COM3503: 3D Computer Graphics: Assignment (*40%*)

Dr. Steve Maddock

Deadline: 3pm, Wednesday 6 December

1. Introduction

The assignment will involve using modern OpenGL to render a scene. The scene includes a hierarchical model which is represented as a scene graph. Also, the hierarchical model can animate.

Start by *designing* your program. This should only take a few hours since you may re-use any program code from the exercise sheets used in lab classes and you will already have worked through most of this code in order to understand it. Then implement the program. Don't try to implement the entire program in one sitting. Do it in stages. And keep the interface simple.

2. The task

Figure 1 shows a model of a robot hand. Imagine this robot hand is being installed as an exhibition piece in an art gallery. It is mounted on a plinth that looks like an arm (see Figure 2), which is attached to the floor of a room in the art gallery. The arm can rotate about the vertical y axis and the fingers can spell out the letters of American Sign Language, as illustrated in Figure 3. The robot hand should be big so that it dominates the room it is in. Your task is to create this scenario.

You must satisfy all the following requirements:

- Produce a hierarchical 3D model of the robot hand and arm. The robot hand is made up of a palm, four fingers and a thumb. (In Figures 1 and 2, the thumb is a darker colour purely for illustration purposes in order to distinguish it from the fingers.) Simple objects are used for the pieces in the models in Figures 1 and 2, i.e. spheres and cuboids. Alternative pieces could be used, e.g. scaled cylinders. You can choose any of these simple pieces. You could also choose just to use cubes for all the hand pieces (as in Figure 2). But you must choose simple pieces.

- The hierarchy and associated transformations are more important than the quality of the pieces in the hierarchy. I want you to demonstrate that you understand transformations and a scene graph hierarchy. It is a robot hand so it doesn't matter if the pieces only just touch each other (as in Figure 1) or are slightly separated from each other (as in Figure 2). If you don't like the look, consider adding small spheres or cubes to overlap the joins between pieces.

- The pieces of the robot hand should be texture mapped. For example, you might decide that the robot hand is made of metal which is rusting, for which you could use diffuse and specular maps. Or you might decide to make the pieces of the hand look like they are made of wood or hair or brick or whatever, perhaps with shiny fingernails. However, there should be some diffuse and shiny parts so that
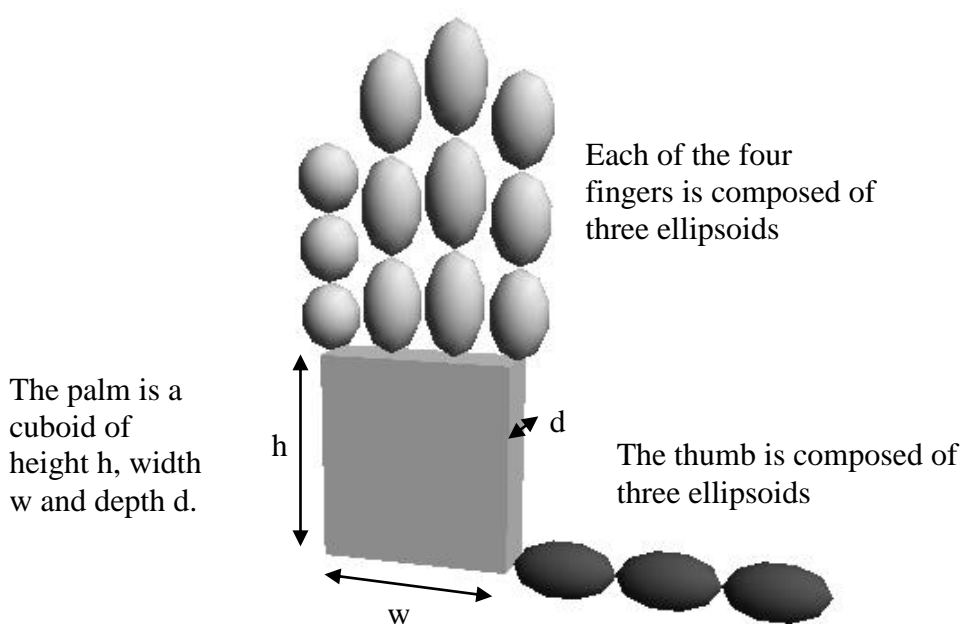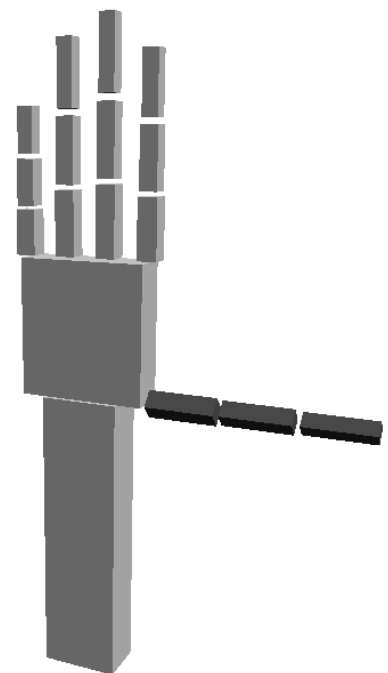

The palm is a cuboid of height h, width w and depth d.

Each of the four fingers is composed of three ellipsoids

The thumb is composed of three ellipsoids

Figure 1: A hand

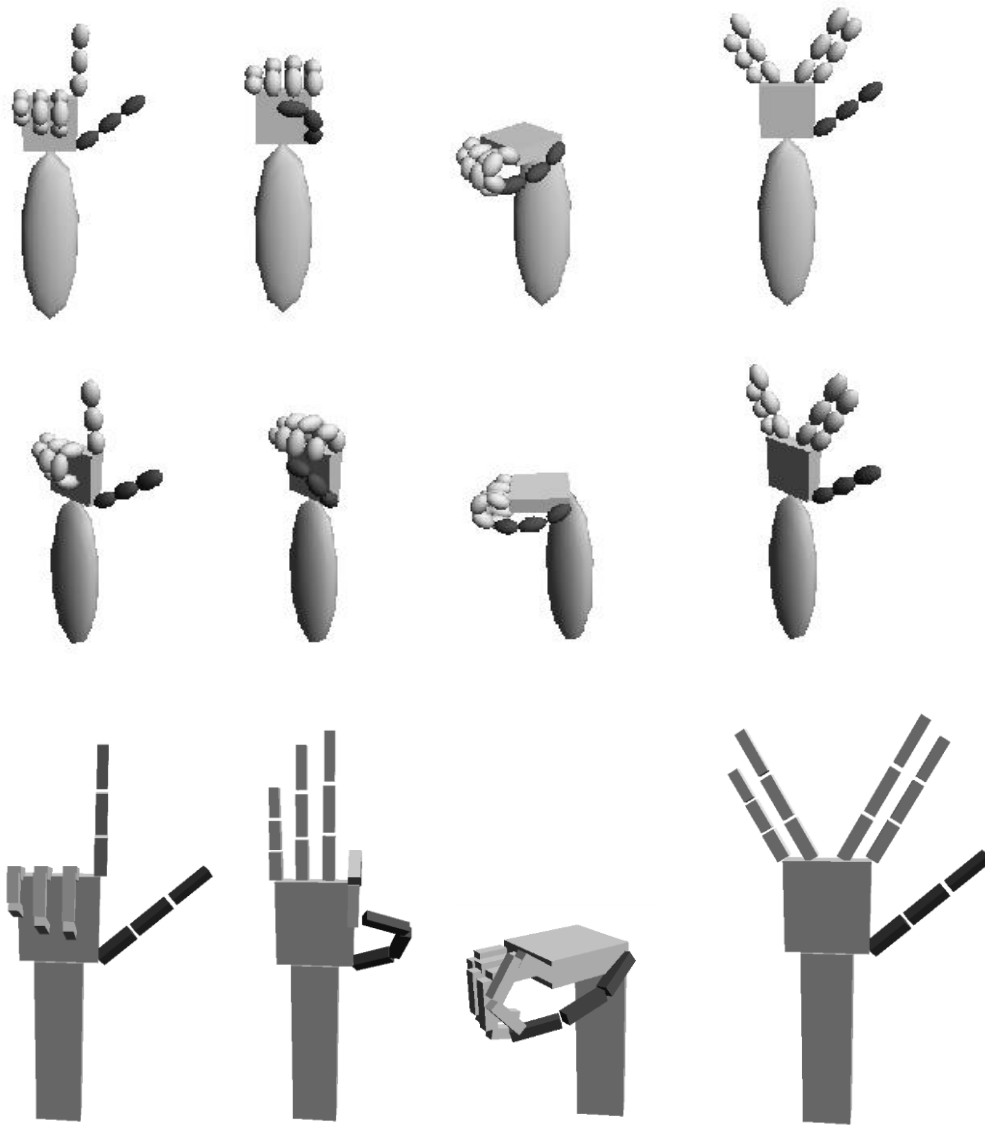**Figure 2:** A robot hand on an arm piece

Figure 3: Left-to-right: American Sign Language gestures for 'L', 'E' and 'X', followed by a Vulcan gesture

both diffuse and specular maps can be used. This will test your texture-mapping skills. I'm looking for some creativity in using texture-mapping on the parts of the hand. The sphere will be more difficult to texture map because the texture map will distort. The cube is easier. It is perfectly acceptable for you to use cubes for the individual pieces of the robot hand if you prefer. You choose.

- Animate the hand so that it finger-spells three different letters from your name in American Sign Language followed by a gesture of your own choice, such as the exaggerated Vulcan salute in Figure 3. The three letters from your name must be in order of appearance in your name. For example, I might finger-spell S, T, E from my first name, or M, A, D, or D, O, C, or M, C, K from my surname, but I can't use the sequence A,D,D, as this would not be 3 different

letters, nor D, A, M, as these letters do not appear in this order in my surname. (In British Sign Language, each letter of the alphabet requires two hands to make the required gesture, whereas in American Sign Language each letter of the alphabet can be represented by a gesture made by one hand – see https://en.wikipedia.org/wiki/American_Sign_Language or https://en.wikipedia.org/wiki/Fingerspelling.)

- The arm can only rotate about the vertical axis, so it should not bend down towards the floor.
- The hand should not jump from one pose to another. It should animate (interpolate) smoothly between poses. Two issues that need to be addressed in any animation are how to control the timing of the movement and how to avoid collisions. For this assignment, you do not need to solve the issue of fingers colliding with each other, as this is a difficult

problem, and is beyond the requirements. However, think carefully about timing and how to make the animation process flexible and reusable. Euler angle interpolation is sufficient for this assignment. Do not consider using quaternions, as this is beyond the requirements for this assignment.

- Use simple interface controls for the animation, e.g. interface buttons to stop, start and reset the complete animation of your four-gesture sequence. A reset button should reposition the hand in a neutral pose of your choosing. You should also include interface buttons to show the static hand position for each single letter or gesture in your sequence of four. This will be helpful for testing purposes, as well as when I am marking.

- Position the robot hand model inside a model of a room, as illustrated in Figure 4, such that the arm is attached to the floor of the room.

- The walls, floor and ceiling of the room should be texture mapped to look like an art gallery. For example, the floor could be made of wood. The ceiling may be plain. The walls may have pictures on them. Given that the room contains the animated robot hand, perhaps the pictures on the wall would be related to the robot hand in some way, e.g. photographs of hands.

- There should be a large window in one of the walls through which the scene outside the room can be seen – this might be a garden scene or a city scene Consider how you might do the scene outside. Should it be a texture map pasted onto the window, or should it be a texture map pasted onto another surface that is a certain distance outside the window? You need to use the right OpenGL settings to make sure the textures display well. For extra marks, consider switching between different window textures at certain points in time to model a change outside the room, e.g. daytime versus night-time or adding a moving texture to the window. (Note: You will have to work out how to model the wall with a hole in it for the window, and decide how big the hole for the window should be.)

- Add a ring to one of the fingers, with a spotlight positioned on the ring to illuminate the room as the finger moves (as illustrated in Figure 5). The spotlight could be disguised as a small light-emitting object attached to the ring, like a small gemstone on the ring. (Hint: The spotlight should look like a spotlight, as well as behave like a spotlight. So, consider emission properties for the object that is modelling the spotlight.) The ring could be modelled as a sphere for the gemstone and a cylinder or flattened sphere for the band of the ring. The finger would pass through the solid cylinder or sphere to give the
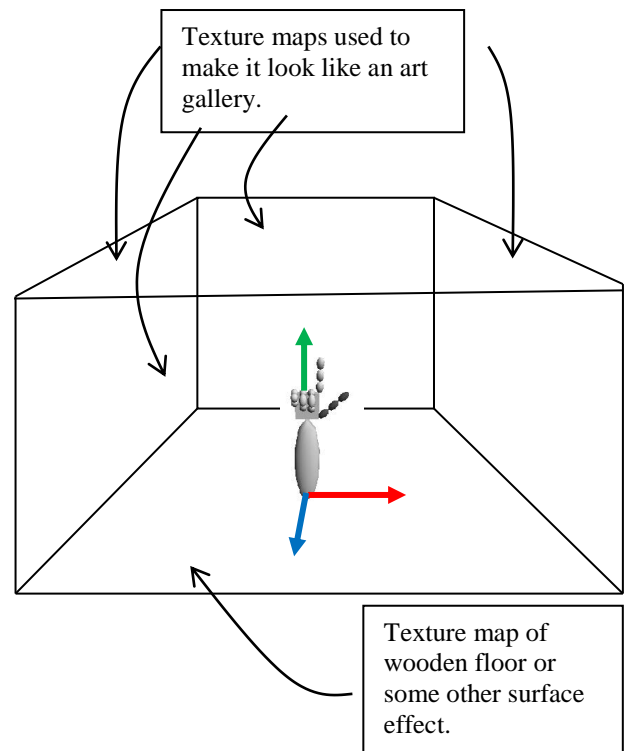

Figure 4: The robot hand in the centre of the room – the world coordinate axes are shown to illustrate the positioning of pieces of the full scene. These do not need to be visible in your scene.
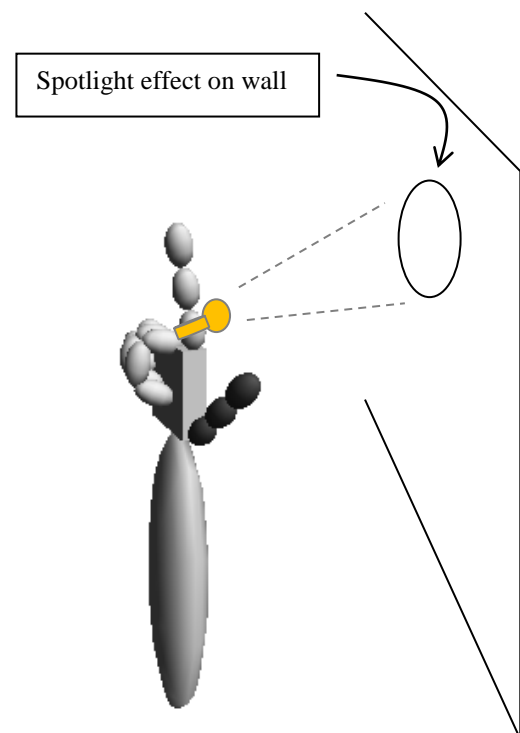

Figure 5: The ring on first finger acts as a spotlight lighting up an area of the wall. Note: The grey dotted lines are drawn to illustrate the spotlight effect and would not appear in practice.

effect that the cylinder or sphere wraps around the finger. Also, consider different lighting colours for the spotlight.

- The room should be illuminated with one or more general world lights which can be positioned at any point in the world (e.g. outside the room), which it should be possible to turn on and off (or dim, i.e. reduce the intensity) from the interface. This general world light (or lights) will illuminate all parts of the scene and help visualise the scene during development and testing. When you switch off the general light(s), the effects of the spotlight on the ring will be much clearer in the room.

- There should be one or two lamps within the room modelled to look like lamps – again simple geometric objects can be used for this, e.g. cubes, cylinders and spheres. The lamp or lamps could be free standing or attached to the wall or ceiling. The interface should have an on/off switch for these.

- A user-controlled camera should be positioned in the room. Use the camera that was given in one of the exercise sheets – the mouse can be used to change the direction the camera is pointing in and the keys can be used to move about. Do not change the key mappings from the one on the exercise sheet. If you change the key mappings it will make it difficult for me to mark.

- You do NOT have to do shadows. Do not worry about shadow effects.

3. Deliverables

- You should submit a zip file containing a copy of your program code (and any other necessary resources, e.g. image files for the textures and a readme.txt file that describes everything) via MOLE – this can be done via the link to the assignment handout. You should submit whatever you have done, even if you have not completed all the requirements – for example, you might have produced a model but not done the animation. If you submit nothing, you cannot receive any marks. *The program MUST compile and run from the command line* on a standard Windows PC (such as the ones in the Diamond). You should assume that the jogl environment (and paths) has already been set up, so you do not have to include this as part of what you hand in. I won't install 'YetAnotherIDE' to make your program work; I want to run the program (and, if necessary, check the compilation) from the command line.

- You must include appropriate comments in your program to identify that you wrote the code, e.g. /* I declare that this code is my own work */

/* Author <insert your name here> <insert your email address here> */

- You can make use of all the code that I have given you on exercise sheets. However, state that you have used it as part of your comments, and identify which bits you used.

- The body of the MOLE submission message should state that the work you have handed in is your own. It should also state which of the advanced options outlined in the deliverables above that you have undertaken.

- The name of the main class in your program should be **Arty**. That way it is easy for me to run the program. (Last year, I wasted time for some handins trying to work out which was the main class to run.) It would be useful to include an Arty.bat file to automatically compile and/or run the program.

- *Optional*: You might like to make a short video of your animation. (using some screen recording or screencasting software: https://en.wikipedia.org/wi ki /Comparison_of_screencasting_software. It is possible to do this from within PowerPoint – select Insert, Screen Recording and then select the area of the screen to record). If you do so, **DO NOT** include this in the handin as it will be too big for MOLE to handle – we tried using MOLE for this in the past and it crashed the system!! Instead, put the animation on youtube or your personal website and give the URL of the animation in a readme.txt file. Indeed, if you are thinking of a career in the graphics industry, then you should be adding such animation pieces to your personal website (your digital portfolio) to show off what you are capable of.

4. Marking

I will check that the program meets the requirements listed above. To make sure you get some marks, the program **must** compile and do some part of the work requested even if it is not complete, e.g. you might produce a model but not be able to animate it. Your program code will be run and exercised thoroughly.

Marks will be available for:

- The quality of the programming (20%)
- Satisfying the requirements (80%)

In assessing the quality of your program code, four aspects will be considered:

- (5 marks) General style: layout; neat, organised code; comments; use of constants and variables; methods not over long;

- (5 marks) Program and data structures for the models: use of separate methods and classes, e.g. a separate class for the room;

- (5 marks) Neat and tidy coding for dealing with transformations in the scene;
- (5 marks) Animation control: how tidy and flexible is the coding?

In considering the requirements, five aspects will be considered:

- (25 marks) Modelling the robot hand and other parts of the scene: the hand must be a hierarchical model. (Consider drawing a scene graph for the hand model and another for the full scene before starting to program.)
- (20 marks) Texturing: robot hand, room and window. The *quality* of the texturing will be considered, e.g. seams between textures and any extra texturing effects such as the changing window texture.
- (17 marks) Lighting and interface controls: lights should behave correctly such that their effect is seen on the scene. Also, make sure you include a general light(s). Necessary interface controls, as described in the above specification, should also be included.
- (18 marks) Robot hand animation. Is the animation smooth? Does it look plausible? The *quality* of the animation will be considered.

5. Unfair means

The standard Department rules for use of unfair means will be applied:

http://www.dcs.shef.ac.uk/intranet/teaching/public/assessment/plagiarism.html

6. Some tips on developing your solution in stages

It is possible for you to start work on the assignment immediately. You could build the room and texture it. You could place the arm in the centre of the room and animate it rotating. After we have looked at scene graphs on a future exercise sheet, you will be able to build the robot hand and add that to the scene. A sphere object will be included in the same exercise sheet. You must choose if you will use cubes or spheres or a mixture for the pieces of the robot hand.

You are responsible for working out how to implement a spotlight effect from the ring on the finger – read the online tutorials. You are also responsible for creating the animation. Think about how to make it flexible so it is easy to set up new hand gestures.

This is only one possible development scenario. You must find the right process for you.