



**UTM**  
UNIVERSITI TEKNOLOGI MALAYSIA

# **Final Project**

## **3D Hierarchical Modelling**

**Fundamental of Computer Graphics – SCSV 221**

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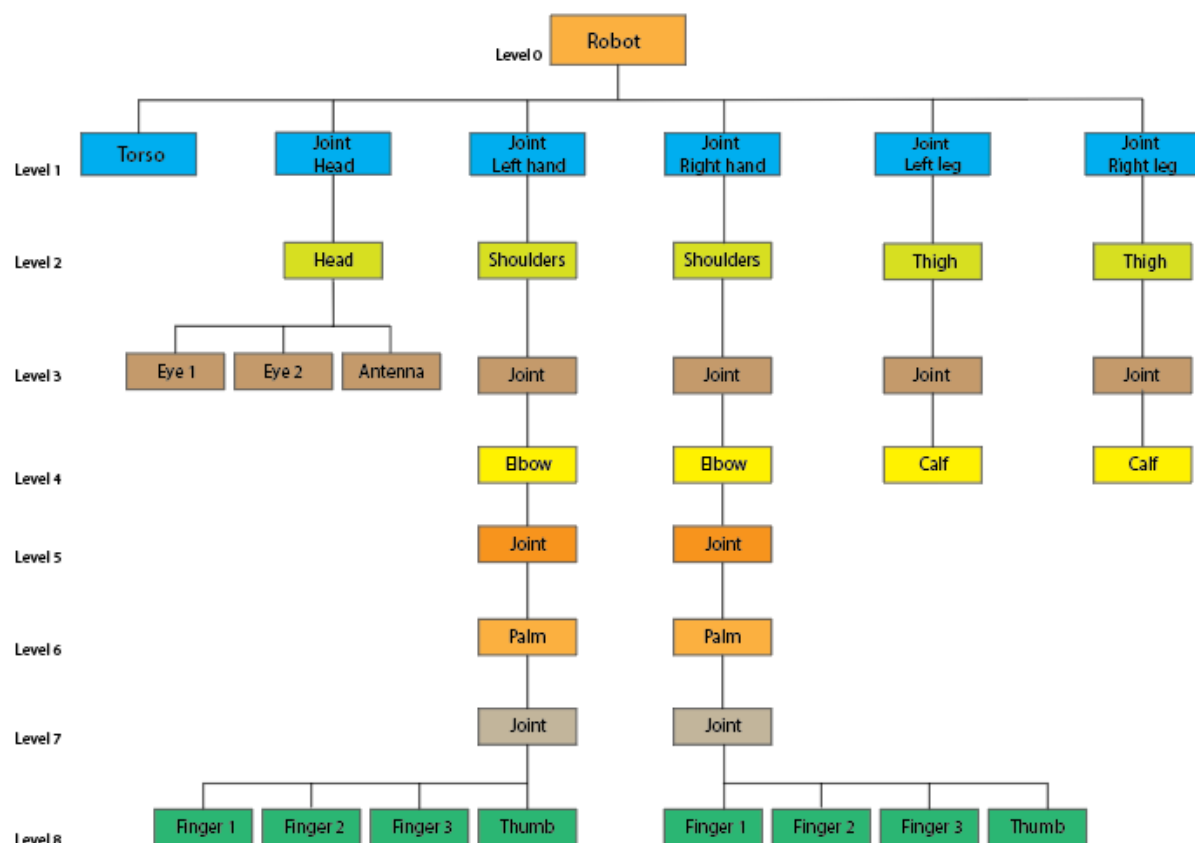
## **1. INTRODUCTION**

This final task is given by our Fundamental of Computer Graphics lecturer, Dr. Norhaida bt Mohd Suaib, as the final project for us. In this report, we will discuss on making a complex 3d object by using hierarchical modelling.

The objectives of this assignment are student manage to implement a 3D hierarchical model and 3D transformations such as translating, scaling, and rotating object. Student also are managed to include proper 3D computer graphics elements such as modify the position of camera model, modifying the projection, lighting and shading on the objects using OpenGL functions. Student also manage to prepare suitable documentation and report for the task.

For the final project, I create a 3d robot that consists of 6 main parts that is head, torso, left hand, right hand, left leg, and right leg. The robot can move its both hands upward and downward. The robot also can lift its legs and move its head upward and downward.

## 2. 3D Hierarchical Model (Robot)



*Hierarchical Model Diagram for 3D Robot*

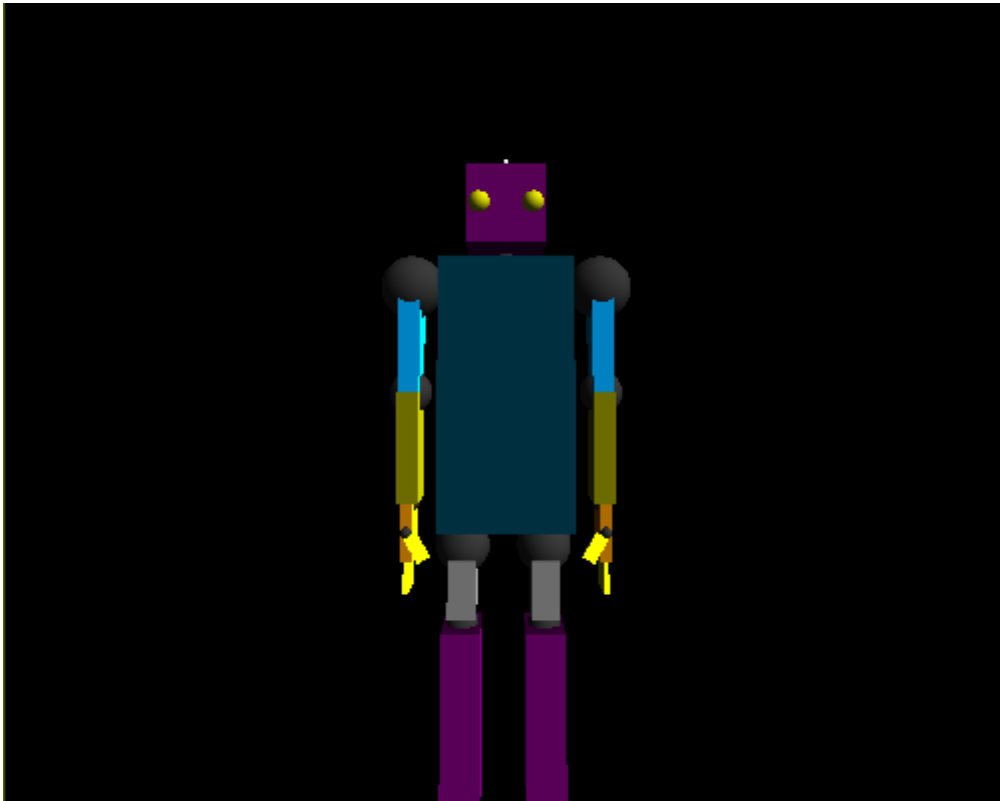
At level 1 there are six parts created to form a robot that are Torso, Head, Left hand, Right hand, Left leg, and Right leg. For this model, there are eight level of hierarchical model to create a robot.

For torso, I create a simple solid cube to make it the body of a robot. For head, it consists of a solid cube that represents the head, three solid sphere that represents the joint of head, a pair of eyes, and a solid cone that represent the antenna of robot.

For both hands, I create three solid spheres with different size that represent the joints of the hands. Then, I create seven solid cube that represent its shoulder, elbow, palm, fingers, and thumb.

For the legs, I create two solid spheres that represent its joints. Then, I create two solid cubes to make its thigh and calf.

### 3. STRUCTURE OF CODING



*The output of the program*

To make this program, I divided the program into six parts of method that represents the part of the robot that is torso, head, left hand, right hand, left leg, and right leg as in the level 1 of hierarchical model.

For torso, I created the body using simple cube primitive that is `glSolidCube()`. As for the head, I created a cube primitive using `glSolidCube()` and three solid spheres using `glSolidSphere()` that represent its pair of eyes and joint of the head. Then, I create an antenna if the robot using `glSolidCone()`.

For both hands, I created seven solid spheres using `glSolidSphere()` that represents the joint of shoulder, elbow, palm, and fingers of a hand. Then, I create the shoulders, elbow, palm and fingers using simple cube `glSolidCube()` function.

For both legs, I created two solid spheres using `glSolidSphere()` that represent as the joint of the thigh and calf of a leg. Then I create the thigh and calf using `glSolidCube()` with different sizes.

After, making the parts of the body, I combine the part in the display method using `glPushMatrix()` and `glPopMatrix()`. `glPushMatrix()` is a function where we can stack functions into the matrix while `glPopMatrix()` is a function where we can remove the top stack from the matrix.

To centre the view of the camera when displaying the robot, I modify the camera position using `glLookAt()`. I also make a coding where the camera can zoom in or out using `glLookAt()`. To make the user can see 360 degree of the robot, I make a coding where the robot can rotate object so the user can the robot from all views using `glRotatef()`.

The robot can move its hands, legs, and head. For the hands, user can rotate the hand clockwise or counterclockwise. User also can lift the hands upward and downward. User also can lift separate parts of the hand such as moving the palm or lifting the elbow.

For the legs, use can lift the legs upward and downward. User also can lift separate parts of the leg such as moving the calves back and forth.

For the head, user can use lift the head upward and downward. User also can turn the head left or right according to what key user pressed.

For shading and lighting of the robot, I put the lighting position above and in front of the position of robot. For shading, I choose 'Smooth' shade model mode to make more smooth shading to the robot. I also enable `gl_Color` mode to enable the colour of the robot displayed at the output.

## 4. CONCLUSION

There are several things that I learnt during finishing this project. I learnt how to make a complex model by using simple primitives more effectively. I also learnt how to make hierarchical model for a 3D object by using `glPushMatrix()` and `glPopMatrix()`.

I also learn how to use shading and lighting on objects more effectively. I have just discovered that when we enable lighting in our program, the `glColor` function that we already implemented on an object will automatically disabled as it will only display black and white on our object. So, to enable `glColor`, we need to enable the colour mode by using `gl_Enable(GL_COLOR_MATERIAL)` function.

I also learnt how to use 3D transformations more effectively. As for example, I learn how to a 3D object in different directions such is x-axis, y-axis, and z-axis. Then I also learn the difference of rotating an object in its position and rotating an object that been translated to original coordinate before rotating the object.

I also learn how to manage our coding more effectively. During making the coding of this project, I just put every function and primitives inside the display method. When making progress on the coding, I found out that the coding become hard to understand as it has no division on the content of the coding. So, I divided the content into six parts that is the parts of the robot to make other users more understand when examining the code.

## **5. INSTRUCTIONS ON USING THE ROBOT**

Instructions for moving the robot:

### **HEAD**

q = Head up

Q = Head down

a = Head tilt left

A = Head tilt right

### **LEFT HAND**

u = Rotate left hand anti-clockwise

U = Rotate left hand clockwise

y = Palm move inwards

Y = Palm move outwards

t = Elbow move inwards

T = Elbow move outwards

r = Hand move up

R = Hand move down

### **RIGHT HAND**

j = Rotate right hand clockwise

J = Rotate right hand anti - clockwise

h = Palm move inwards

H = Palm move outwards

g = Elbow move inwards

G = Elbow move outwards

f = Hand move up

F = Hand move down

**LEFT LEG**

v = Lift leg

V = Put down leg

c = Fold leg

C = Unfold leg

**RIGHT LEG**

b = Lift leg

B = Put down leg

n = Fold leg

N = Unfold leg

**Zoom camera**

+ = Zoom in

- = Zoom out