Digital Matte Painting – An Effective Undergraduate Assignment

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Figure 1: *A before (left) and after (right) image of a case-study digital matte painting that forms the basis of the 2D digital painting workshops delivered as part of the course.*

Abstract
This paper presents an effective digital matte painting assignment from a course delivered as part of an undergraduate degree programme in visual effects. The assignment involves the creation of a final 3D shot from an initial 2D image, using various 2D image manipulation tools and appropriate 2.5D image projection techniques.

1. Educational Context

Production based projects are an increasingly more common aspect of industry-oriented undergraduate degree programmes, such as visual effects and computer animation. For more than 25 years the National Centre for Computer Animation (NCCA) at Bournemouth University has run numerous production focused projects and assessments across all three years of their undergraduate programmes. NCCA graduates aspire to progress into employment in areas of computer animation, games, and visual effects across a wide range of media including feature film, commercials, and visualization.

This assignment is the summative assessment of the "Digital Matte Painting" course (worth 10 ECTS credits in the European Credit Transfer and Accumulation system). The course is mandatory in the Bachelor of Arts in Visual Effects degree programme, part of the NCCA's undergraduate framework [CMA10], and an optional elective on the other programmes of the framework. The duration of the course is 15 weeks, 12 of which contain taught workshops that explore the tools and techniques for advanced 2D image manipulation and 3D projection, whereas the remaining 3 are student-led project working weeks. Each taught week of the course also includes a feedback session where the students can get feedback from academics regarding their work in progress. Prior

to this course, all students will have completed 2 previous years of their programme, including a prerequisite course that covers the basics of the visual effects production pipeline [RFA19], namely 3D modelling, UV unfolding, texturing, camera line-up and proxy geometry creation, rigid body dynamic simulation, lighting and light matching, shading, rendering, and compositing [Dun14]. The students will also have completed courses that are focused on the design and aesthetics of image composition, as well as the theory and practice of photography & image acquisition, and cinematography.

2. Course Aims and Assessment

The aim of this course is to expose students who have little to no previous experience in digital matte painting (DMP) to the basics of the 2D and 2.5D DMP pipeline [Mat11]. The emphasis is on the creation of a photo-real final shot by giving the students the necessary knowledge and understanding of the core principles of each of the areas of the pipeline, and how those areas work together to create the final finished piece. The course is assessed through a single piece of coursework comprising of the final rendered shot and supporting working files (Maya, Photoshop, and Nuke files etc.). The assessment requires the students to complete each part of the DMP pipeline to create a high-quality photo-real 2D image, and then convert that image into a final animated 3D shot using 2.5D projection

techniques as shown in the weekly workshops. Practice assets and reference materials are provided online via a virtual learning environment (VLM) for the students, along with video tutorials and other supplementary resources such as camera data information. "Especially for workshops on specific disciplines it is often better to provide video tutorials for the students to follow along, but these should be provided to complement the workshop and not as a replacement" [ADLR17].

3. Coursework Assignment

The assignment is made up of 100% coursework, with multiple assessed elements as outlined in section 3.3 below.

During the first lecture of the course, the assignment brief – creation of a photo-real DMP – is distributed to the students (see this paper's supplemental material for details).

3.1. COVID-19 Mitigation

Due to the COVID-19 pandemic, during the 2020 academic year, a revised version of the assignment brief was distributed to the students. In some cases students may have had to self-isolate, which would make it difficult to photograph a backplate located outside. Another issue was campus closure, which meant that students were unable to access the university's camera equipment for taking their base image photographs. Our mitigating solution was to allow students to use a 3rd party photograph (e.g. sourced from the internet) instead of requiring them to take the photograph themselves.

Introducing the possibility for the students to use base images sourced from the internet was a way of ensuring parity and fairness across the cohort, regardless of the possible restrictions caused by the pandemic.

3.2. Additional Guidance

The students are advised that particular attention should be given to overall detail, shot design, aesthetic quality, and photo-realism of the final shot, the quality of the initial photograph taken with regards to image resolution, appropriate depth-of-field, composition, lighting, and detail, as well as the quality of the 2D matte painting augmentations chosen to be implemented (additional guidance is detailed in the supplemental material).

The students are advised that the final shot must be full screen high definition – 1920 x 1080 resolution, and must be landscape in orientation, not portrait. As this is a matte painting assignment, with an emphasis on photo-realism, the students are advised to design a simple shot so that the amount of geometry which will be required to be modelled does not take too much time away from the aim of this project. They are also advised that they should attempt to generate geometry that has an adequate level of detail for the shot they are creating, as excessive and purposeless amounts of detail in the projection geometry will only take time away from the aim of the project, will not be seen in the final rendered shot and will be detrimental to the final output quality.

The students are encouraged to focus on designing a simple, visually strong image with a high-quality aesthetic, rather than an overly complex image which might be difficult to manage, as well as to make use of primary research in the form of photographic reference of the real world, and to use their observational skills.

3.3. Assessment Marking Criteria

The students will be assessed on the visual aesthetic quality of the submitted work (see the supplemental material for submission requirements), with emphasis on the shot design, which includes the quality of the composition, and the overall photo-realism of the results. The technical accuracy of the final piece is judged with emphasis on the light match, depth-of-field match, perspective match, camera line-up, parallax, and projection accuracy, as well as correct use of techniques required for generating a 3D shot from a 2D matte painting using 2.5D projection techniques and compositing. The assessment marking criteria are split into the following areas:

- 50% – Visual aesthetic quality, shot design, and photo-realism.
- 25% – 2D DMP techniques, quality, and accuracy.
- 25% – 2.5D conversion into final 3D shot (including geometry creation, camera line-up, projection and cleanup) techniques, quality, and accuracy.

4. Workshop Programme

The 12 two-hour long workshops are supported by weekly feedback ("dailies") sessions where students can submit work-in-progress for feedback from the academic team. They are also supported by supplemental materials in the form of video tutorials, delivered via the VLM. The workshops are split into three main areas of focus: the 2D image manipulation process (mainly employing Adobe Photoshop[1]), the 2.5D conversion, and the final compositing and output process.

The 2D workshops focus on a single case study (Figure 1), with the students being shown one or two steps of the painting process in each workshop. Each step of the case study painting is designed to introduce the students to a new tool or technique, which they are then expected to apply to their individual assessment context if needed. The first workshop discusses the planning stage, which includes drawing perspective lines on the base image to aid the addition of extra elements later on in the painting process, as well

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[1] https://www.adobe.com/uk/products/photoshop.html

Figure 2: *The planning stage showing the marking of perspective lines (left), and elements for removal (right).*

as marking existing elements of the image that will need to be removed (Figure 2). It also covers the process of removing elements from the base photograph using layer masks and adjustment layers (Figure 3).

Figure 3: *Removing unwanted elements from the base photograph.*

Figure 4: *Using the match colour tool to seamlessly integrate additional tree elements into the photograph.*

The second workshop introduces the transformation tools necessary to warp and skew added elements to match the base photograph's perspective, as well as the colour matching process for seamlessly integrating extra elements into the painting (Figure 4).

The third workshop covers the process of matching the lighting and shadows when integrating additional elements into the painting by employing multiple techniques, including gradient masking and hand painting of shadows, again using adjustment layers (Figure 5).
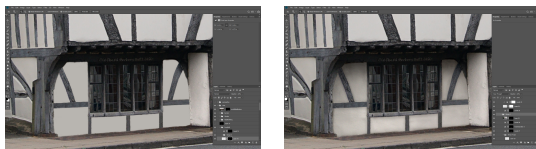

Figure 5: *Matching the lighting and shadows to increase the realism of integrated elements.*

Figure 6: *Adding a large building element to the image, using the previously marked out perspective lines.*

The fourth workshop covers the process of adding larger additional elements to the image utilizing the previously marked out perspective lines to get the additional element to integrate seamlessly within the image, as shown in Figure 6. It also includes the process of extracting an alpha mask for parts of the image using a luminance value technique similar to that used in compositing [App19], as shown in Figure 7.

The fifth workshop reviews and builds upon previous workshops

Figure 7: *Replacing the sky by using adjustment layers to extract a luminance key.*

and introduces the process of substituting large areas of the ground in the original image with a more aesthetically and contextually fitting replacement. It also covers the process of using drop shadow layer styles to integrate additional elements, as well as a method for adding accurate looking reflections to reflective objects in the scene (Figure 8).

Figure 8: *Ground replacement (adding reflective puddle elements).*

Figure 9: *Adding barrel elements using hand painted shadows to aid integration, and water staining marks on the rooftops.*

The sixth, and final 2D digital painting workshop, covers the process of hand-painting shadows to aid in seamlessly integrating elements to the image. It also covers the process of adding minor degradation to elements in the image in the form of water streaks, as can be seen in Figure 9.

In the 2.5D workshops a much simpler scene is used to cover areas of 3D texturing and UV unwrapping relating to the DMP pipeline [Van03], as well as the cleanup of projection texture shadowing. The first of these workshops explains the process of creating a virtual camera that matches the positional, rotational, and lens properties of the real camera used to take the image. It then covers the creation of proxy (dummy) geometry that lines up with the object in the scene, in this case a matchbox (Figure 10). The
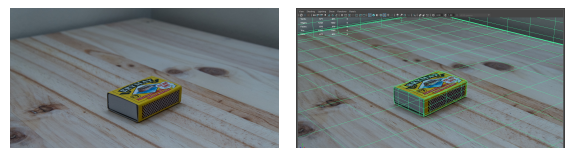

Figure 10: *A photograph of a simple object (left), with an aligned camera and basic proxy geometry (right).*

second 2.5D workshop discusses the process of UV unfolding the geometry before projecting the photograph onto it and baking out the resulting projection onto the UVs as a texture map (Figure 11).
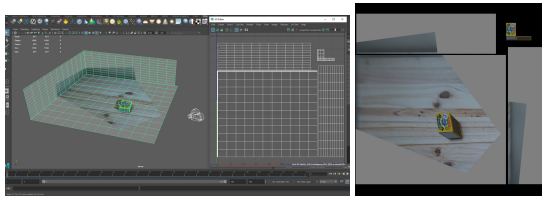

Figure 11: *The camera projection of the photograph onto the geometry (left), and the resulting baked texture map (right).*
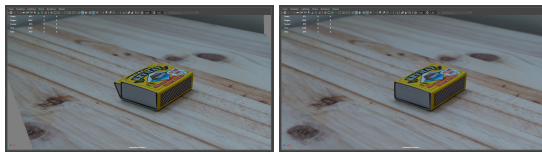

Figure 12: *Before (left) and after (right) the process of cleaning up projection shadowing.*

The final part of the 2.5D workshops covers the process of cleaning up the image projection shadowing using the basic 2D painting techniques of the initial 2D painting workshops (Figure 12), before continuing with the process of creating a simple animated camera and rendering the final shot. The final render output is achieved using a simple surface shader without the need for any lighting, as the lighting is baked into the textures from the projection image.

The compositing workshops introduces the process of background projections using simple geometric cards where needed, colour grading, and other 2D compositing tools and techniques for adding effects such as film grain, chromatic aberration, motion blur, and general noise to make the final output look more like an original video recording [Wri01].

5. Results and Discussion

The course and assessment have been delivered every year for the last 4 years, and have been received very positively by the students, with some commenting that it was their favourite assignment in the whole three years of their degree programme. Attendance at weekly workshops and feedback sessions has been very good, as has engagement with the supplemental lesson material provided via the VLM. For their assessment the students chose a variety of base images upon which to create their final project (see supplemental material for examples). Overall, the students achieved an exceptionally high level of quality and photo-realism in the final output of the project.

For example, the student who submitted the work shown in Figure 13 made excellent choices in terms of the aesthetic composition of the base image, as well as good strategic choices with regards to the acquisition of extra photographic elements that would help with the necessary modifications and manipulations of the original base image. Throughout the project she maintained a high level of attention to detail, in both the 2D image manipulation and the 3D

Figure 13: *Student submission of the "Digital Matte Painting" assignment, showing original backplate (left) and final DMP (right).*

modelling processes, as well as a high level of accuracy in technical aspects such as camera line-up and image projection.

In general, we have found that the choice of an environment shot over a still life, or vice versa, has not had any significant impact on the final grade awarded. The students are able to achieve high marks regardless of the type of shot chosen to undertake, as long as they adhere to the guidance provided.

6. Acknowledgements

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