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Discovering Ill-Conditioned Systems Via Plane Deformations.

Ill-conditioned linear systems $Ax = b$ may result in surprisingly large perturbations of the solution from very small perturbations to the objective vector, b . With unexpected results as bait, Quantitative Analysis students examined 2 by 2 linear systems for potential ill-conditioning via deformations of circles in the plane. Matrix and vector operations were introduced for solutions via inverses and to explain matrix manipulations conducted by calculator. Students calculated the pre-image for a small circle of points (small perturbations) around the objective vector. Graphs were obtained for the pre-images, and from these, students inferred troublesome/favorable directions of change (eigenvectors) and the max/min distortions (singular values) for the system.

Ultimately, students were able to characterize the condition of a system based on the amount of distortion of the perturbation circle and became sensitive to potential pitfalls of rounding of the objective vector. Although course requirements limited technology to calculators, the exercise can be greatly improved with a programming platform. (Received September 25, 2018)