Specialization Plan

Assignment Title: **Physically based rendering and lighting in current-gen games.**

Information

Student Name:	**Tom Veltmeijer**	Student ID:	**122675**
Variation:	**Programming**	Date:	**27/02/2015**
Curriculum co-ordinator:	**Robbert Grigg**	Credit status:	**85**
Competency (ies):	**P5. 3D Engine Programming**	Start date:	**02/02/2015**
Supervisor	**Dongbin Chen**	Variant (A, B, C):	**C**

A = 100% Research
B = 50% Research, 50% Practical
C = 20% Research, 80% Practical

Research Question

How are physically based rendering and lighting implemented in current-gen AAA games?

Assignment Description

The aim of the assignment is to create a 3D rendering engine that uses the most important physically based rendering (PBR) features to create realistic images in real-time. Aside from physically based materials, this assignment will also focus on lighting. Clustered forward rendering will be used, which supports more lights than a deferred rendering approach, while keeping the advantages of traditional forward rendering. These advantages include the support of MSAA, transparency, and flexible shaders. The latter two being especially useful for implementing physically based materials. The assignment will also cover HDR.

The first course of action will be the study and implementation of the core PBR features. This includes topics such as gamma correction, BRDFs, and (prefiltered) cubemaps for approximating reflections. Next, I will look into how HDR fits into the rendering pipeline. Techniques such as tonemapping and automatic exposure will be used to transform the high dynamic range of light values into the low dynamic range of the screen in a way that is pleasant for the eye.

Background

A recent state-of-the-art example of physically based rendering is a game called The Order: 1886 by Ready at Dawn Studios. A presentation on their critically acclaimed PBR implementation can be found here
http://blog.selfshadow.com/publications/s2013-shading-course/rad/s2013_pbs_rad_slides.pdf
Another great source of information are the SIGGRAPH courses on the subject:
http://blog.selfshadow.com/publications/s2014-shading-course/
There you can find the latest presentations on PBR, which include the practical presentations by game studios that have successfully ported their games or engines to a PBR system. An example aside from The Order: 1886 is this presentation about porting the Frostbite engine to PBR:
http://blog.selfshadow.com/publications/s2014-shading-course/frostbite/s2014_pbs_frostbite_slides.pdf

Clustered forward rendering is a less common practice than PBR, but it shows great promise. The leading expert in this field is Ola Olsson, who came up with the technique and has created multiple extensions for it. The relevant papers can be found here:
http://www.cse.chalmers.se/~olaolss/main_frame.php?contents=publication&id=efficient_shading_sa2014
That link also includes a more practical presentation by Emil Persson about implementing clustered shading in the Avalanche engine.

I have already studied the papers mentioned above, so I know how the techniques work form a theoretical standpoint.

Learning Outcomes: By the end of this assignment I will be able to:
My learning goals are to have a deep understanding about PBR, as this is the industry standard at the moment.
I also want to have a good understanding of different rendering pipelines, such as tiled/clustered forward/deferred rendering.

Final deliverables:
My final deliverables will be:
(80%): A clustered forward rendering engine with the core PBR features implemented and a sample application that uses this engine to demonstrate its features.
(20%): A document that outlines the features of the engine and the research done.

These outcome are relevant for a future work placement and graduation project, because PBR is currently the industry standard and clustered forward rendering is becoming more widespread because it offers several advantages over classic forward and deferred rendering.

Time Line

Week: Day:	Task	Milestone deliverable	Feedback/Meeting
Week 4:	The core Direct3D interaction is setup, so I can start on the actual features now.		Friday probably (every 2 weeks).
Week 5:	Keep working on engine and writing the learning journal and documentation.	Learning journal and documentation.	
Week 6:	Keep reading and working. Probably starting the material system.		Progress check.
Week 7:		Have some core principles such as gamma correction and cubemaps working.	
Exam:	Starting the forward clustered renderer.	Learning journal, documentation, comeback day preperation.	Comeback Day.
Week 1:	Keep working on the clustered rendering.	Should have a clear idea whether the clustered rendering is going to be possible at all, and if it's possible how long it should take.	
Week 2:	If clustered rendering is a viable option, keep working mostly on that because that is an important focus in my opinion.		Progress check.
Week 3:	If clustered rendering is done, work on the final things such as tonemapping/HDR.	Documentation update.	
Week 4:	Keep evaluating which tasks are good options and which tasks I should maybe drop based on time constraints.	Should have a demo and clear idea of what the final product will be.	
Week 5:	Starting on finalizing everything by fixing bugs, making everything presentable and working on the documentation.	Have almost the final product done (beta maybe?)	Progress check.
Week 6:	Final bug fixes and documentation.	Final delivery.	

Objectives Form(s)

Core problem and critical professional situation: Constructing technology to render realistic 3D environments for products like games is a challenging task especially in achieving the desired visual result and interactive performance. The 3D specialist knows the newest technologies and is able to have the graphic processor draw a virtual world quickly and with a high sense of realism. The 3D specialist is able customise to specific requirements and translate this into a good design and resulting interactive 3D product.	My Core problem and critical professional situation will be: The core problem is writing a 3D renderer that is as physically correct as can be in real-time and conforms to the industry standards of current-gen AAA rendering engines.
Professional product: 3D engine.	My professional product will be: A 3D rendering engine with a demo that shows the features.
Criteria regarding product and process (also referred to as indicators): *Criteria regarding the process* - The 3D specialist analyses the requirements stated in the game design document. - The 3D specialist implements an engine that is flexible, efficient and stable whilst using hardware optimally. - The 3D specialist keeps their knowledge up to date by playing the newest games and researching the latest techniques. *Criteria regarding the product* - The 3D engine enables the game programmer and the artist to implement their ideas with minimal constraints. - The 3D engine uses hardware optimally. - The 3D engine is easily integrated into the game engine.	To achieve the criteria I will: - Actively follow the newest developments in graphics technology. - Read papers on the subjects by game studios, compare the different implementations, and implement my own version. - Create an easy to use interface for the engine so it can be reused for future projects.

Knowledge:	
- 3D technology including graphic processors, 3D algorithms and 3D structures. - Simulations of real world phenomena as closely as possible.	To gain this knowledge I will: - Read papers and other presentations about PBR. - Compare multiple implementations of certain algorithms to find the most suitable ones.
Skills & Attitude:	
- Able to apply appropriate combinations of algorithms and data structures for given situations. - Able to work together with the platform specialist. - Analytical. - Perfectionist. - Team Player. - Meticulous and precise.	To gain these skills and attitudes I will: - Compare the quality and preformance of different algorithms. - Have other programmers test my engine for easy of use, quality, and performance.

Amendments

- In exceptional cases the plan might need adjustments along the project, these adjustments need to be described and justified here **by the Supervisor.**
- Highlight, in red, the amended text in the document and add a note asking the reader to 'refer to the amendments at the end of the document.'
- Each amendment needs to be signed off by the supervisor below.

X
_____

Amendment approved by:
Supervisor

Once the amended plan plan is returned you may continue with the project.

For staff only

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Professionalism Check		

Professional relevance: How pertinent is this plan to contemporary and 'projected' workplace demands:	Excellent	
	Good	
	Sufficient	
	Insufficient	

Professional standards: To what extent does this plan provide the opportunity for the student to generate work that is of a professional standard:	Excellent	
	Good	
	Sufficient	
	Insufficient	

Professional situation: To what extent does this plan provide the opportunity for the student to gain and implement knowledge that supports professional practise and work procedures:	Excellent	
	Good	
	Sufficient	
	Insufficient	

Professional attitude: To what extent does this plan provide the opportunity for the student to implement a professional work ethic and attitude:	Excellent	
	Good	
	Sufficient	
	Insufficient	

Professional skills: To what extent does this plan provide the opportunity for the student to gain sought after, professional knowledge and skills :	Excellent	
	Good	
	Sufficient	
	Insufficient	

Dublin Descriptors Check (PRACTICAL)

Knowledge and Understanding:
To what extent does this plan provide the opportunity for the student to generate work that is supported by advanced text books with some aspects informed by knowledge at the forefront of their field of study:

Excellent	
Good	
Sufficient	
Insufficient	

Applying Knowledge and understanding:
To what extent does this plan provide the opportunity for the student to apply knowledge and understanding in order to solve problems

Excellent	
Good	
Sufficient	
Insufficient	

Making Judgements:
To what extent does this plan provide the opportunity for the student to gather and interpret relevant data:

Excellent	
Good	
Sufficient	
Insufficient	

Communication:
To what extent does this plan provide the opportunity for the student to Communicate information, ideas, problems and solutions to both specialist and none specialist audiences:

Excellent	
Good	
Sufficient	
Insufficient	

Learning Skills:
To what extent does this plan provide the opportunity for the student to develop the skills needed to study further with a high level of autonomy:

Excellent	
Good	
Sufficient	
Insufficient	

Dublin Descriptors Check (THEORETICAL WRITING)

Knowledge and Understanding:
To what extent does this plan provide the opportunity for the student to generate work that is supported by advanced text books with some aspects informed by knowledge at the forefront of their field of study:

Excellent	
Good	
Sufficient	
Insufficient	

Applying Knowledge and understanding:
To what extent does this plan provide the opportunity for the student to apply knowledge and understanding though devising and sustaining arguments:

Excellent	
Good	
Sufficient	
Insufficient	

Making Judgements:
To what extent does this plan provide the opportunity for the student to gather and interpret relevant data to form judgements and reflections on their field of study:

Excellent	
Good	
Sufficient	
Insufficient	

Communication:
To what extent does this plan provide the opportunity for the student to Communicate information, ideas, problems and solutions to both specialist and none specialist audiences:

Excellent	
Good	
Sufficient	
Insufficient	

Learning Skills:
To what extent does this plan provide the opportunity for the student to develop the skills needed to study further with a high level of autonomy:

Excellent	
Good	
Sufficient	
Insufficient	

Standard of Communication: (Standard of writing) To what level was the plan written clearly? Was the level of English used acceptable? Was the writing style intelligible?	Excellent	
	Good	
	Sufficient	
	Insufficient	

Description of aims and outcomes: To what level does the plan delineate and elucidate the aims of the assignment? Are the outcomes clearly and specifically defined?	Excellent	
	Good	
	Sufficient	
	Insufficient	

Time line and milestone: To what extent does this plan deliver a comprehensive breakdown of tasks and deadlines?	Excellent	
	Good	
	Sufficient	
	Insufficient	

Objectives (objective form): To what standard are the objectives written? Are they specific (with careful use of adjectives; without vagaries and platitudes)? Are they measurable (with concrete criteria)? Are they achievable (realistic, attainable)? Are they relevant to the competency? Are they timed, with a due date?	Excellent	
	Good	
	Sufficient	
	Insufficient	

Competency: To what extent does the assignment allow the student to address the chosen competency?	Excellent	
	Good	
	Sufficient	
	Insufficient	

Right click the signature line then select sign. You can either type your name or add an image of your signature.

X _____
Plan Validated by:
Supervisor

X _____
Plan approved by:
Variation Co-ordinator

I, the Variation Co-ordinator, hereby authorise the above named student to execute this plan. In doing so I recognise that the student has a sufficient credit status and that the plan complies to the appropriate educational standards, allowing for the fulfilment of the 'Dublin Descriptors' as well as enabling the student to function at Level 3 (…able to apply knowledge and skills for the competency on a level that is required within the game industry as a starting professional, with the ability to advance quickly).
Once the form is complete please return to the Student… The signed form needs to be submitted by the student as a deliverable.