

CS174A Assignment 1 - Part 2

Programing Section

Out: Mon 9 Oct 2017 11pm

Due: Fri 20 Oct 2017 11:55pm

Value: 10% of final grade

Total Points: 70

Collaboration: None permitted. If you discuss this assignment with others you should submit their names along with the assignment material. Using code from previous offerings of the course constitutes plagiarism and is prohibited.

Submission: Follow the instructions carefully to avoid point reductions.

Submit on CCLE a zipped file (UID.zip — e.g: 398342394.zip) that includes the template files and if applicable a README file explaining which parts you only partially fulfilled, or any unusual instructions needed for the grader to successfully inspect your project.

Setup Information: Download the files provided on CCLE and double-click index.html to open it in your web browser. Since this example does not load any outside files (pictures or 3D models), running it locally will work for now.

Assignment:

Write a program using our JavaScript template (provided on the course CCLE page) that **draws the butterfly scene we describe below. Screenshots showing the whole butterfly or showing how the hinges should hook up to each other are included.**

For drawing objects, use the template's `draw()` function on a box (cube) and a ball (sphere) by replicating lines of code in the provided `Butterfly_Scene` class, with appropriate variations. Remember that `draw()` takes the current transformation matrix as an argument in order to place the shape where it belongs. Build your current (model) matrix out of calls to `translation()`, `rotation()`, and `scale()`.

Those functions take as arguments a `Vec` of three (3) scalars, except for `rotation`, which takes one (1) scalar, the angle in radians, and one (1) `Vec` object (the axis) of three floats. Only the static `Vec.of()` function can generate new `Vec`s. Here is a short example (with valid code to use with your template) employing these functions:

```
T = Mat4.translation( Vec.of( 1, .5, 1 ) );  
R = Mat4.rotation( Math.PI/2, Vec.of( 0, 1, 0 ) );  
S = Mat4.scale( Vec.of( 1, .5, 1 ) );  
  
M = Mat4.identity();  
M = M.times( T ).times( R ).times( S );
```

Implementation:

JavaScript has no operator overloading, so operations like `+`, `-`, `*`, `+=`, `*=`, etc. will not compile for the provided vector and matrix types (`Vec` and `Mat`). Instead use `times()` as shown in the `Tutorial_Animation` class and assign its return value back into your matrix to incrementally modify it. These can be chained together:

```
M = M.times( T ).times( R ).times( S );  
this.shapes.box.draw( graphics_state, M, red );
```

Do this to combine your steps, and place it in between your function calls that actually draw the cubes/spheres.

Requirements:

(a) You must conceptually use a hierarchical approach to model the complex objects. This means incrementally creating composite transformations by using `times()` to multiply new terms onto the **right**. This allows you to benefit from intermediate values. As you progress toward the “leaf nodes” in your scene’s organization (such as the antennae tips and lower legs) you can draw the rest of your shapes (all the non-leaf nodes) using the intermediate matrices. **(2 Points)**

(b) Your source code must use a hierarchical approach as well (breaking up your code into a **hierarchy of subroutines**). Don’t put all your code into only `display()`. **(3 Points)**

(c) Start by drawing a horizontally stretched box in front of the camera for the Butterfly thorax. On either side, attach balls for the head and abdomen. The ball surfaces and box surface should barely touch (distance=0) and the volumes should not intersect. **(3 Points)**

(d) Attach flapping wings (flat diamond shaped boxes) to the four top corners of thorax box. See the pictures below. Wings must precisely touch the thorax at corner points only. So that the boxes do not detach from here during rotation, they should hinge at these exact points along the butterfly’s lengthwise axis to flap. The front and back piece of each wing must connect along a corner edge. **(4 points)**

(e) Attach legs to the butterfly and animate them opening and closing. The legs have **two segments each**, not one. Pieces should rotate along the butterfly’s lengthwise axis, and even while they move they should stay precisely connected; the bottom outer corner edge of the upper leg segment must always contact the top outer corner edge of the bottom leg segment, like in the pictures below. Legs must contact the thorax only by a thin corner edge as shown. Leg segments rotate along the butterfly’s lengthwise axis. While hinging, the boxes that make up the legs must not intersect their volumes through each other or through the thorax. These leg segments have a stretched length compared to cubes and this must not cause subsequent segments to shear. **(6 points)**

(f) Attach an antenna to the head on each side, and animate them flexing under the weight of their tips. The antennae consist of nine boxes each plus a larger ball touching the ends. See the pictures below. The base (initial box) of each antenna must touch the butterfly’s face somewhere by performing rotations before translating out to the surface of the head sphere. From there, be sure to translate out once more half a box length before drawing the box so that the box’s bottom (not its center of mass) becomes the attachment point. **(2 points)**

(g) Iteratively attach the rest of the box segments on top of each antenna base to complete each stack of nine. The top outer corner edge of each box must always be in contact with the bottom outer corner edge of the next box while they animate. Using that corner edge as a hinge point, rotate **R** radians outwardly for each box before moving on to the next box, where **R** varies over time. **R** should smoothly vary, yet it should also never go negative (i.e. the volumes of the box segments must never intersect through one another). **(6 points)**

(h) Until now your butterfly has been sitting still, allowing you to get better camera angles to see the joints without the butterfly flying away. Now, make the whole butterfly fly in a circle around the vertical axis, centered around the world origin $[0, 0, 0]$. It should always be aligned with the tangent of the circle and facing forward down its path, although you may tilt the butterfly upward (make its head higher than its tail) to give it a more realistic fluttering pose. Secondly, the butterfly must move up and down while it flaps. Perform these two butterfly movements only when the variable “`this.hover`” is false; this way, by clicking the “hover in place” button you can still stop the butterfly to watch its joints move if you need to build more parts onto it or adjust anything. **(4 points)**

You must rotate objects around the correct point; i.e., where they touch the parent object matters. Pay special attention to the locations of these hinges - points or edges where two boxes make contact - and center your

rotations along those. You will be mainly graded on touching box corner points/edges and on the fluidity of motions.

Your scene must be qualitatively similar to the one provided, but need not match the exact motion or dimensions or colors of the sample code. Use colors, sizes, or an added feature to customize your butterfly and make it unique so we do not get your submission mixed up with the others. In doing so, you must still adhere to the requirement details -- remember, boxes must all stay hooked up at certain corner points or corner edges.

Hints:

(a) Create a method `draw_leg()` and use it for each of the legs. Call it six times, passing in a different matrix each time.

(b) Your butterfly code to fill in is in `index.html` in a class called `Butterfly_Scene`, and already contains a ground plane, a couple of example shapes for you to experiment with or remove, a time variable in seconds (`this.t`), and a “`this.hover`” variable controlled by a functional “hover in place” button.

(c) In addition to `Butterfly_Scene`, refer to the class “`Tutorial_Animation`” for more examples of shapes being drawn. Add “`Tutorial_Animation`” to the array on line 10 of `index.html` and run your code to see this alternative scene.

(d) Functions of the form $f(t) = a + b \cdot \sin(w \cdot t)$ are useful for modeling periodic motion.





