Mittuniversitetet
MID SWEDEN UNIVERSITY

Campus Härnösand Universitetsbacken 1, SE-871 88. **Campus Sundsvall** Holmgatan 10, SE-851 70 Sundsvall.
Campus Östersund Kunskapens väg 8, SE-831 25 Östersund.
Phone: +46 (0)771 97 50 00, Fax: +46 (0)771 97 50 01.

Title

Adam Temmel

MID SWEDEN UNIVERSITY
Department of Information Systems and Technology (IST)

Main field of study: Computer Engineering
Credits:
Semester, year: XX, YYYY
Supervisor: First name Surname
Examiner: First name Surname
Degree Programme: (optional)

Abstract

The abstract acts as a description of the reports contents. This allows for the possibility to have a quick review of the report and provides an overview of the whole report, i.e. contains everything from the objectives and methods to the results and conclusions. Examples: "The objective of this study has been to answer the question.... The study has been conducted with the aid of.... The study has shown that..." Do not mention anything that is not covered in the report. An abstract is written as one piece and the recommended length is 200-250 words. References to the report's text, sources or appendices are not allowed; the abstract should "stand on its own". Only use plain text, with no characters in italic or boldface, and no mathematical formulas. The abstract can be completed by the inclusion of keywords; this can ease the search for the report in the library databases.

Keywords: Human-computer-interaction, XML, Linux, Java.

Acknowledgements

Acknowledgements or Foreword (choose one of the heading alternatives) are not mandatory but can be applied if you as the writer wish to provide general information about your exam work or project work, educational program, institution, business, tutors and personal comments, i.e. thanks to any persons that may have helped you. Acknowledgements are to be placed on a separate page.

Table of Contents

Abbreviations

ACK	Acknowledge
AWGN	Additive White Gaussian Noise

1 Introduction

Representing digital information has always been an interesting problem for science to solve, all the way back since the infancy of computing. Today, we have a diverse set of methods for representing computed data, ranging from simple terminals displaying lines of commands to complex rendering systems able to display realistic 3D-graphics. As rendering today has grown into becoming a moderately advanced topic, there exists quite a lot of wisdom to be found in this field.

1.1 Background and problem motivation

Given this, it would be of interest to make a deep dive into this particular field, in order to both get an understanding regarding the different subtopics covered within the actual topic as well as to apply this understanding in a practical manner. One way to accomplish this feat would be to look into a course for this topic.

1.2 Overall aim

The overall aim of this project is to by digesting material provided in a course (as well as other potential sources of knowledge) gain an increased understanding of computer graphics in some of its different forms.

1.3 Concrete and verifiable goals

The goals present for this project are as follows:

- The author should be able to present a basic understanding of OpenGL
- The author should be able to present a basic understanding of GLSL
- The author should be able to apply knowledge gained during the project regarding linear algebra within the field of computer graphics.
- The author should be able to apply some concepts attained from physics within the field of computer graphics.
- The author should have a basic understanding of the pipeline between graphics processing unit and the screen.

1.4 Outline

Skriv det här

2 Theory

This chapter will present theory related to the project.

2.1 Graphics Processing Unit (GPU)

The GPU works as a complementary workhorse to the CPU. Whereas the CPU remains flexible in terms of what it is able to compute, the GPU is straight up a stronger version of a CPU when regarding raw computing power. The majority of GPUs enjoy working with triangles, partially due to it being a mathematically pleasant shape to work with, as well as it being a very flexible shape geometrically - most other shapes can be approximated by using the correct amount of triangles.[1]

2.2 OpenGL

The Open Graphics Library has been the most widely adopted graphics API within the industry for quite some time now, regardless of given the context of a 3D or 2D environment. The first version was released in 1992, with the latest version being released in 2017.[2]

2.2.1 OpenGL Shading Language (GLSL)

The GLSL programming language is the language used to interact with and manipulate the graphics pipeline. The main benefit gained from using a specific language for this task is that developers no longer need to write hardware-specific or OS-specific code in order to program the GPU.[3]

2.3 Linear Algebra

Linear Algebra is the subset of mathematics which, amongst other things, discusses the presentation of different kinds of geometry and its transformations, including how geometry can be mapped from one location to another. Two central concepts to the field of linear algebra include the vector: an N -dimensional scalar, as well as the matrix: an $N \cdot M$ -dimensional scalar.

2.3.1 Dot product

The dot product is an operation between two vectors (a and b) of equal dimension which produces a scalar. A more formal definition would look something like:

$$a \cdot b = \sum_{i=1}^{n} a_i b_i = a_1 b_1 + a_2 b_2 + ...a_n b_n$$

Figure 1: The definition of the dot product.

2.3.2 Cross product

The cross product is an operation between two vectors (a and b) of equal dimension which produces a third vector which is orthogonal to both prior vectors. A more formal definition would look something like:

$$a \times b = ||a||\,||b||\,sin(\theta)n$$

Figure 2: The definition of the cross product.

In *figure 2* θ represents the angle between a and b and n represents the unit vector of the plane which contains a and b in the direction which is given by the right hand rule. A more practical definition can be given if the dimension of the vectors is given, such as:[4]

$$u = (u_x, u_y, u_z), v = (v_x, v_y, v_z)$$
$$u \times v = ((u_y v_z - u_z v_y), (u_x v_z - u_z v_x), (u_x v_y - u_y v_x))$$

Figure 3: The second, sometimes more practical definition of the cross product.

2.3.3 Matrix Multiplication

$$A_{m,n} = \begin{pmatrix} a_{1,1} & a_{1,2} & \cdots & a_{1,n} \\ a_{2,1} & a_{2,2} & \cdots & a_{2,n} \\ \vdots & \vdots & \ddots & \vdots \\ a_{m,1} & a_{m,2} & \cdots & a_{m,n} \end{pmatrix}$$

3 Methodology / Model

With regards to C- and D-level diploma work, it is insufficient to merely perform a practical construction or programming project. A systematic study must also be carried out, e.g. an evaluation and analysis of the design or program. The study should result in objective facts, preferably in the form of tables and diagrams, into which your own conclusions are built in. The study can be a verification of a design that meets the requirement specification, or a comparison of competing alternatives. It is acceptable to allow users to answer a questionnaire or be interviewed. It is also possible to evaluate web-pages and other user interfaces according to usability criteria.

The method section is the point at which your chosen method and intended procedure during the research are discussed. This section shall not be a chronological diary filled with irrelevant details, but should contain information given in such a way that it is understandable for the reader and enables him/her to interpret your results and repeat your work, i.e. in order to check the results. Here, the tools, assumptions, mathematical models, performance measures and assessment criteria are presented. It is also at this point that the means adopted for the evaluation and verification of the computer programs and technical solution proposals are presented. This can include a test plan to check that the structure works and criteria to assess its usefulness. In research reports regarding natural science and technology this chapter is often called “Model”, “System Model” or “Simulation Model”.

Justify your choice of methodology/model. This choice is very important, because it could be the actual key to the result of your research. Comment on the method’s possible weaknesses and problems that may arise during actual implementation. Refer to the problem wording in the introduction chapter. It is possible, for example, to write “problem P1 is attempted through the method M1 and problem P2 through...”

In your report, you should - depending on what the report is about- find information about what you have investigated and how you have gathered and processed data. Possible questionnaires, interview questions and the likes can be presented as appendices. Detailed descriptions concerning experimental formats of possible interest to those wanting to repeat the experiment should also be included in this chapter.

4 Design / Implementation

The Design or Implementation chapter often appears in technical reports, but not always in scientific reports. Here, the analysis of the problem is implemented and a technical requirement specification is formulated. At this stage, the most important principles in the suggested alternatives for solution are described and formulated in preparation for evaluation at a later point in the report. The description is sometimes placed before, but generally after the methodology/model chapter, if included at all.

The reader is seldom interested in extremely detailed documentation of computer program code, algorithms, electrical circuit diagrams, user guidance, etc. Such details are placed in the appendices.

As mentioned in the Introduction chapter you have during earlier studies mainly worked with small well defined tasks that have taken minutes or as most hours to solve. In comparison an exam work or a project course can sometimes appear to be an almost overwhelming amount of information because it is so extensive, and this may cause anxiety with regards to where to start. One way to facilitate big projects is to use the top-down-method, i.e. to divide the problem or the structure into smaller problem parts or system parts, and to state specification of requirements, problem analysis and proposed solution for each part. Eventually small and concrete information will have been identified with similar characteristics to those found in your previous studies.

It is not always practically possible to apply the top-down-method, since the problem may be too complex and initially very difficult to visualise the complete overview. It might prove necessary to alternate between the top-down - and bottom-up-method. The latter means that you start with parts already known to you and from simple problems that have been tackled previously you make use of that knowledge for aspects that you expect to resolve at a later stage in the project. Gradually increase these parts into the bigger systems and problems and then pursue the direction of project's objective.

The top-down-method has the advantage of giving the report a solid structure, which makes it easier for the reader. The documentation therefore often follows the top-down-method. It is thus possible to divide the structure part into several chapters, and to name them after each problem part and system part, i.e. "Specification of requirements", "Algorithms", "User interface", "Program documentation", "Prototype" and "Implementation".

5 Results

The results chapter is included when you have produced a systematic study, i.e. an evaluation of a program that you have developed, which is required for C - and D-level diploma work. In the results chapter objective results of the empirical study are presented. Keep in mind that possible comments in this chapter should only be used for clarification. Your own views and subjective (personal) comments belong in the chapter conclusion/discussion.

Strive to present the results, for example measurement-, calculations- and/or the simulation result, in a form that is as lucid and easily understandable as possible. The results are preferably presented in diagrams or tables. Accounts of interviews can be summarised, but may include concrete examples supporting your work.

Extensive results, for example complete summaries of survey results, large tables and long mathematical deductions, are placed in the appendices.

6 Conclusions / Discussion

The conclusion/discussion (choose a heading) is a separate chapter in which the results are analysed and critically assessed. At this point your own conclusions, your subjective view, and explanations of the results are presented.

If this chapter is extensive it can be divided up into more chapters or subchapters i.e. one analysis or discussion chapter with explanations of and critical assessment of the results, a concluding chapter where the most important results and well supported conclusions are discussed and to sum it up a chapter with suggestions for further research in the same area. In this chapter it is of vital importance that a connection back to the aim of the survey is made and thus the purpose is pointed out in a summary and analysis of the results.

In this chapter you should also include answers to the following questions: What is the project's news value and its most vital contribution to the research or technology development? Have the project's goals been achieved? Has the task been accomplished? What is the answer to the opening problem formula? Was the result as expected? Are the conclusions general, or do they only apply during certain conditions? Discuss the importance of the choice of method and model for the results. Have new questions arisen due to the result?

The last question invites the possibility to offer proposals to others relevant research, i.e. proposal points for measures and recommendations, points for continued research or development for those wishing to build upon your work. In technical reports on behalf of companies, the recommended solution to a problem is presented at this stage and it is possible to offer a consequence analysis of the solution from both a technical and layman perspective, for example regarding environment, economy and changed work procedures. The chapter then contains recommended measures and proposals for further development or research, and thus to function as a basis for decision-making for the employer or client.

6.1 Ethical and Societal Discussion

You will need to include a discussion on ethics, societal impact, and considerations.

6.2 Future Work

You should also explain potential future work based on your work.

References

[1] David Luebke and Greg Humphreys. In: *How Things Work* (2007), pp. 126, 130.

[2] The Khronos Group. *OpenGL Overview*. URL: `https://www.khronos.org/api/opengl` (visited on 01/15/2022).

[3] John Kessenich, Dave Baldwin, and Randi Rost. *The OpenGL Shading Language, Version 4.60.7*. 2019.

[4] Wolfram MathWorld. *Cross Product*. URL: `https://mathworld.wolfram.com/CrossProduct.html` (visited on 01/15/2022).

A Source Code

```c
#include <stdio.h>

int main() {
    printf("Hello, World!\n");
}
```