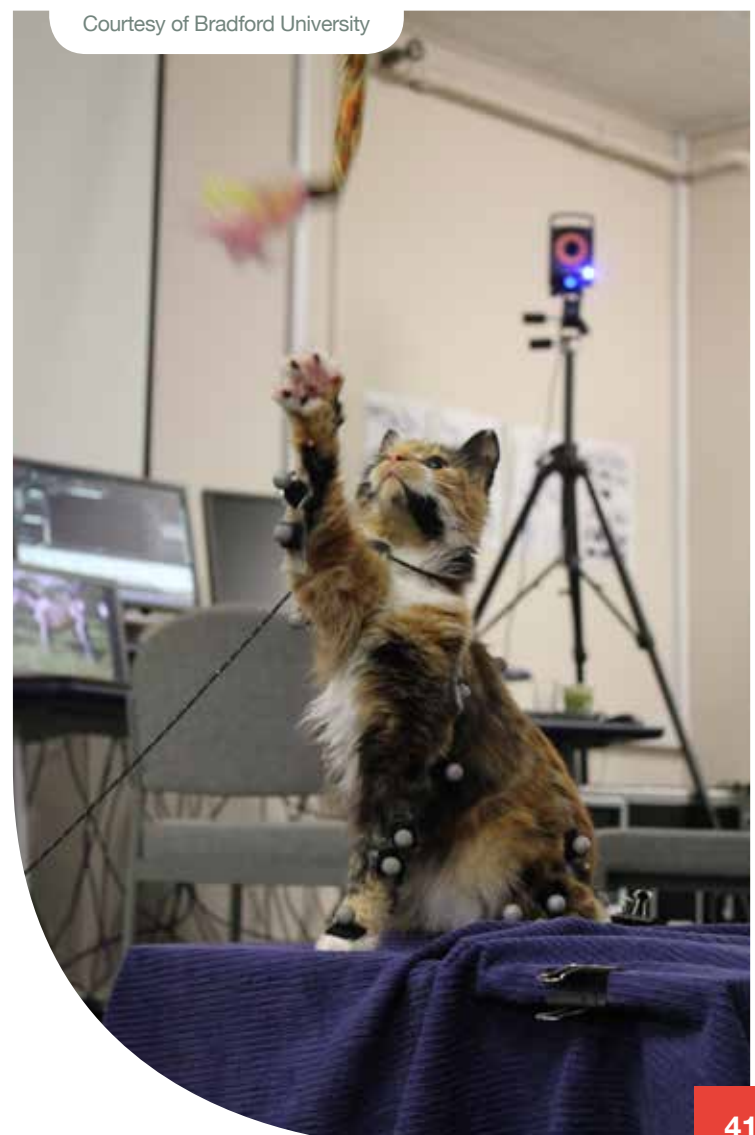
ENVIRONMENT ARTIST

TEXTURE ARTIST

## 4. WHAT STUDENTS NEED TO KNOW AND DO

### Intro level descending to advanced level

- Knowledge of matte painting, environment TD and art department roles in a range of contemporary VFX houses.
- A portfolio showing how they have successfully brought their fine art skills into the digital discipline of matte painting.
- Practical techniques broadly defined under the matte painting and environments headings.
- Ability to actively engage with 2D, 2.5D and 3D environments from a photographic, 'trompe l'oeil' perspective. The test is it must look real.
- Achieve paint and environment roles within VFX practice.
- Photographic paint techniques evidenced through both 2D background work and 2.5D artefacts.
- An understanding of the principles and techniques of photogrammetry and painting on geometry.



## 5. OUTLINE CONTENT

Matte painting is an art and not something that can be learnt to completion satisfactorily within a small timeframe without exceptional artistic talent to start with.

This needs to be borne in mind when situating this topic. The level of success will depend very much on the quality of artist undertaking it.

- A history of matte painting is presented to the student, making them aware of lineage. It is important that the focus is on matte painting and its glass painting roots, in addition to its contextual relationship with traditional painting or fine art.

### Key tuition in painting techniques

- These must have the aim of trompe l'oeil; making a painting look like a photograph (even if fantastical in terms of theme) and an understanding of the level of detail needed for key pixel resolutions, or the 'canvas' the matte painter will be creating for.
- As such the student needs to take time deconstructing what visual cues of light, colour and focus make a photograph look real and mimicking that in their paint and texture techniques.

### Understanding photography

- Knowing what qualities a lens lends an image and how to mimic that.
- Matte painting impacts on the quality of the whole digital environment or virtual set, rather than just supplying a theatrical back-drop. It is always fed by an intrinsic visual deconstruction and mimicry of the physical world around the artist and their understanding of the language of film.
- The student needs to be introduced to the difference and inter-relationship between environment TDs and matte painters – both areas of convergence and departure.

A useful definition to be aware of – and to communicate to students – is that a matte painter often creates images and panoramas with the interplay of light 'baked' in, whilst an environment TD may create textures and geometry designed to be lit and modulated by light and texture later.

Because of today's 3D-heavy pipelines, the 'digital environment department' is in the ascendancy and matte painting (in its most commonly understood meaning) functions as a smaller yet vital component. This wider perspective needs to be noted in the construction and teaching of this topic.

### Verbal and visual communication

- The student needs to work to the director's brief, but when sharing their vision and ideas verbally (and in terms of rough visuals or 'concepts') it's easy to lead a director to wrong conclusions.
- The tutor will explore with the student which methods of communication and discourse will minimise this.

### Simple direction on colour spaces

- Show how different Colour Spaces might be used in matte painting.
- Students should create sketchbooks and/or a library of meaningful references.

### Environment TDs

- Students are introduced to their growing role and the rationale behind it and methods for working in 2.5D.

Environment TDs may use photogrammetry, build geometry and set up a scene that fills the frame. Then, ideally, a matte painter will take it further by adding a paint component and can sometimes have more interpretative leeway (for instance to create mood or provide additional details).

Much of today's matte painting is achieved on geometry. 2.5D is often an efficient alternative to full 3D.

### Art and photography-based understanding

- Understand the concepts of horizon, vanishing point, one point and two point perspective.
- Appreciate the relationship between image texture, scale and placement in the scene.
- How atmospheric decay works (usually referred to as aerial perspective in traditional painting). Objects in the far distance appear de-saturated with only highlight visible. Low-register detail tends to not be visible and contrast is lost.
- Understanding the limits of photographic exposure and determining how 'true' the digital painting stays to this phenomenon. References can be found in landscape and/or cityscape photography (for example, if a bright sky or glass-covered building is exposed for, other areas will appear under-exposed. If dark areas are exposed for, bright sky and highlights will appear over-exposed or 'blown out'.

## Software and technique-based understanding

- A range of 3D-facing technical skills are increasingly needed to enable the use of 3D and communication with 3D departments. Awareness of where cameras will be and how much they are moving can aid the matte painter's job.
- An outline of the principles and techniques of photogrammetry, dense point clouds and image-based modelling techniques, within software.
- Combining Photoshop imagery with projection techniques.
- When to texture objects and when it is more appropriate to use projections.
- Re-painting onto textures using UV-mapping techniques.
- Creating basic geometry.
- The need to understand photographic cues and apply those to creating something that can't be created from photos.
- Sourcing and manipulating textures.
- Knowing how to deal with grain and noise.

## Bit depth and colour space

Note: students will have an introductory knowledge of this, having encountered it in the Acquisition for VFX topic, which could be a pre-requisite to this topic.

- An understanding of colour space and the general principles employed when deciding what colour space to use. For example, should you use 8bit, 16bit or 32bit floating point? Should you paint in Linear, sRGB or LOG colour space and should you save your files as jpeg, tiff, dpx or openEXR?

## Concept art through to creation of environments

- Designing concepts and the difference between concept art and matte paintwork for a shot.

Senior matte painters can often turn to concept design, designing multiple concepts in a day, but the student needs to be made aware how this differs in format, convention and detail to matte painting work.

## Digital painting technique

- The student can learn much about painting digital environments from the traditional teaching of landscape painting as a foundation for digital art (in this topic some students may choose to put an emphasis on learning to paint digitally from scratch, as opposed to the collage of photographs).

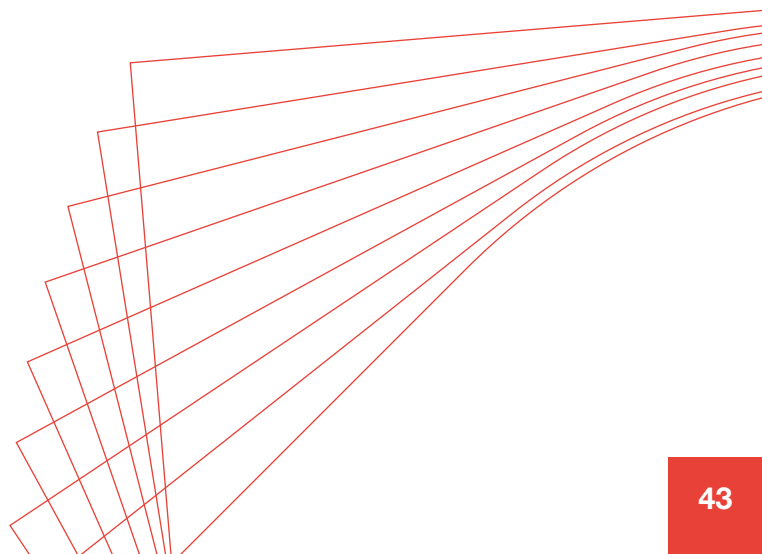
## Landscape oil painting, for example, may be taught in stages of:

- 1) The sketched layout.
- 2) Blocking in areas of basic tonality (imagine an outdoor scene observed through squinted eyes – great tonal ranges appear simplified into several zones).
- 3) Consider notions of atmospheric decay and the light source (this is most likely to be direct or diffused sunlight depending on whether there is cloud cover).

The next stage of adding texture and detail will benefit from a mastery of digital tools, although the student will still do well to make and/or collect a range of texture brushes, just like a traditional painter would collect a range of paintbrushes. Digital custom texture brushes may be found online or made from motifs within photographs (cloud shapes make great custom texture brushes for example).

## Using software, the student will need to develop a real intuition for:

- The use of layers, layer masks, opacity and blend modes (for example, colour dodge, overlay, soft light, hard light, screen, add and multiply) and an understanding of how these can be used to reveal/clone brush in detail from photographic sources.
- Painting with colour; the smudge and history brush as well as soft brushing and erasing back some of your paint work, as necessary.
- Curves, histogram and image editing tools – to finesse areas of colour.
- High-level dexterity with pen and graphics tablet, as well as making good use of its pressure sensitivity.





## 6. KEY TEXTS/LITERATURE

Barron, C. Cotta Vaz, M. (2004) *The Invisible Art, The Legends of Movie Matte Painting*, Chronicle Books

Mattingly, D. (2011) *The Digital Matte Painting Handbook*, John Wiley & Sons

3DTotal.com (2009) *Digital Painting Techniques: Practical Techniques of Digital Art Masters: Masters Collection: Volume 1*, Focal Press

Tonge, G (2008) *Bold Visions: A Digital Painting Bible*, David & Charles

Page, N. Robertson, S. Belker, H. Goerner, M. (2006) *Concept Design 2*, Titan Books

Various *D'artiste Matte Painting series*, Ballistic Publishing

Dusseault, Y. (2008) *Matte Painting 2: Digital Artists Masterclass (D'Artiste)*, Ballistic Publishing

## 7. SUGGESTED LEARNING ACTIVITIES

The matte painter has to interpret the director/client's vision, rather than operate in a vacuum. As such, it is important that the student is constantly briefed and responsive to feedback about their designs throughout the tuition.

Students should come across challenging situations where verbal and visual communication is attuned and tightened up to avoid misunderstandings or confusion. It's easy to lead a director to the wrong conclusions. What methods of communication and discourse minimise this?

### Indicative environment TD-oriented exercise

Create a virtual set from photographs using photogrammetry or by visual reference. Choose and take pictures of a street/building/urban viewpoint and then build a believable copy in 2.5D and set up a 'legal' virtual camera, i.e. employing focal length, film back and depth of field. Then, through painting, alter the lighting to suit a different mood/feel. For example, transforming sunset to dawn or summer to winter snow if appropriate.

You might choose to take this to an advanced level (a real litmus test of student ability) by adding a camera move through this created environment and including a seemingly invisible transition to a real photograph/scene.

Use macros or gizmos to create custom tools for the environment that complete useful tasks, such as adding or removing objects, fog, rain or convert matte painting to stereo.

As an alternative to environments, where you work to fill the frame, take a still from a film sequence and extend or infill part of the existing set with a small area of matte painting (which will also need work on the embedded alpha channel). Work with a compositor, who will have the job of integrating your painting back into the live action by means of tracking and grading.

Note: there is an opportunity here to examine how miscommunication between artists or poor workflow management can introduce problems relating to colour space and pre-multiplication. There is also an opportunity to compare how similar techniques are used to subtly different ends in rig removal and matte painting work.

Apply photographic cues to creating something that can't be created from photos – a fantasy image that obeys photographic rules.

Assessment should primarily be a measurement of 'how believable' the work is. The work should demonstrate an acute awareness and understanding of detail, light play, colour and depth.

The students should also highlight what reference they have employed in order to create their work. For example, they should be able to show reference photography that supports their interpretation of the mood and feel of the work. If they have painted a sunset, then this reference should be able to demonstrate and prove that their interpretation is valid.

Finally, part of the assessment should be a group critique. This will give the student experience of presenting their work to a client and test their ability to take constructive feedback.





Paddington

Courtesy of Heyday Films / Framestore.

# TOPIC 008: RIGGING AND CREATURE EFFECTS FOR VFX

## 1. THEME AND SCOPE

**This topic allows the student to explore the role of the rigger and the working relationship and interactions with animators and modellers.**

The rigger occupies a crucial point in the development and enhancement of workflow and pipeline, collaborating with animators to define rig requirements and communicating with and responding to supervisors, character TDs and/or other leads to ensure the rigging is suitable for animation, texturing, lighting and rendering.

Riggers need to design, create, test and maintain character, vehicle, cloth and prop set ups (according to project) and provide a service that responds to animators and works with modellers to create a model that meets technical needs. They collaborate with animators to design appropriate motion controls, often testing extremes of position or pose, to ensure the most efficient and flexible solution is employed.

Rigging work is pivotal in CGI and therefore has to be carried out on schedule and on budget. Psychologically, the rigger needs to handle the challenge of others in their team waiting for their modifications and the danger that a faulty rig could stymie the final animation.

The student will need to clearly communicate rigging systems and processes to other team members.

Riggers may need to develop new techniques and processes to solve character production challenges and may even be involved in R&D and tool building to improve and add to the rigging pipeline. As such, the ability to write utility scripts and programs to streamline or automate the rigging set-up process is explored in this topic.



## 2. WHY TEACH THIS?

New students often think they want to be animators, but this is sometimes because they are not aware of wider roles that would fit their talents. By opening up the rigging route you provide another option that appeals to certain types of students, especially those who love solving technical problems and those good at pose and articulation but not motion and timing.

## 3. RELATED JOB ROLES

RIGGER

ANIMATOR

CREATURE TD

## 4. WHAT STUDENTS NEED TO KNOW AND DO

### Intro level descending to advanced level

- In-depth knowledge of Maya is needed for professional rigging practice.
- The fundamentals of functional anatomy – joints, bones, skeletons through an analytical exploration of the inner mechanics of articulated forms.
- Design appropriate motion controls for an animator's needs.
- Collaborate with animators to design and iterate motion controls. Familiarity with the work environment where the student plays the role of the rigger, in a working relationship and interaction with animators and modellers.
- Clearly communicate rigging systems and processes to other team members.
- Advanced anatomy, subcutaneous systems driving secondary animation of cloth, fur, hair or muscle. Expertise on raptors, quadrupeds, snakes, etc.
- Complete a series of varied rigs including characters, vehicle, cloth and prop set-ups that meet professional standards and solve creative issues efficiently, all presented in breakdowns on reels



Pan  
Courtesy of Warner Bros / Framestore.



## 5. OUTLINE CONTENT

- This topic must supply the in-depth knowledge of Maya needed for professional rigging, including a good understanding of 3D forward kinematic/inverse kinematic (FK/IK) skeletal animation systems for both control and deformation of 3D characters (stylised and realistic). The student will be shown that a good rigger needs to break down key structures, yet have an animator's sensibility and a sound overview of modelling techniques.
  - The topic also teaches the fundamentals of functional anatomy – joints, bones and skeletons. This should not be about artistic interpretation, but rather an analytical exploration of the inner mechanics of articulated forms.
  - How types of movement are achieved through joints and subcutaneous systems and how this might also drive secondary animation of cloth, fur, hair or muscle.
  - Study of physiognomy and facial expression is encouraged. Studying medical illustrations and photographs can give useful guidance.
  - Early in the topic there will be an introduction to how digital sculpting, creature effects, animation and rigging interact and exchange assets within today's larger facilities. The student gets practical experience of such roles and their interplay.
  - Two types of rig are introduced – animation (puppet) and deformation – along with a discussion of how they might be divided into body rigging, facial, non-character (vehicles, mechanics, etc.). Students should explore how deformation rigs take data from the animation or puppet rig and deform the final mesh.
  - Students create a simple rig, adding bones or a skeleton, exploring concepts and tools including skinning, gimbal locks, rotation, joint tool, pivots, mirroring, x-ray function, IK handles, smooth bind, skin clusters, weights, sculpt deformer, jiggle deformer, wire tools (eg for mouths), setting up constraints, working with muscles and collisions.
  - Moving from FK to IK.
  - The student needs to understand rotate orders to prevent gimbal lock and to make sense in terms of how axes are aligned.
  - An explanation of the use of different languages when creating set ups: C or C++, MEL script, PERL or Python. The use of maths (matrices).
  - Engineering efficient UI controls needed for the rig and presenting the rig through the UI. Looking at animation-friendly controllers and local v global control.
- Controls should be visually unique and simple to read from different viewpoints of the model (eg heavily zoomed in), ensuring the visual design discourages the error of grabbing the wrong control.
- Students will learn that rigging can operate at different levels or be divided conceptually into different functions. These could be separate roles or the responsibility of one person. The student should have experience of all these areas to varying degrees.
- There is the maths and engineering level – creating tools or nodes.
  - There are the TD roles – creating the appropriate UI.
  - There are riggers as skeleton builders.
  - Deformers that operate the skin and muscles and secondary animation.
  - ...and finally, simulation, such as cloth.
  - Students need to be proficient in both 'puppet' rigs and deformation rigs and understand their inter-relationship. They should be able to justify their rig by how it allows the animator to get the performance they demand. It is important to design rigs that animators can use and feel enabled by.
  - Students need to understand that different riggers approach problems in different ways, so there may not be a 'correct' rig, only appropriate rigs. It's about creative solutions as much as technical mastery – it may be that you can get the movement you need from simple deformers alone. A fish, for example. Don't over-engineer. It's about keeping your rig efficient and therefore fast. Check what is the fastest way to calculate (a rig is basically just a big calculator). Nodes are faster than expressions in Maya.
  - Students are made aware that they don't need to do everything in one rig. Make things efficient and logical regarding controls, with an easily operated layout. This may mean sensible parenting and hierarchy – in both IK and FK.
  - Using FACS, rationale and limitations.
  - Facial rigs – enabling a greater level of detail.

Riggers should be able to respond to the animator and that means understanding animation and having animation sensibilities. Also, they need to be able to talk topology with the modeller and sometimes they need to make a judgement about when to fix and when to hand back to the modeller. So a good rigger needs to think and communicate like both a modeller and animator.

The student needs to practise asking: “if I was to animate this, how would I do it?”

- Bringing anatomy observation to bear, students are encouraged to compare real life references to their rig. Look at people walking, for instance. This will help students recognise and work with real world limitations that certain configurations of bones/joints will lend their rig.
- Students should be supplied with concept drawings/ references for a character – and then build and check the rig for dramatic poses, even further than it is envisaged using it (since things can change), ensuring it has ‘give’ to accommodate further scenarios.

It’s important to test the rig with extreme dynamic poses, beyond what might actually be needed. Often animators will want to push poses and if the rig breaks it’ll come back to you, so try to second guess, eg what happens if the mouth is open wider or the wings are fully unfurled? Exercise the rig to see where its breaking points are.

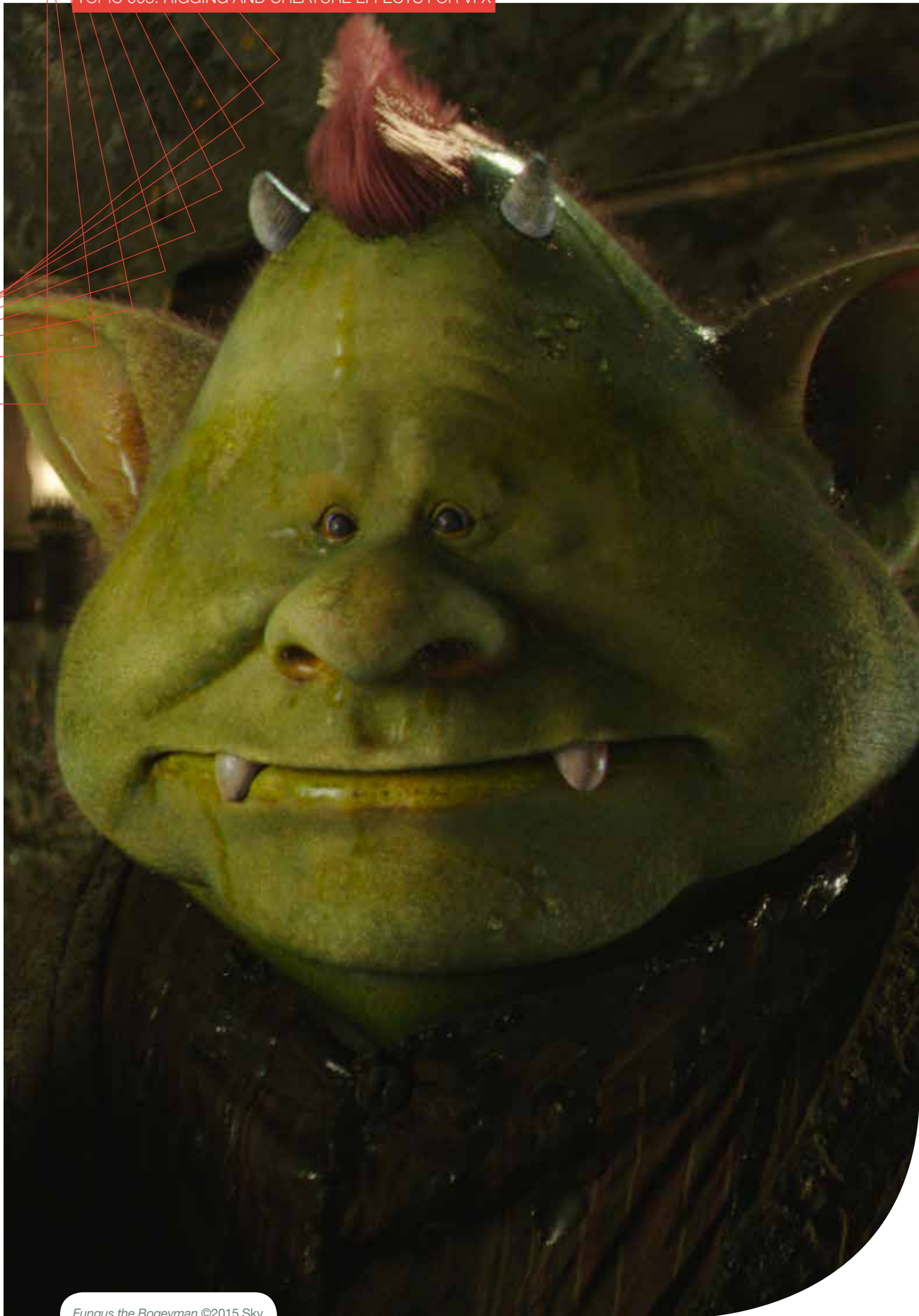
- Is the rig’s hierarchy laid out such that you can revisit and modify later? Were the naming conventions such that it is easy to modify? Have you left enough leeway for the animator to add their flair? Is the rig appropriate for the production?
- Throughout the topic students get to grip with rapid prototyping: they deliver a rig in stages the value of enabling colleagues to get working, testing and, in return, giving early feedback on performance. It’s about prioritising: control limbs before eyelids! Get the overall skeleton built/scoped and passed to the animator so they can commence work, before moving onto finer details like muscle or jiggle.
- Throughout the topic students will gain an appreciation that rigging appeals to certain types of people – the technical problem solvers. Rigging can be stressful with everyone waiting for you to feed them.

- There’s sometimes an assumption that rigging gets easier as you develop a library of reusable rigs, but the challenges of rigging never recede – technology and expectation always exceed proficiency.
- Hair and fur: students need to be introduced to hair and fur simulation, using key hair as controls, with characteristics of growth such as density, clumping, frequency, curliness, inclination, practicing control of movement via the use of area designation maps, dynamics, constraining and spline animation.

Hair and fur also needs distinct and complex look development. Here, students should aim for a basic understanding of how materials can be assigned to hair, its opacity and the colour of the underlying skin’s contribution to the look of the creature in question and explicit rendering options. Shader development for hair and fur is the stuff of SIGGRAPH papers and as such is considered to be outside the scope of this topic.

- The biggest concern in hair and fur simulation for the creature effects animator is how it should bend, stretch and interact with movement caused by primary animation or by the environment the creature finds itself in. As an example of this, students should be directed to think about how fur should squash down on the inside of a bending arm (rather than break through the arms surface), or what should happen to the fur in water or how it might blow in a gale.





## 6. KEY TEXTS/LITERATURE

Ritchie, K., Callery, J., Biri, K. (2007) *The Art of Rigging (Volume 1)*, CGToolkit

Ritchie, K., Alexander, O., Biri, K. (2006) *The Art of Rigging + DVD: A Definitive Guide to Character Technical Direction with Alias Maya (Volume 2)*, CG Toolkit (2007)

*The Art of Rigging + DVD: A Definitive Guide to Character Technical Direction with Alias Maya (Volume 3)*, CG Toolkit

O'Hailey, T. (2013) *Rig it Right! Maya Animation Rigging Concepts*, Focal Press

Osipa, J. (2010) *Stop Staring!: Facial Modelling and Animation Done Right*, Sybex

Allen, E., Murdock K.L, Fong J., Sidwell A.G., (2008) *Body Language: Advanced 3D Character Rigging*, John Wiley & Sons

Jason Schleifer *Rigging Bundle* By Jason Schleifer, <http://jasonschleifer.com/>

[www.hippydrome.com](http://www.hippydrome.com)

Ekman, P. Friesen, W. (1978) *Facial Action Coding System (FACS)*, Palo Alto CA: Consulting Psychologists Press

Faigin, G. (2008) *The Artist's Complete Guide to Facial Expression*, Watson-Guptill

Simon, M. (2005) *Facial Expressions: A Visual Reference for Artists*, Watson-Guptill

## 7. SUGGESTED LEARNING ACTIVITIES

Collaboration: assuming ready access to skilled student cohorts, the tutor should set up a work schedule where the modeller works on a rough claysculpt, which is then handed to the rigger to engage with. Meanwhile the modeller continues to add lumps, bumps, volume and detail. The rigger simultaneously works with the animator to see what controls and constraints need to be modified in the rig. Issues such as pinching and stretching are communicated back to the modeller, who makes corrections.

A regime of dailies should be instituted, with work signed off by tutors based around this exchange.

Road-testing a rig to establish its coherence should be an important exercise.

For instance, move your character by a large factor, say 10,000 units in Z. Does it still look the same? Rotate your character in all directions. Is it solid, or do things 'spin out'? Does the rig shift if you set all controls to zero? (There are more tests.)

If you do a quick export, is the scene the same or have you 'flushed out' much extraneous data?

There should be no redundant controls (eg two controls doing the same thing, resulting in two f-curves describing the same motion).

**Idea: think about holding a (physical) puppetry workshop to examine building and breathing motive and emotion into pose.**

Teamwork exercise: students work together on an animation shot – a chase sequence, for instance. The rigger works with the modeller to create the CG assailant, based around the characteristics of the rig, which in turn influences creature design. As an example it might be a lumbering giant or a flapping pterodactyl placed within film footage of a fleeing victim, which has previously been tracked.

The point is to get students to respond to incremental requests, with the director role maybe problematised by the tutor, asking for changes that have repercussions for everyone on the team and ensuring many iterations before conclusion.





Courtesy of Bradford University

# TOPIC 009: DIGITAL SCULPTURE FOR VFX

## 1. THEME AND SCOPE

In this topic students will extend and advance their skills in modelling. Having learnt the fundamentals of building a hard surface form as well as the basic workflow of CGI production from the Introduction to CGI for VFX topic, here there is further opportunity to learn about creating form and surface for an organic form that needs to be posed, re-posed and animated over time.

As well as learning about anatomy and 'digital sculpture', proper use of topology to eliminate or minimise pinches and stretches during animation is essential. This topic instructs on how modelling and animation need to be broken down into distinct stages so work is tested and refined throughout the process of modelling, rigging and animation.

## 2. WHY TEACH THIS?

Best digital sculpt practice is as much about the fundamentals of the art of sculpture as it is software and that can be problematic on a computer-based course without external assistance, maybe from art and design staff outside the course or institution. However, this is what can make it exciting.

Also, we assume your students have hard surface modelling skills and have seen the need for soft surfaces and organic forms to expand their repertoire, so this is a natural next step for them.

### 3. RELATED JOB ROLES

CONCEPT ARTIST

CG MODELLER

3D ARTIST

### 4. WHAT STUDENTS NEED TO KNOW AND DO

#### Intro level descending to advanced level

- Create a range of analytical studies of organic and natural forms.
- Develop a proficient level of artistry with sculpture brush tools.
- Complement and build on existing hard surface modelling skills with soft surface modelling aimed at creating organic forms to technical specifications.
- Further exploration of anatomy and musculature through traditional media that stays in parallel with their CGI work where they can create complex organic forms to technical specifications.
- Confidently and efficiently clean-up or re-topologise assets.
- Dissect or break down models into useful and manageable components according to industry workflow.

### 5. OUTLINE CONTENT

- This topic allows the student to explore the role of digital sculpting and soft surface modelling within a typical VFX workflow.
- Students will further their understanding of CGI modelling practices. Having previously completed the CGI Animation Foundation for VFX topic and modelled a hard surface object using a range of techniques while keeping the poly count as low as possible, students will now progress to developing skills as digital sculptors (or 'soft surface modelling') by spending time using software sculpting brushes. Skill with pressure sensitivity and dexterity with a pen and graphics tablet need to be established as second nature when it comes to working in digital sculpture.

- Students will be immersed in a culture of sketchbooks of observational and analytical drawing. Anatomy and myology (musculature) reference works are copied and synthesised. Life drawing needs to be available, but should be focused on the particular needs of this topic, rather than loose artistic interpretation. Anatomy should be functional – how muscles and joints are evident beneath the form.
- As well as aiming to achieve a mastery of digital sculpting tools, there is a premium placed on thinking through how modelling for animation is different from modelling for pure sculpture. This includes understanding the reasons that the mesh created during the sculpture process needs to be cleaned-up or re-topologised and the effect this may have on texturing work that is done later. The student needs to be comfortable in working between different 3D modelling applications (particularly ZBrush and Maya).
- In VFX companies, digital sculptors will work closely with animators, riggers and creature effects TDs as well as cloth and hair/fur TDs and texture artists.

A definition note for tutors: We have explored the 'effects' work done by hair/fur or cloth TDs within our Effects Animation for VFX topic, along with particle and fluid simulation. In the taxonomy by which we are organising our topics, work done by creature effects TDs relates to things such as skin slide or muscle reaction and is driven by primary CGI character animation.

#### Develop artistry with sculpture brush tools:

- Practice and iteration are needed. Sculpting up basic but accurate soft body or organic forms with lots of rounded edges, lumps, bumps and big surface texture is all good practice. You can sculpt from a 'still life' set up in front of you.
- Begin with things that can be sculpted up from 'primitive' base meshes. For example, vegetables, fruit, foliage, fast food, shoes or other objects to hand. Analyse the form for symmetry. Can you draw a line (imagined or real) through the form and see where one side 'mirrors' the other? Symmetry switched on in software can often save time.

### An introduction to character modelling:

- As the student gains skill and confidence with digital sculpting tools (namely sculpture brushes and a graphics pen and tablet), the student should then start to explore the workflow for sculpting for animation and progress on to character-based modelling.
- In a VFX company, a concept artist will very often give the digital sculpt artist a visual for the character, which would allow them to draw up 'image planes' for the figure. Most sculptors will use a front and side (profile) view to work from. The student will need to think about how they will build a base mesh for the character based on analysis of form, structure, weight and proportion.
- To enable them to do this they will be instructed on how to develop a thorough understanding of the modelling tools in ZBrush and Maya.

### Character modelling and workflow

- The student will be shown how to interpret and create appropriate character structures. What are the main forms that need to be sculpted? Which sections consist of different materials (such as costume or hair) or will need surface detail? What parts might be done with hard surface modelling, cloth/hair simulation or via texture mapping?
- The student will be taught how to break down the form and how to sculpt/model underlying or part-occluded forms such as eyes and teeth as separate models.
- Students will learn how to make openings or holes in the form and understand how characters or apparel may need to be sculpted up in sections or groups.
- Recognising when the use of hard surface modelling techniques may be appropriate for objects such as weaponry or mechanics. Exporting parts of the model to other software as necessary.
- Making line drawings for planes through the form, at least the front cross section and profile cross section (working with character designs from the concept artist).
- Considering pose, proportion and symmetry for the parts of the job that need digital sculpture work.
- Constructing base mesh using appropriate tools such as ZSpheres.
- Editing mesh detail, as appropriate.
- Adding main lumps and bumps via sculpture brush artistry.
- Reviewing the preliminary work in animation, attending to pinching/stretching type problems (getting sign-off for the model at this stage).
- Refining and adding further shape and mass via sculpture brush artistry.

- Understanding how to clean up (re-topologise) the model as necessary.
- Considering how surface details will be added either by the student or by a texture artist later on.

## 6. KEY TEXTS/LITERATURE

Eric Keller, E. (2011) *Introducing ZBrush 4*, John Wiley & Sons

Spencer, S. (2011) *ZBrush Character Creation: Advanced Digital Sculpting*, John Wiley & Sons

Spencer, S. (2010) *ZBrush Digital Sculpting Human Anatomy*, Sybex

Goldfinger, E. (1992) *Human Anatomy for Artists: The Elements of Form*, OUP USA

Simblet, S. (2009) *The Drawing Book: An Innovative, Practical Approach to Drawing the World Around You*, Dorling Kindersley

Speed, H. (2009) *The Practice and Science of Drawing*, BiblioBazaar

Dubé, R.L. (1996) *Natural Pattern Forms: A Practical Sourcebook*, John Wiley & Sons



Courtesy of  
National Film and Television School /  
Compositing Coach









*Guardians of the Galaxy*  
Courtesy of Marvel Studios / Walt Disney Pictures / Framestore.

# TOPIC 010: CGI ANIMATION FOUNDATION FOR VFX

## 1. THEME AND SCOPE

**This topic examines animation as part of a VFX pipeline, rather than as an isolated discipline. While elements of the topic may well pertain to Pixar or Aardman-style CGI animation, it is examined here as part of a process initiated by, and then complementing, a live action shoot. As such the VFX animator often has different constraints on their work, with matchmove and layout departments setting the scope of their work.**

Layout represents the translation of the original storyboard into the 3D animation world and matchmove provides the positional and temporal rules of engagement for the animator. It's here that the camera is defined and the relative positions of key animated elements or characters are set. The animator's role is then to react and build on these constraints and sometimes to feed back to others. This is often different from the relatively free rein that animation students are given in more general CGI animation modules at university, where they can dictate camera position, lighting and extraneous elements for dramatic effect themselves.



Courtesy of National Film and Television School / Compositing Coach

With the accent on VFX, this topic does not concern itself wholly with character animation and its often-exaggerated plasticity. The student will instead animate objects and characters as dictated by background film plates. As animation skills are learnt iteratively, this topic stands distinct from modelling and rigging – and these assets are supplied to allow more focus on the practice of animation.

It is important that new entrants into the industry appreciate that believable or realistic movement of often-unnoticed CGI elements onto a live action plate isn't a less creative activity than wholly character-based CGI features, which often seem more flexible in terms of style.

Senior VFX character animators agree that there is still much room for interpretation and individual nuance within VFX animation and that they have often been hired specifically for this individual creativity. Today's student should expect to take a few years to get to this stage though.

## 2. WHY TEACH THIS?

**It seems the vast majority of animation taught in universities is aimed at expressive character animation for short films with an accent on squash and stretch, anticipation and follow-through.**

It is important that animation students keen to work in the VFX industry appreciate that creating believable or realistic movement onto a live action plate isn't a less creative activity than wholly character-based CGI features. Rather, the rewards of getting it right and having a more focused showreel mean they have a head start.

## 3. RELATED JOB ROLES

LAYOUT ARTIST

VFX ANIMATOR

CG SUPERVISOR

## 4. WHAT STUDENTS NEED TO KNOW AND DO

### Intro level descending to advanced level

- Demonstrate they have learnt 3D animation software to a high level, informed by strong animation skills.
- Display a series of turntables of characters and objects poses.
- Clearly explain VFX animation pipelines.
- Utilise appropriate animation of rough/simple models within a live action background plate.
- A strong understanding of core animation skills such as weight, balance, follow-through and secondary action required for believable VFX animation based on observation and mimicry of 'live' moving forms, as opposed to exaggeration and squash and stretch.
- An appreciation of when to animate and when to use simulation.
- A portfolio of animation that responds and conforms to interaction between layout and rigging artist prerequisites.
- The ability to perform visual and analytical problem solving in three dimensional space, including the ability to accurately interpret 3D layouts and analyse 3D form.



Guardians of the Galaxy  
Courtesy of Marvel Studios  
/ Walt Disney Pictures / Framestore.

## 5. OUTLINE CONTENT

### Fundamentals of animation

- Core animation skills are taught on and off the computer screen, notably realistic squash and stretch and weight (for instance, themed as a series: bubbles, water-filled balloons, beach balls, footballs, cannonballs).
- Follow-through (for instance, adding a string or loose tail to a moving object).
- Principles and practice of a range of walk cycles starting with bipedal, progressing to quadruped.
- Walk cycles, run cycles, footslip.
- Translating a walk cycle forward and turning on a path, advancing to walking up stairs and over obstacles.
- Emphasising character weight and balance.

### Fundamentals of 3D CGI animation

(Taught through Maya or 3DSMax, etc.)

- The topic explains the distinction between primary animation and secondary animation or 'creature FX'.
- How form is articulated through space.
- Hierarchical animation.
- Clusters, blend shapes and pivot points.
- Advanced graph editor.
- Inverse kinematics v forward kinematics.

Students will note that most animation jobs need "excellent Maya animation skills" and will receive training towards this end, but will be expected to be proactive in seeking out time and resources themselves.

### Rigs

- The student is presented with a rigged creature and taught how to put this through a series of poses and simple animated routines.

Simple movements can show recruiters that the student has animation skills. A simple fall, or a rig reacting to a force, can show the student has thought about centre of weight, momentum and can deal with other abstract essential qualities for animation.

- Throughout the teaching, students should be immersed in a culture of sketchbooks of observational and analytical drawing. Anatomy and myology (musculature) reference works are copied and synthesised.
- Life drawing can be offered, but should be focused on the needs of a VFX animator rather than loose artistic interpretation. Anatomy should be functional – how muscles and joints contribute to movement.



Such drawing should extend beyond the human form; observing animal movement first hand in the zoo or park or at least on YouTube or video. Sketching a variety of skeletons in a museum would be an option. Students gain the ability to analyse organic motion and have a good understanding of realistic weight and timing.

- The student should learn to value mimicry, based on observation, without stylisation. Even mythic animals or imagined creatures can be referenced via close equivalents in the animal world, observed via video if not live.
- Physical sculpture sessions (clay, for instance) may also be encouraged as a means to understand how form betrays its underlying structure.
- As an introduction, students will explore the limitations of different animated forms – procedural animation, simulation-based systems such as fluids, rigid body dynamics and how they compare in terms of efficiency and function to various tasks. An appreciation of when to animate and when to use simulation is needed.
- Students may partake in workshops in acting, exploring different interpretations and nuances of the same action or a workshop with a professional puppeteer – learning how to communicate motive and emotion through strong pose.
- In the VFX industry, drawing can inform the preparation of animation work by allowing the student to uncover the mechanics of movement, but it also increases the animator's ability to communicate non-verbally with layout and rigging departments, as well as bringing later benefits towards communicating to clients and supervisors.
- It is helpful for the student to think of animation through the dual perspective of 1) motion (mechanics, physics, timing) and 2) emotion (acting, motivation, pose, expression) and understand they may be called on to replicate the real, or exaggerate and extrapolate it.
- Motion fundamentals – seeing animation as time/position.
- What are key poses? Dissecting an action – what is going on under the skin or as forces are applied.

The student needs to be aware of the spectrum of realistic movement through to exaggerated character and understand the core of their study in this topic is around servicing VFX pipelines, not Pixar-style feature animation.

- The process by which an animator fits into a pipeline should be examined, with an introduction to matchmoving and animation layout and the process by which scenes are blocked and basic positions are signed off explained.

In large VFX houses the matchmove department provides assets to the layout department. Blocking is often where key decisions are made that will affect the animator's work later, setting characters into position. This is then passed on to animation.

- In this topic the student is exposed to variants of this pipeline. It is important for the animator to understand that camera position and rough action has already been set. In addition, in this topic the student will be concentrating on working in this pipeline, not on getting bogged down in modelling, lighting, texture, etc.

There needs to be ample opportunity in the teaching for riggers and animators to interact, to ensure the delivery of a rig that will meet an animator's need for control, functionality, usability and performance. Rigs will be supplied, enabling the student to test and critique and learn by reverse engineering.

- As we are encouraging the student to work with a pipeline mentality, dailies and crits should be embedded in the student cohort's schedule.

Group projects and collaboration will be combined with constant opportunities for peer critique, instilling notions of what goes on before and after the animator has created work.

- Students will appreciate how others are affected by their decisions. It's not about just how it moves, but how it will look later too and elements need to be flexible for this eventuality.
- Turntabling/in the round: characters' integrity from all angles must be clearly displayed and students will need to turntable their work.
- Students will work on 'pre-viz', possibly for other students (or as an exercise to re-engineer films already made), displaying and stretching their previous understanding of the filmmaking process and cinematography. There will be an emphasis on shot turnover that achieves a balance between both meeting deadlines and quality expectations.
- Lipsync should be explored through a series of exercises from a VFX rather than a CGI feature perspective with its inherently exaggerated characters. One might address how realistic objects might articulate sound and have expression.



Everest  
Courtesy of Universal Pictures / Framestore.





Courtesy of National Film  
and Television School /  
Compositing Coach

## 6. KEY TEXTS/LITERATURE

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Williams, R. E. (2009) *The Animator's Survival Kit*, Faber and Faber

White, T. (2006) *Animation from Pencils to Pixels: Classical Techniques for the Digital Animator*, Focal Press

Webster, C. (2005) *Animation: The Mechanics of Motion*, Focal Press

Muybridge, E. (2007) *Muybridge's Human Figure in Motion*, Dover Electronic Clip Art

Simon, M. (2003) *Facial Expressions: A Visual Reference for Artists*, Watson-Guptill Publications

Simon, M. (2008) *Facial Expressions: Babies to Teens – A Visual Reference for Artists*, Watson-Guptill Publications

Chakkour, M. H. (2004) *Virtual Pose: The Ultimate Visual Reference Series for Drawing the Human Figure*, North Light Books

Beiman, N. (2010) *Animated Performance: Bringing Imaginary Animal, Human and Fantasy Characters to Life*, AVA Publishing

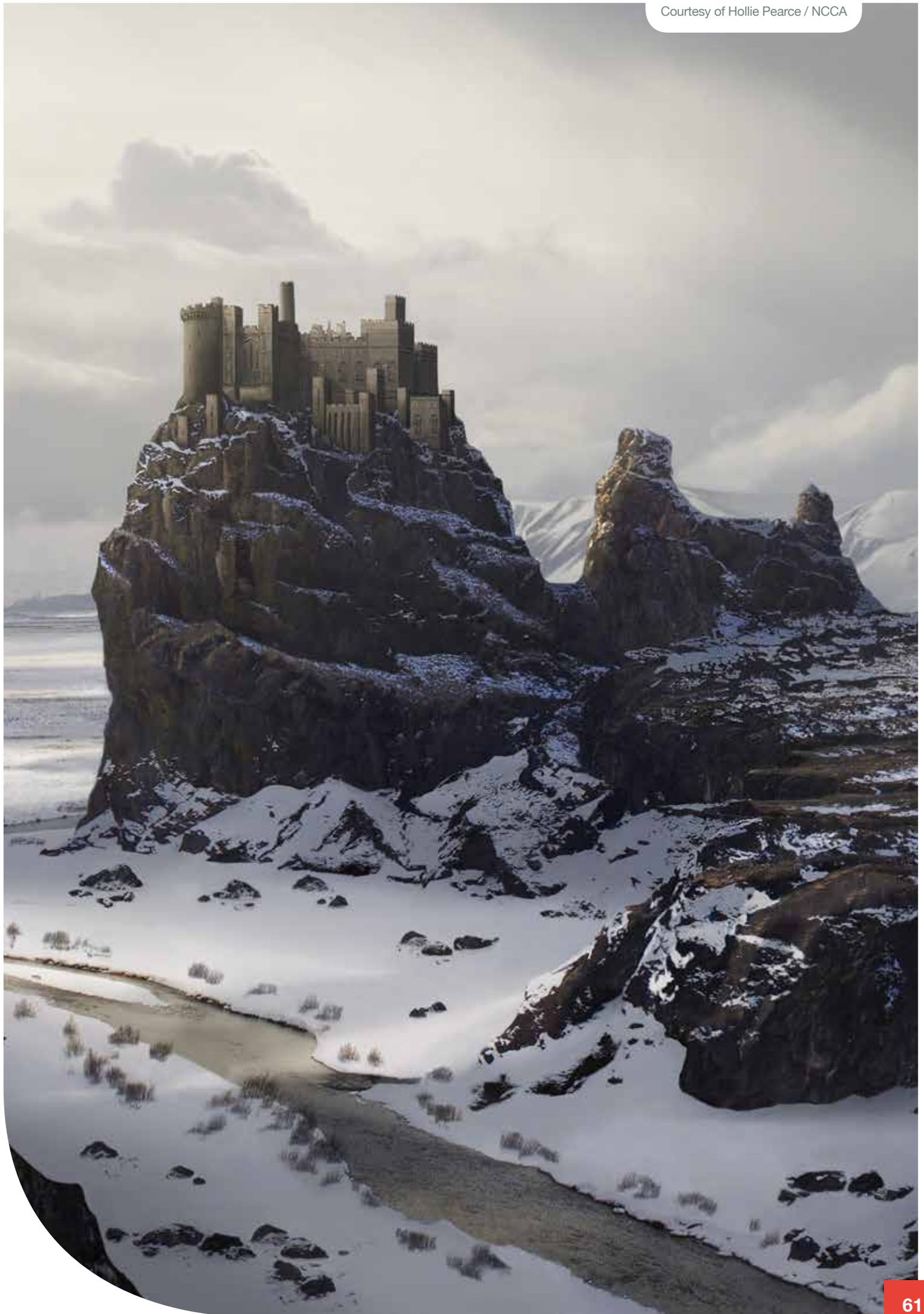
Sito, T. (2013) *Moving Innovation: A History of Computer Animation*, MIT Press

## 7. SUGGESTED LEARNING ACTIVITIES

**Exercise:** swapping one set of properties for another. Mimic something light and nimble, then change its qualities – animate as if it is heavy, or more sluggish.

**Exercise:** the student is required to make their shot work between given shots that are already animated in situ with live action plates. The character/objects needn't be more than a rough greyscale, since the exercise is centred on movement and the interpretation of cinematographic rules.

**Exercise:** variants on this exercise should be encouraged. The student cohort all do a matchmove of a different shot (from plates supplied) then exchange these shots so they all complete a layout for another shot, swap shots again and then all complete an individual animation that conforms to the given shot. The student learns about the implications of what they receive and pass on. Learning is strengthened and accelerated by daily critiques along the way. Such an exercise could involve interaction between different year groups, if this is possible.







Courtesy of MPC

# TOPIC 011: EFFECTS ANIMATION FOR VFX

## 1. THEME AND SCOPE

**In this topic, the student will learn about making particle systems, structures, cloth, fluids and crowds move under the forces of physics. These tasks are the job of an effects animator or effects technical director.**

Instead of using keyframes to animate, the student will be setting 'simulation' behaviours and judging what works and what doesn't. Complex phenomena are often more convincingly simulated rather than keyframed. Effects animators may get involved in blowing things up, setting fire to objects, adding dust over the top of a dinosaur's foot fall, breaking glass, simulating fluids or a ship's sails as they flap in the wind. So, the student needs to be able to understand and communicate using the language of Newtonian mechanics.

They will be expected to analyse in detail the important characteristics of what are largely natural phenomenon before setting out to simulate such by dialling in and trialling changes within the parameters of simulators or solvers.

A thorough understanding of the VFX pipeline, as well as general animation principles, applied maths and VFX element photography is necessary to inform elegant solutions to this kind of effects work, as it can demand a blend of approaches to meet client expectations as well as keeping datasets efficient and manageable. The student will learn how important planning and efficiency are as factors and why pre-visualisation and processor-saving shortcuts are important.

Through learning how to modify solvers and develop scripting skills (eg Python), as well as how to batch, automate and improve software interoperability, they will get a firm introduction into tool/pipeline research and development for VFX, should the student want to move in that direction.

## 2. WHY TEACH THIS?

Effects animation is a growing area – simulation and the kind of animation and visuals it affords have a home beyond big budget film. Access to software within education has become easier as the ‘mindshare’ argument has permeated software developers. This is a specialist area though and students will need to carefully document how they have solved real world problems, as opposed to creating an interesting swarm or crowd and show analytical and predictive skills.

## 3. RELATED JOB ROLES

FX TD

FLUIDS, FUR, CLOTH TD

R&D DEVELOPER

CROWD ARTIST

## 4. WHAT STUDENTS NEED TO KNOW AND DO

### Intro level descending to advanced level

- Understand practical effects solutions to real problems.
- Produce a combination of different kinds of simulation, applied appropriately.
- Build a library of reference works and observations and how they have informed and progressed their development.
- Have a clear understanding of how to combine scientific, logical thinking and observational skills to create effective simulation and effects solutions.
- Instil a work practice based around goal oriented iteration rather than random experimentation and adherence to efficient workflows.
- Faking simulations with 2D sprites for efficiency.
- Use simulations and effects appropriately, taking into account complexity, rendering, time, memory and resource overheads.



Courtesy of University of York



## 5. OUTLINE CONTENT

- The student's starting point is observation. They are encouraged to look at recommended films for good and bad examples of simulation – and to start trying to understand how the physics might have been constructed in what they see.
- They need to observe how objects collide in the physical world – by means of analysis of available video and through filming their own references.
- The topic will include exercises that start in observation, go through research of mechanics and then progress to software iteration.
- The student needs to realise that simulation is not necessarily about exotic fire effects and monster goo – it is often about mimicking the mundane to complement a story or embellish or enrich the ordinary. Underwater bubbles, kettle steam, a whirlwind of litter on a housing estate or dust falling from rafters might be the sort of challenges that students should be steered towards.
- Students should be introduced to a methodology of rapid prototyping and iteration, rather than working on a perfect model of phenomena.
- There should be an emphasis on creative problem solving rather than software mastery: interpretation of a brief (what do you need to simulate and what parameters are actually needed?), design, pre-visualisation, presentation and revision are key steps.
- Students will need to manage time spent on setups and sim times effectively and pay attention to disk space that is appropriate for the scale of the production.
- Students should grapple with the question of how to design an effect from the start, but also get used to pitching and presenting it and communicating their thought processes, bringing to bear their developing knowledge of the VFX pipeline to assess the most efficient ways of providing elements required for lighting and rendering or for further compositing directly.
- Is cloth simulation appropriate or is hand animation the best solution, for instance? Students also need to be made aware of the tendency to over-engineer.

- Students will receive some tuition in applied maths, fluid dynamics terms and an overview of Newtonian mechanics, complemented by a good knowledge of noise functions to make sure everyone shares a similar starting point.
- Concepts around Newtonian motion, ballistics, the effect of proximity, forces, velocity, thrust, dampening and dissipation – all these are useful, especially if this knowledge is combined with observation and analysis of the characteristics of real-world smoke, dust, fog, fire, explosions, water and other fluids; asking what makes them look the way they do and how is 'behaviour' modified?

### This topic outlines and explores five kinds of simulation.

- In each of these (below) the student should explore the notion of cause and effect.
- They will use deformers or splines to rig geometry and simulation set-ups driven via simple expressions. They will experience the use of passive or active collision geometry driven by expressions or keyframe animation.
- They should appreciate the differences in the level of detail applied to collision geometry as opposed to CGI geometry for rendering.
- They should examine the appropriate use of effects fields such as turbulence, gravity, Newton, uniform, air and drag.

## 1 PARTICLE DYNAMICS

Sea foam, dust, precipitation, sandstorms, condensation, jet engine trails and various 'magic' effects are examples, but students should explore practical yet not-so-obvious uses too. Study needs to be goal-oriented, towards supplying a solution, rather than resorting to a 'stab in the dark' and haphazardly trying different sliders or variables.

Elements covered should include point emitters, emitting from surfaces, particles reacting to a hard surface container, use of sprites.

Particles are set in motion and acted upon by external forces like turbulence, gravity, etc. Streaks, points, spheres, blobs, clouds and using instanced geometry. Setting associated attributes such as speed, volume, friction, bounce, lifespan, stickiness, seed and goal. Tricks of the trade regarding processing – if the limit of particles is reached, what then?

## 2 PHYSICAL DYNAMICS

Collapsing buildings, buckling, wrecking ball collisions, debris, flotsam, autumn leaves are examples, but ask students to explore practical yet not-so-obvious uses too. Study needs to be goal-oriented, towards supplying a solution, rather than resorting to a 'stab in the dark' and haphazardly trying different sliders or variables.

Use hard body or soft body geometry (polygon meshes) as a starting point to create structures which break, shatter, collapse, tear, bend or distort in some way over time. Physical characteristics are defined and forces act upon them. Students should concentrate on attempts to mimic real phenomenon, but also explore pushing parameters subtly, to see if reality can be improved! As an example collect and observe film material of how large objects fall down if the foundations are removed. How do different stress points affect a collapse? Physical dynamics are often used to simulate destruction and so have many advantages over 'physical effects' on set.

The student should also see that level of detail and modelling for simulation needs to be different from modelling for rendering and how different solutions can be combined. For instance, a collapsing building can be composed of hard surface for big blocks and particles for smaller falling rubble.

Shattering objects in certain ways will make a huge difference to constraint or glue setups and how the solver will behave. Students will need to pay attention to the UVs carried through the shattering process (and UVs created for the new internal faces made) for rendering purposes, as this knowledge is invaluable since the sim might look perfect but if it can't be rendered the work will have to be redone.

## 3 CLOTH SIMULATION

A red carpet rolling down stairs, silk versus canvas covering a box or uneven surface, ripping newspapers, a sack race, a bulging plastic bag are examples, but ask students to explore practical yet not-so-obvious uses too. Study needs to be goal-oriented, towards supplying a solution, rather than resorting to a 'stab in the dark' and haphazardly trying different sliders or variables.

Cloth simulation uses meshes as a starting point. Subdivision of surfaces, splitting and joining polys as necessary to create a desired effect need to be explored and it's important to understand the impact the quality of the mesh can have on the final cloth simulation.

Obtaining good references are important here. Try video clips or even obtaining different materials. Comparison exercises: by changing software attributes and trialling (caching or rendering), the student judges how close their simulation is to the reference, exploring properties such as compression, bending, stretching, shearing, rigidity, thickness, mass, lift, drag and friction.

## 4 FLUID SIMULATION

A calm or rough seascape, how jetties or moored vessels displace water and how it might lap around, treacle dripping off a spoon at different viscosities, a ship's wake are all examples, but fluid simulation is used more for smoke, fire and explosions. Students are guided to explore practical yet not-so-obvious uses too. Study needs to be goal-oriented, towards supplying a solution, rather than resorting to a 'stab in the dark' and haphazardly trying different sliders or variables.

### Output mesh, particles, or some kind of volume data. Scripting and editing fluid solvers.

An introduction to look development and compositing is especially pertinent at this point: students need to be told how any simulation may later be lit and built upon.

Water's properties are especially difficult due to reflection, refraction and translucency, which are properties of passes created later by look dev (lighting TDs). This means that requests may then come back down the line after this happens to change the simulation, as certain characteristics may then need accentuating or downplaying.

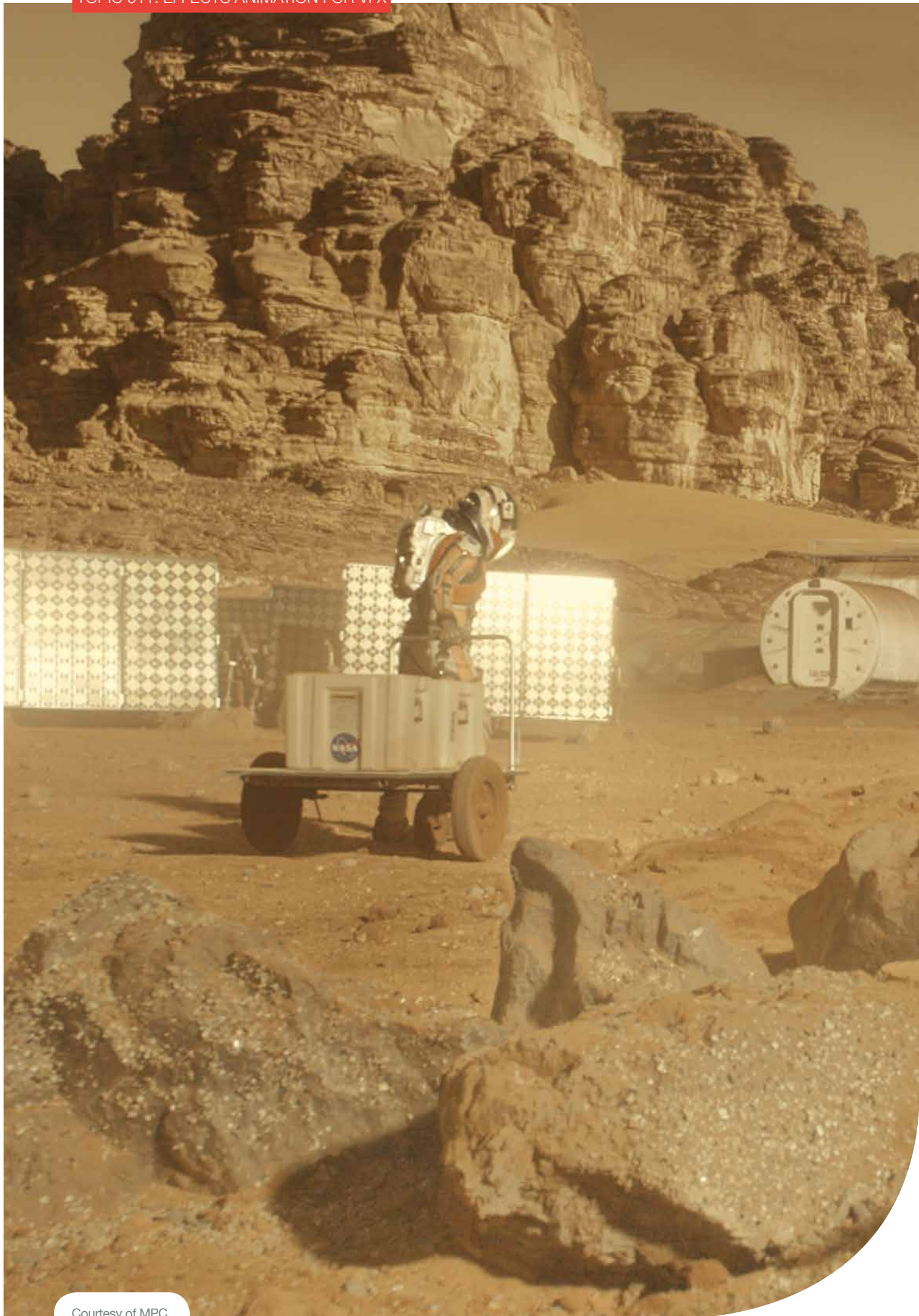
The interaction of different simulation types is also important: using fluids to move particles, emitting spark particles from a fire, fluid simulation, etc.

Fluid simulation may be a good point to talk through the integration of effect into plate: rendering, motion blur, depth blur, colour effects, grain, transparency and shadow, edge quality and restoring background areas of the plate can all have implications for effects. Building efficient workflows will be important to get quick turnarounds.



Everest  
Courtesy of Universal Pictures / Framestore.





## 5 CROWD SIMULATION

Herds of cattle intersecting, a mass panic, swarming, retreating soldiers, shoals of fish fleeing or feeding are examples, but ask students to explore practical yet not-so-obvious uses too. Study needs to be goal-oriented, towards supplying a solution, rather than resorting to a 'stab in the dark' and haphazardly trying different sliders or variables.

### Procedural creation. Flocking behaviour, etc.

- Look at Massive software. Looking at how background sims might interact or reflect the behaviour of photographed foreground actors.
- An overview of the use of motion capture for crowd animation and photographed elements as sprites on cards.

### Rendering

- The last component of this topic is rendering and looking at pipeline and software interoperability: moving from modelling to simulation and from simulation to lighting and rendering.
- Students may examine software and hardware rendering and different approaches to rendering the final asset.
- They should be presented with case studies of how work might pass through from Maya to Houdini to Maya and how Python might be used to enable flexible pipelines.
- Students should be made aware of the issues involved in the integration of elements from different renderers or passes.

### A note on stereo 3D

- Stereo 3D conversion work includes re-projection and/or displacement via depth maps, but effects will not work via this process. In conversion work (popular at the moment) the use of essentially flat cards of particles is exposed as having no volume or depth in stereo 3D and the illusion is negated. Volumetric effects require more thought in stereo, as it can be very hard to post-convert this type of element.
- In other words, cheats and processor-saving shortcuts like flat representations of particles won't work in stereo 3D conversion work.
- In true CGI stereo 3D – with its native 3D space – effects systems have no such limitations, but obviously there are processor and resource overheads to consider since you can't cheat with flat baked-in cards.

## 6. KEY TEXTS/LITERATURE

*Motion Mountain*, [www.motionmountain.net](http://www.motionmountain.net)  
by Dr. Christof Schiller

Zwerman, Okun (2010) *The VES Handbook of Visual Effects*, Focal Press

## 7. SUGGESTED LEARNING ACTIVITIES

### Issues for universities to consider

Building or having access to a library of video clips of relevant natural phenomena would be advantageous and could support students' own efforts.

Also access to recording: tutors could look at whether students from film or video departments might be called on to shoot natural phenomena to a brief (with requisite H&S awareness and risk assessment). Shooting fire, steam, water is not something that should be done lightly.

Students should try and note down for each clip what physical forces are acting on the objects they are studying or filming and explain, based on the material and environmental physics, why the phenomena behave as they do.

Whilst Maya maybe the main tool of choice at most institutions, consideration might be given to acquisition of other industry reference software: RealFlow, FumeFX, Massive and Houdini, for instance.



Courtesy of National Film and Television School / Compositing Coach





Courtesy of Julian Rodriguez / MADE projects

# TOPIC 012: CGI LIGHTING AND LOOK DEVELOPMENT FOR VFX

## 1. THEME AND SCOPE

This topic explores the skills that constitute and surround the role of the lighting TD. Lighting is also a fundamental skill required by generalists who cover more than one role when working on smaller projects.

The process of balancing CGI texturing, shader development, lighting and rendering to match a reference image is called look development (look dev) and this topic is concerned with providing the mixture of art, science and maths skills needed. Maths and software may power the technical processes, but art and cinematographic observation and awareness can contribute to the emotional impact and believability of the world portrayed on screen. As such this topic attempts to teach and blend the science and art of light.

It is important for the student to understand that look dev should be done as a global exercise pertaining to the model or creature that appears in a number of shots. This look needs to be approved by staff before any animation work begins; yet in reality the look dev will continue to progress from this point onwards. In industry, it is very rare on a film project that look dev would be completed before the animation itself is complete. Usually the two will run in parallel.

Lighting TDs add the lighting that creates atmosphere, adding realism, tone and depth to a scene; visually balancing individual elements to enable a compositor to produce a convincing and consistent range of images. They need to use technical skill and aesthetic judgement in order to create images that not only look right but can also be rendered efficiently. They ensure the CG looks believable to match the live action plates.

## 2. WHY TEACH THIS?

To create the look of a film, a number of multidisciplinary approaches can be called upon and separate art and science faculties can contribute. This can be an exciting challenge. While this is not an entry level role (because of the experience needed and level of responsibility) it will open doors for students in smaller boutique companies and can give them the opportunity to progress rapidly in their roles.

A high-level understanding of VFX lighting, rendering and compositing pipelines will be needed from tutors, so consider a high proportion of visiting lecturers from industry to assist if your department needs this.



Courtesy of National Film and Television School / Compositing Coach

## 3. RELATED JOB ROLES

LOOK DEV

LIGHTING TD

RENDER TD

SHADER DEVELOPMENT TD

## 4. WHAT STUDENTS NEED TO KNOW AND DO

### Intro level descending to advanced level

- Have an understanding of the main technologies and processes of look dev.
- Show they have developed skill and confidence with light in order to create a spread of different set-ups.
- Understand the inter-relationship of lighting, shaders, rendering and compositing.
- Acquire a blend of maths and art that they can synthesise into good look development work.
- Articulate, analyse and reflect upon their work through using both the languages of art/cinema and maths/science.
- Demonstrate a foundation in all aspects of the field of look development, to the level that they can start making sound assessments and building informed but efficient pipelines.

## 5. OUTLINE CONTENT

### The language of art and cinema

- Lighting TDs, like many roles within VFX, are a mix of art and technology competencies. As such they need to be able to communicate and think in two languages. One of these languages relates to cinema and art – to communicate ‘the look’ to other artists or even a DoP or director.
- This topic needs to give students a tour of milestones of art history within the context of lighting and its effect on surfaces, so students develop an artistic lexicon to articulate and communicate lighting scenarios.
- Studies of masters of light in both art and cinema, such as Rembrandt and Vermeer or John Alton and Gregg Toland need to be contextualised and presented to students.
- Being aware of the ‘look’ of major films and being able to dissect the contributing factors is important, since other films often become references when communicating about the current film you are working on.

### Exploring real lighting

- The topic needs to provide a space for exercises and experimentation with real lights. Students should be free to explore the interplay of two or three lights and a camera. It needs to be noted this doesn’t need to be a professional studio space – an empty room capable of black-out will allow this. However, it is vital health and safety and risk assessment are at the heart of any arrangement.

- This is a space for students to rapidly engage with different forms of lighting for learning, not production.
- Students should rapidly be able to explore and try out ideas. Even lighting objects on a tabletop will have benefits.
- Students should explore the difference between diffuse and direct light, how the absence of light can be utilised, different types of lighting (point, area, directional, etc.) and conventions used within live-action cinematography. By such work they should be able to describe and think of characteristics such as light direction, type, wrap, fall-off or directness, colour, contrast, exposure, absorption and colour bleed/bounce.
- The language of the traditional film set lighting department needs to be internalised (eg “make this more high key”) and an understanding of basic three-point lighting (key, fill, rim) should be demonstrated.
- The tool of the DoP that creates the film director’s vision is the lighting kit, so the student should experience a lighting session delivered by a film professional at some point.
- They should be made aware that people often erroneously try to fix problems by adding complexity and why the tech fix of adding more lights is often the wrong solution.

### Matching light

- To assess the students’ understanding, they should be tasked with matching the lighting scheme of a series of photographic and art images with real lights, which are equipped with gels, dimmers and scrim. Some paintings will naturally prove impossible, but from this the student will learn that ‘realistic’ lighting is only part of the possibilities and they will also see how lights can have an affective or emotive impact.

### Light in CG

- Having explored the building blocks of physical lighting the student now needs to see how this translates into CG.
- In the real world the two main choices are direct or bounce (scattered, diffuse) light.
- Firstly, the students should try to mimic real world scenarios in CG and discover comparisons and differences (for instance, a CGI area light might be an equivalent to a physical softbox). What is the equivalent to CG parallel light in the real world? An understanding of how CG light (like parallel, area, spotlights and their inherent properties) can mimic but also extend beyond real world lighting should be explored. The student will build up an idea about how CG lighting is based on traditional lighting concepts but sometimes departs from those qualities (for instance, the concept of negative light).



- What added properties does it allow the CG artist? From these questions emerge investigations into areas of commonality and departure between the two lighting media. Characteristics such as reflections and shadow, radiosity and colour bleed, refraction, Fresnel effects should be noted, through experimentation with both real light and CG light, switching on and off in different combinations.
- Underpinning this exploration must be the aim that the student is using light to create a film 'reality' and style, simulating to a level needed to complete the job, rather than trying to simulate physical reality itself.
- Students should familiarise themselves with the Cornell box test to determine the accuracy of their renders.
- Students should be able to look at an image and articulate its lighting components.
- The student should receive an introduction in image-based lighting (sphere or fisheye, or Spheron camera) and the ensuing lat-long map.

### History of CG light and shaders

- Students will be shown Lambert and Phong shading, the models and maths behind them and how these models have been modified and built upon to add to the range of lighting and surface possibilities.
- Lighting TDs need to understand the maths behind surface normals and dot product maths. The student should progress to looking at physically derived shading models. Relatively modern developments such as ray tracing and sub-surface scattering (and the range of surfaces that can benefit, such as skin or marble) need to be explained.
- It is said that most development from software vendors is currently going into the areas covered by this topic. It needs to be made clear to the student that the technology and application of lighting and materials is still developing and they should be proactive in their own research, for instance SIGGRAPH or Eurographics papers.

### A session on optics

- Terms and phenomena such as colour, absorption, reflectance, refraction, diffraction and polarisation should be covered, as well as atmospheric optics (eg Rayleigh scattering), physical-based lighting theory, path tracing irradiance caches and photon mapping.
- The student should understand that measuring reflectance directly is the scientific way, but its exactness means you cannot account for perceptive quirks of our eyes and brain.
- This should be followed and contrasted with BRDF (Bi-Directional Reflectance Distribution Function) to represent surface reflection properties.

### Grading in depth

- The student should experience match-grading solutions: HSV, curves, exposure (f-stop, t-stop, Cineon code value and printer light points). Offset/add, lift, multiply, blackpoint/whitepoint match grading, clipping, crushing, gamma, contrast and Perlin gain. Primary grading and selective (secondary) grading via ID mattes.
- Practical application of film characteristics: understanding of toe and shoulder film exposure curves, log response, Cineon and linear gamma, open exr, application of such to pipeline, lighting and CGI multi-pass rendering/compositing.

### Roles in look dev

- It could be said that the role of the lighting TD is to mimic digitally what the DoP does practically. The lighting TD needs a thorough understanding of what data or reference images need to be collected from set in order to replicate the DoP's lighting set-up in CG.
- However, collection of such data should be matched with a good understanding and interpretation of the DoP and director's vision and their creative intent.
- On some projects, a lighting TD or lighter may be involved in the research and development of different effects for the art director or lighting supervisor. An experienced lighting TD may work with the art department, concept artist or production designer to develop the look of a CGI creature or object, creating a setup with a hero shot or turntable to get the look dev right and then designing a pipeline based on this shot and ensuring the look is correctly applied to different instances of the creature or object in different shots.
- How far the look is reliant on lights or shaders will depend on how the lighting TD will standardise the look and how flexible it has to be.

It is likely that there will be an established design theme for a sequence or a project, which the lighting TDs/lighters need to respect. They refer to the relevant production designs and apply that visual style as faithfully as possible, taking care to maintain continuity.

- In a large company or on a larger project, lighting TDs/lighters are often part of a team, but they need to be able to work with a minimum of supervision, understand the tools available and know how to utilise them to create the desired effects. On smaller productions, the role of lighting TD/lighter may be combined with that of modeller or texture artist.
- Lighting TDs/lighters need to work closely with the rendering and compositing departments to understand and appreciate what is required at the next stage and ensure their material is easy to use and delivered on time.



## Compositing

- The role between lighting TD and compositor is increasingly blurred or shifting. The student needs an understanding of the compositor/finishing artist's role and their relation to the lighting TD.
- Anything caused by light hitting a lens is the compositor's responsibility, such as halation, bloom, grain, depth of field and in some cases motion blur, although this is usually handled by the TD in the renderer. The lighting TD needs to understand how a compositor uses different passes in order to supply meaningful plates.
- The compositor needs to 'rebuild' a beauty pass or final gather render which is derived from a set of different lighting passes, if needed for a relight. Students could be introduced to how to build a mathematically accurate rebuild of a beauty pass.

There is a trend for the postponement of decisions until later in the chain, meaning the notion of relighting is gaining in prominence. Students should be acutely aware of this. Which lighting effects should be achieved in 3D and which in the composite?

How are different lighting components layered?

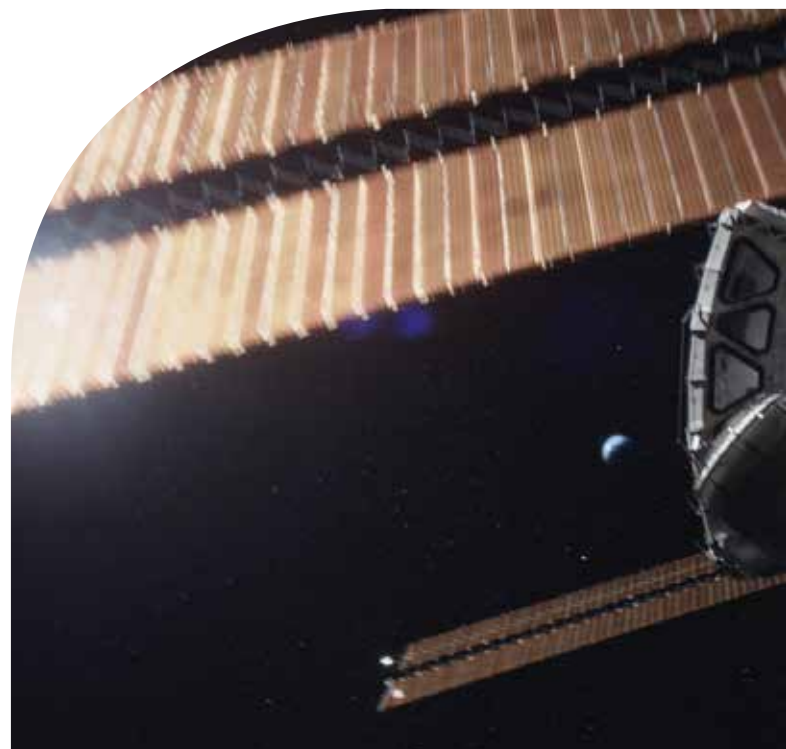
- Students should create a small pipeline from the renderer to the compositing tool, allowing a compositor to finish the shot based on the renderer's output. The student should be able to make decisions on project workflows: is it better to light and render image passes in 3D or better to allow for re-lighting and re-texturing, with secondary passes in 2D? (The industry is moving towards this practice.)
- The student needs to understand all the passes possible and their effect, as well as secondary 'utility' passes (arbitrary output passes – this is a RenderMan term, but very widely used) as well as colour space (which is generally linear) and an understanding of LUTs.

## Shaders

- The student needs to understand that if the light is correct but the surfaces can't take advantage, you have a problem! The creation of shaders (eg for fur, mirrored surfaces, foliage, alien skin) and the difference between hardware and software shading should be expounded.
- Surface shaders, bump and displacement mapping and procedural shading should be covered.
- The student needs to articulate why they might choose different shading models and how the surface properties change the effects of the light.
- Information regarding ray tracing v global illumination models and ray marching (volumetric rendering for smoke, etc.) should also be given.

## Rendering

- The lighting TD needs to be able to look at a CGI scene with textures, shaders and lights in place and understand how the renderer is going to produce the desired output. Identifying and thinking through the best solution to render problems related particularly to reflection, opacity, self-shadowing and radiosity (which are particularly computationally heavy) should be presented as a major challenge for students.
- Different methods of rendering can be explored: the advantages and disadvantages of GPU, CPU or cloud rendering?
- Rather than ray tracing, could the 'map' approach to rendering passes be taken? (For example, providing a Fresnel pass to allow the compositor to attenuate a raw reflection pass; or rendering material maps to designate areas on the surface of a model that are varnished as distinct from being tarnished.)
- An appreciation and comparison of different renderers is needed (such as Mental Ray, Maxwell, V-Ray and RenderMan) and the inter-relationship of renderer, shader, lighting and multi-pass CGI. The student should see that a large percentage of problems with renderers have implications for the whole pipeline and it is not unusual to have caching and data management or back-up issues.
- In essence the task of breaking down a scene so it can be rendered efficiently and can be tweaked in compositing rests with the lighting TD.
- Notions of RenderMan versus relighting can be explored and the implications of secondary passes. An experience of Python scripting language to batch process is preferred.



## 6. KEY TEXTS/LITERATURE

Glassman, A (1993) *Visions of Light: The Art of Cinematography*, ASIN: 630583685X

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Birn, J. (2013) *Digital Lighting and Rendering*, New Riders

Yot R. (2011) *Understanding & Using Light in Art & Design*, Laurence King

Brinkmann, R. (2008) *The Art and Science of Digital Compositing: Techniques for Visual Effects, Animation and Motion Graphics*, Morgan Kaufmann

Wright, S. (2008) *Compositing Visual Effects: Essentials for the Aspiring Artist*, Focal Press

Lanier, L. (2015) *Advanced Maya Texturing and Lighting*, Kindle Edition

S. Andersen, M. (2013) *Annual Dynamics of Daylight Variability and Contrast: A Simulation-Based Approach to Quantifying Visual Effects in Architecture*, Springer

Bloch, C. (2013) *The HDRI Handbook 2.0: High Dynamic Range Imaging for Photographers and CG Artists*, Rocky Nook

Armsden, C. (2011) *The Renderman Tutorial Book*, Kindle Edition

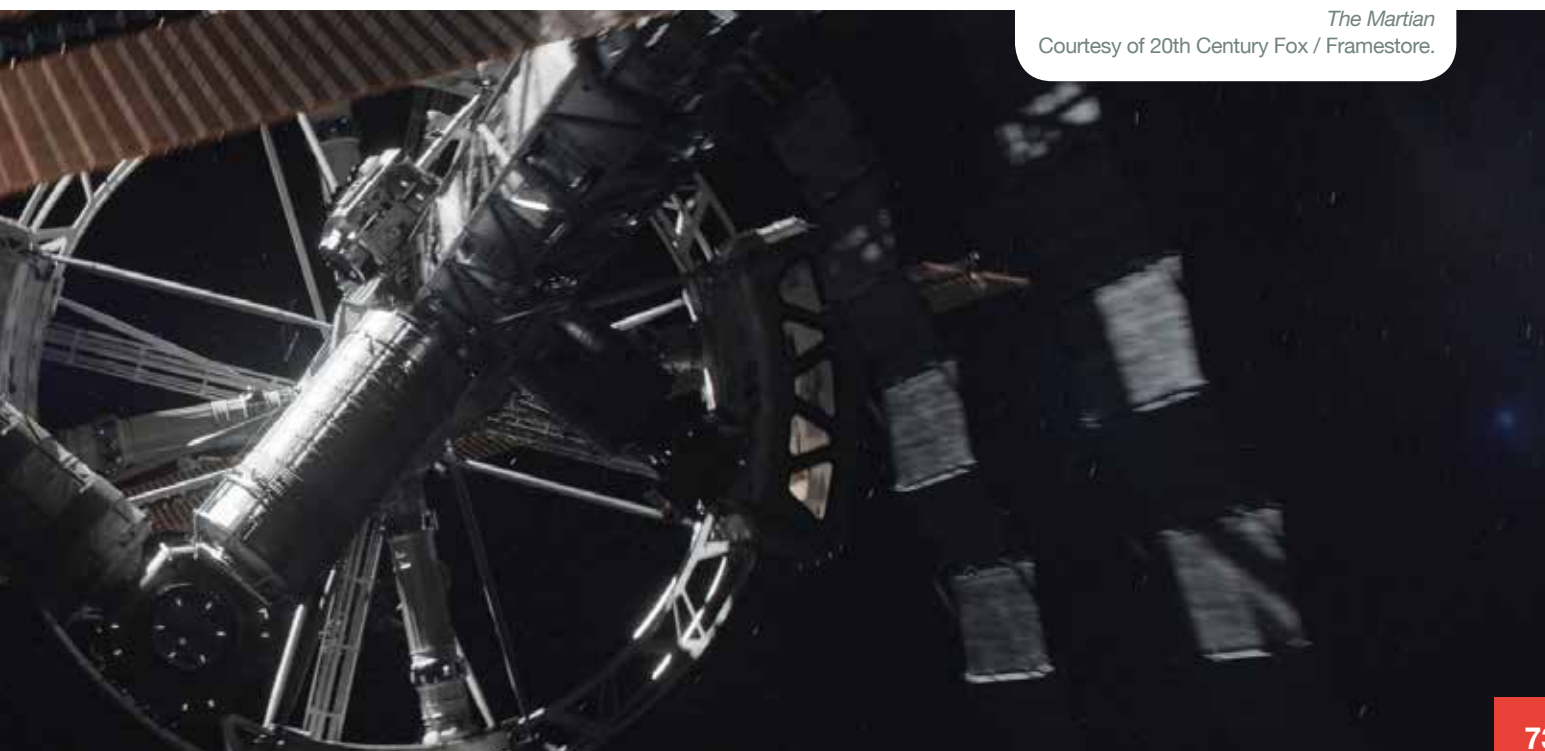
Bailey, M. Cunningham, S. (2009) *Graphics Shaders: Theory and Practice*, A K Peters/CRC Press

## 7. SUGGESTED LEARNING ACTIVITIES

Although a lighting TD is not an entry-level job, some companies do recruit junior lighting TDs, so in this case this topic should be valuable, especially for smaller companies who are looking to recruit good all-rounders.

A high-level understanding of VFX lighting, rendering and compositing pipelines will be needed from tutors.

Rendering CG in the most appropriate way to allow it to be seamlessly composited into live action plates is a big part of the job. A good exercise would be to institute teams; designate someone to do the lighting/rendering job and someone to composite. Get them to look at building simple passes and a rendering pipeline between them. The starting point could be a simple set of diffuse, colour, beauty and specular passes, which are then tested in the composite. Students can reflect on this and check what other passes may be needed, for example ID matte passes for grading or vector passes for motion blurring. On more ambitious courses, the ultimate challenge would be to see whether – with research – a basic re-lighting pipeline could be made.



*The Martian*  
Courtesy of 20th Century Fox / Framestore.

# APPENDIX

# THE VISUAL EFFECTS VFX CAREER MAP

## Getting on: Specialists vs Generalists

Specialisation is essential in the London-based VFX feature film industry, but you can also pursue a career as a VFX generalist in smaller production houses where roles are more varied in scope. Smaller animation and post production companies are also starting to do VFX work for tv, commercials and games, often in cities outside of London, such as Manchester, Bristol, Cardiff, Glasgow and Belfast.

There are a number of specialist areas where the UK film industry particularly excels and in which hundreds of highly skilled jobs exist. The career map overleaf outlines the foundations for particular roles and career routes.



### Runner

You'll help the studio to run smoothly and learn the tools of VFX at the same time. Thousands of people in the film industry learnt their craft while making tea! The job of a Runner is not glamorous but it can be a job with prospects.

You will learn how teams and workflows operate while getting to work on training shots, match moving or roto. In advertising VFX, the biggest part of the job is still to serve drinks and refreshments for company clients and keep the kitchens stocked. In film VFX, expect to run errands, manage deliveries, cover reception and keep the place tidy. To progress you will need to be enthusiastic and prepared to work on training shots during quiet times and in the evenings.



### Roto Artist

Imagine getting to know every detail of a famous actor by cutting around him or her! Roto Artists carefully cut out moving characters and objects from one moving picture so they can be inserted into another (or CGI can be inserted behind them) by compositors. You need to have a keen eye, patience and think like an animator – because you are one!



### Paint/Prep Artist

Help create the illusion that a person can fly by 'cleaning' or erasing unwanted items from live action images such as wires, harnesses, or film equipment. Paint/Prep artists also remove things that betray the story, for example, removing a jet or a pylon from the scene of an Edwardian period drama.



### Compositing Artist

Consider the pride you'll have in knowing you matched the computer-generated creature or object to make it appear as part of the frame. As a Compositing Artist you work at the end of the VFX process to combine CGI and digital matte paintings with live action and make it all look seamless.



### Match Mover (sometimes called Camera Tracker)

You'll be the person that everyone relies on to extract movement and spatial information from previously shot material so that objects and people can be dropped into the shot realistically – without anyone knowing. You are making a virtual 3D copy of a flat image so that others can create new elements to make them appear realistic.



### Modelling Artist

Imagine being able to make anything digitally. As a Modelling Artist you'll create a whole range of 3D objects using digital modelling and sculpture software. You could be asked to make anything on the computer, from the fantastic to the mundane. You create the 'building blocks' for VFX that need to be built before they can be placed coloured, lit and animated.



### Texturing Artist

As a Texture Artist you will create surface detail and colour through a combination of photographs and painting in three dimensions. Texture Artists enjoy dirtying things up, making rusty, tarnished edges and surface imperfections to give computer models the messy sophistication of the real world.



### Lighting Artist

Just as our physical world has many different light sources which contribute to how objects and scenes look, so does VFX. A computer generated object needs to be lit too. Lighting Artists use computer software lighting and work with images photographed on set to illuminate 3D objects so they match live-action backgrounds. These are then enhanced and accented to help tell the story.



### Environment Artist

Imagine going on a film set and taking the photos that allow you to digitally recreate the scene that all the other VFX artists will use. Environment Artists are 3D generalists that use modelling, texturing and photo manipulation to re-create the environments that the action takes place in.

## EACH OF THE JOB ROLES SHOWN REFERS TO SKILLS IN AT LEAST ONE OF THE VFX REPOSITORY TOPICS.

This is a re-issue of the "Visual Effects (VFX) Careers Map that was released in 2014, commissioned by Yen Yau at Into Film. Original design 2014 Ian Murphy and Allan Burrell. All rights reserved. We reprint a section here for readers to consult. The original document is available from [www.creativeskillset.org/VFXresource](http://www.creativeskillset.org/VFXresource)



### Concept Artist

All great ideas on paper or in the head of the creator need to be turned into images that communicate a look or a shared vision. Concept Artists use digital and traditional drawing and painting to visualise concepts for the film maker so that other VFX artists have something to work from. Concept Artists might also work in the film's art department, costume department or work in the computer games industry.



### Matte Painter/Artist

Imagine taking photographs and cutting/pasting and digitally painting visual elements to make entirely new environments or images, which might be used in the background or to illustrate a landscape or wide-angle cityscape for instance. As a Matte Painter you might use your own stock of images to cut up, flip and manipulate to create new digital worlds.



### Animator

Your work breathes life into a creature so they move realistically and display a personality, becoming part of the cast. Animating vehicles or machinery is also part of the job. No matter how good the CGI, if its movement isn't realistic the audience won't believe in it!



### Look Development Artist

What does the skin of a fantasy character such as an alien actually look like? When the concept for the computer generated creature has been designed you will work with other film production departments, Lighting and Texture Artists and Shader Development TDs to establish how the alien will look in different VFX shots.



### Creature/Rigging TD

Fancy solving the puzzle of the mechanics of how a creature moves? Creature TDs create skeletal and muscle systems, adding well placed handles and controls for animators to use to create realistic creature movements. This is a role that combines computer interface and digital tool design with anatomy and science.



### Effects TD

Imagine creating fire, ice, rain and explosions (digitally!). Effects TDs create things that seem to move under the rules of physics, for example developing spectacular simulations of floods and destruction or just the bit of sand that is blown up when the computer-generated helicopter lands.



### Pipeline TD

You are the Mr or Ms fix it, writing or modifying computer code to solve problems related to art or productivity as they arise on a project-by-project basis.



### R&D (Research and Development) Programmer

You'll be the inventor of the software that every other VFX artist relies on. In R&D, you'll use computer programming to modify and originate bespoke code to provide artists with new creative tools and enable the efficient passing of assets from one VFX process to the next.



### Shader Development TD

Milk, marble, iron, skin and snow all have complex surface structures that dictate how they look in different lighting conditions. You are the computer programmer that writes code to describe the 'material' surface quality of things modelled and generated inside the CGI world.



### Assistant TD

You'll be a technical assistant to effects and pipeline TDs and R&D programmers, learning and refining your coding craft, cleaning up effects simulation data, backing up and moving digital files from one location to another.



### Production Co-ordinator

As a 'Junior Producer', your job is to input and collate data relating to schedules, tasks and client/VFX supervisor feedback notes. This is the project information that the producer will rely on to track progress against the planned schedule.



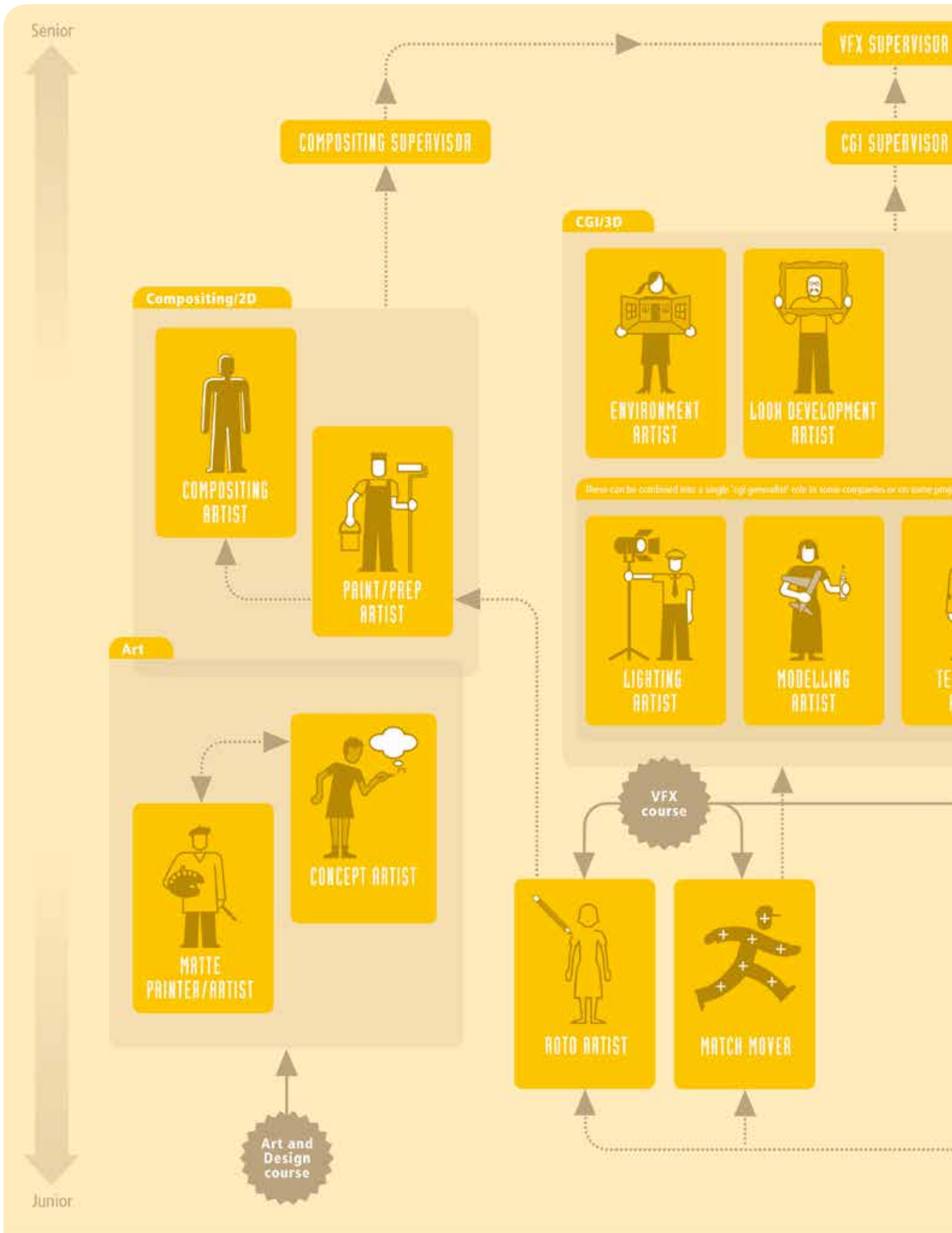
### Producer

By working closely with the VFX supervisor, you will project manage the VFX process, from writing the client bid, through to setting and managing schedules and budgets. You will recruit, or advise on the recruitment, of artists and technical staff for projects and will liaise with both crew and clients throughout production. You'll need to have a strong personality, be highly organised and good with people.

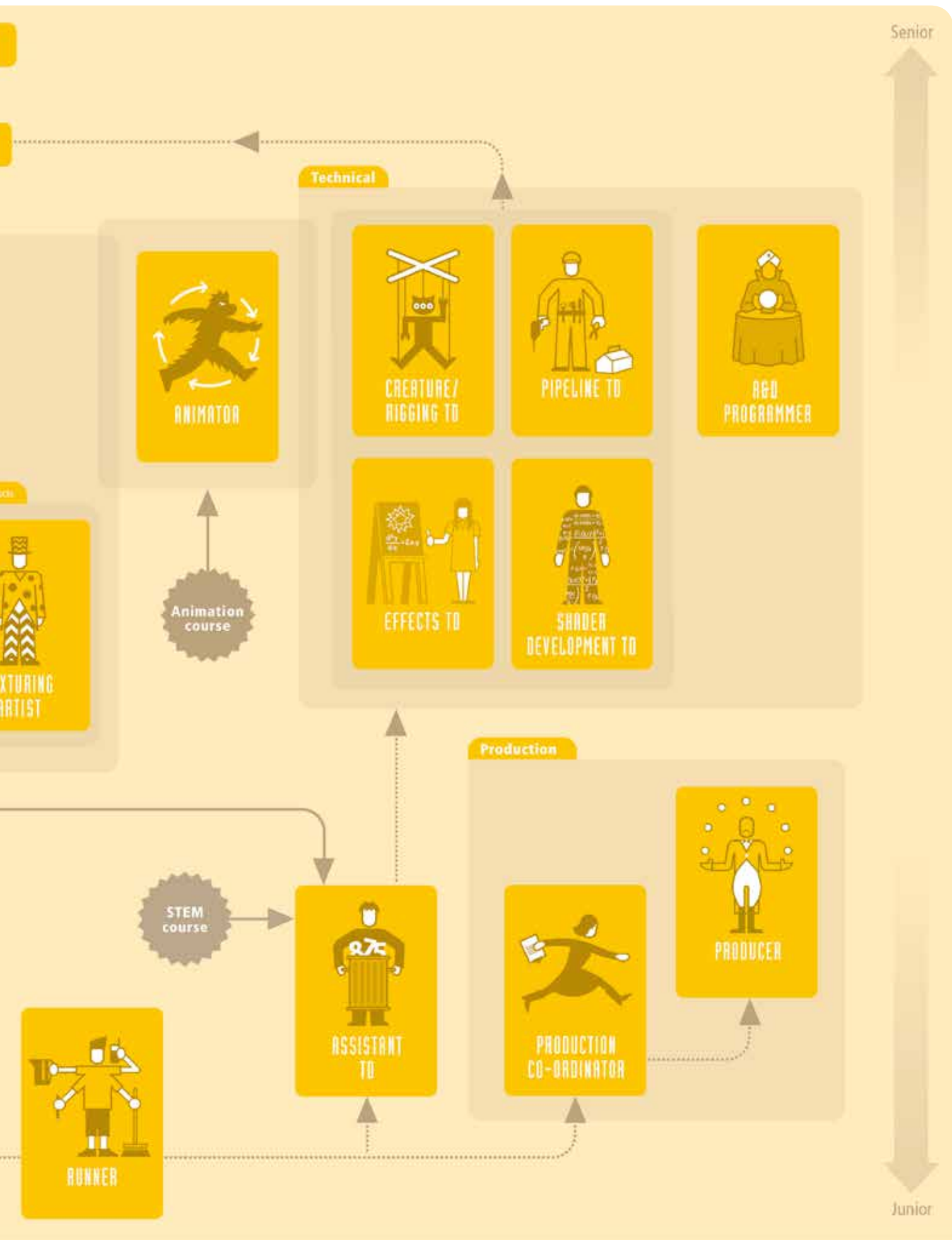


Technical Director (TD) is a job title you will come across often when researching jobs within VFX. Any role you see appended with 'TD', you should assume requires a high level of STEM skills, in particular computer science and coding, but some also require a solid foundation in physics and maths. Technical Director roles can range from junior to senior.





# VISUAL EFFECTS (VFX) CAREER MAP



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