CPSC 526: Computer Animation
Assignment 1

Due in class, Wednesday, January 14, 2015

Answer the questions in the spaces provided on the question sheets. If you run out of room for an answer, continue on the back of the page.

This assignment is a mix of review questions, some more open-ended questions, and some experimentation with a simple animation system. It is probably longer than the average weekly assignment for this course, but it is meant to get everyone off to a solid start in thinking about the course material.

Names: ____________________________

<table>
<thead>
<tr>
<th>Question</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Question 1</td>
<td>14</td>
</tr>
<tr>
<td>Question 2</td>
<td>4</td>
</tr>
<tr>
<td>Question 3</td>
<td>4</td>
</tr>
<tr>
<td>Question 4</td>
<td>6</td>
</tr>
<tr>
<td>Question 5</td>
<td>5</td>
</tr>
<tr>
<td>Question 6</td>
<td>12</td>
</tr>
<tr>
<td>TOTAL</td>
<td>45</td>
</tr>
</tbody>
</table>
1. Math review

\[ a = \begin{bmatrix} 3 \\ -1 \\ 4 \end{bmatrix}, \ b = \begin{bmatrix} -1 \\ 2 \\ 3 \end{bmatrix}, \ C = \begin{bmatrix} 0 & -1 & 2 \\ 2 & 1 & -4 \\ 1 & -4 & 3 \end{bmatrix}, \ d = 2 \]

(a) (10 points) For each of the following, compute the answer or, if it cannot be evaluated, state that it is a nonsense expression.

\[ a^T b \]
\[ a b \]
\[ a b^T \]
\[ b^T a \]
\[ a d \]
\[ d C \]
\[ b C \]
\[ b C \]
\[ C a \]
\[ a^T C a \]
\[ b^2 \]
(b) (2 points) Give an expression for the cross product, $a \times b$, where $a = \begin{bmatrix} a_1 & a_2 & a_3 \end{bmatrix}^T$ and $b = \begin{bmatrix} b_1 & b_2 & b_3 \end{bmatrix}^T$.

(c) (2 points) Develop a $3 \times 3$ matrix, $\tilde{a}$, such that $\tilde{a}b = a \times b$. I.e., develop a way of writing a cross product as a matrix multiplication.

2. (4 points) Trigonometry and graphics

A point $P(x, y)$ is rotated about the origin by $\theta$ degrees to obtain a new point, $P'(x', y')$. Develop expressions for $x'$ and $y'$ in terms of $x$, $y$, and $\theta$. Illustrate your work. Using these expressions, develop the form of a 2D rotation matrix $M$, where

$$ \begin{bmatrix} x' \\ y' \\ 1 \end{bmatrix} = M \begin{bmatrix} x \\ y \\ 1 \end{bmatrix}. $$
3. (4 points) Interpolation

You wish to animate the motion of the angle of a knee joint over time, described by $\theta(t)$.

(a) Given a specification of what the knee angle should be at a set of key instants in time, i.e., the keyframes $\{(t_i, \theta_i)\}$, describe what you believe to be a good method to create a smooth animated motion for the knee that meets the given keyframe constraints. Provide as much of the mathematical detail as you can. I.e., develop a smooth function for $\theta(t)$ that interpolates the given keyframes.

(b) Can you think of any disadvantages to the approach you propose to use?

(c) Also describe an example where one would not necessarily want smooth, continuous motion through a keyframe.

Please note that the point of this question is to get you thinking about the mathematical modeling issues related to modeling motion. There is no single “correct” answer. Do not be concerned about knowing the “standard” ways of doing this in animation systems! Unconventional answers will be appreciated!
4. (6 points) You are given a set of angles, \( \{\theta_1, \theta_2, \ldots, \theta_n\} \), which represent the orientation of a set of objects in the plane. Note that orientations live in a circular domain, e.g., an orientation of \( 270^\circ \) is the same as an orientation of \( -90^\circ \). You wish to compute the average orientation. First, come up with an example set of angles where the standard definition of the mean would give an unintuitive answer. Then describe an expression or algorithm for computing a more meaningful mean orientation.

Please note that the point of this question is to get you thinking about the mathematical modeling issues related to modeling motion. There is no single “correct” answer.
5. (5 points) Sketch out a possible taxonomy for some of the many different display technologies (past, present, and future) related to displaying or visualizing motion that we have discussed in class – I will post links to all the display technologies on the website. Thus the question really about asking: what are some useful ways of categorizing the many possibilities?
6. (12 points) Experiment with creating a short animation that describes something specific about UBC or Vancouver using Animatron:
Email the URL for your animation to van@cs.ubc.ca at least an hour before the class that this assignment is due. If you finish sooner, feel free to send me the URL earlier, as there is never a full guarantee of sites such as this continuing to host your prized animation. Create the animation by signing up for a free account. There are a large number of features that you can experiment with. Your final animation need not be terribly sophisticated. Do have fun with this.

You will need to look at a number of the tutorials and to experiment with the interface in order to learn how to create objects and then keyframes for the objects. In particular, you should use some animation curves. To do this, create an object. Then, while in animate mode, move the time slider to a new key time. Select the object and drag it to a new location. This will now create a linear translation over time between the original location at $t = 0$ and the new location at the designated time. You will also see the translation curve (a line in this case) for the object. You can select this and then edit it; you will see that it is in fact a parametric cubic curve that allows you to move the end vertices and change the end tangents. Ctrl-select on the timeline will bring up a menu that will let you add further keyframes.

I will show some of the results in class.