

## 1 Programming

In this assignment you will animate several deformable objects in 2D. The program `deformable2d` combines a rotated finite element simulation (similar to that described in “Interactive Virtual Materials” by Müller et al. in Graphics Interface 2004) with an OpenGL display.

I have provided some code to start you off, in the directory `deformable2d`. See the README for instructions on what you need to add, how to compile, etc.

## 2 Analysis

(1) Figure out a formula for finding the signed polar decomposition of a  $2 \times 2$  matrix  $A$ . That is, find  $2 \times 2$  matrices  $Q$  and  $F$  so that  $A = QF$ ,  $Q^T Q = I$ ,  $\det(Q) = 1$ ,  $F = F^T$ , and  $\text{tr}(F) \geq 0$ . Hint: write

$$Q = \begin{pmatrix} c & -s \\ s & c \end{pmatrix}$$

thinking of  $c$  and  $s$  as the cosine and sine of the rotation angle respectively. Determine what  $c$  and  $s$  should be first, being careful with the case where  $A$  is already symmetric and has zero trace.

(2) Research and find out what the “second Piola-Kirchhoff stress tensor” is, and explain how it is different from the Cauchy stress tensor discussed in class.

## 3 Handing It In

You need to hand in the code you write for `deformable2d` (I will compile and run it on my machine to test it), and answers to the questions in the analysis section.

To hand in the programming part of an assignment, tar and gzip the directory containing your source code (but not output data, object files or executables!). If you have changed how the code is compiled or run, or some anything you want to comment on, include a README file. Then email me the `.tar.gz` file as an attachment.

To hand in the written part of an assignment, either email it to me (preferably in plain text or PDF), give it to me in person, or slide it under my office door.