Stanford University, Fall 2015, CS 448Z: Physically Based Animation and Sound

Homework #3: Final Project

Due: Friday Dec 11, 2015 (Presentation on Thursday Dec 3, 2015)

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You have two choices for the final project:

1. Implement the "acoustic transfer for modal sound" project described in Section 1; or
2. Implement a final project on a topic of your choosing. If you choose this option, you should discuss it with Prof. James to be sure that it is reasonable and that he approves your pick. If you do not propose your own topic and have it approved, then it will be assumed that you will do the transfer project.

In either case, the final project should be of similar scope to each of the previous two programming assignments. You should begin work immediately to avoid delay.

1 Acoustic transfer for modal sound

The goal of this project will be to build (a) a acoustic transfer preprocess, and (b) acoustic transfer runtime evaluator, for the modal sound models (slab, sphere, rod) used in HW2. Your approach will be a simplified version of the precomputed acoustic transfer model [James et al. 2006]. Using your approach you should be able to generate real-time sound for your extended HW2 simulation.

1.1 Transfer Preprocess

You must build a solver to estimate the single-point multipole coefficients based on an equivalent source approximation to the acoustic transfer problem. For each vibration mode, you can construct a least-squares problem based on Neumann boundary conditions at boundary collocation points. The least-squares problem can be solved used TSVD as in [James et al. 2006], or using a regularized ridge-regression scheme as in [Zheng and James 2009] (using a QR solver). In either case you will obtain a vector of complex-valued multipole coefficients to represent the radiation field. If you use a single-point multipole expansion, then you will need high-order basis functions (see [Zheng and James 2010]).

Verify your solver works on test cases: You can easily construct test cases by first picking multipole coefficients, then generating the Neumann boundary data to pass to the solver. You can verify that the solver does indeed recover the original multipole coefficients reasonable accurately. For starters, place a single unit monopole inside the object.

Generate a convergence plot for each of the examples to demonstrate the relative BC error versus the number of coefficients used (as in [James et al. 2006]).

Optional: You may instead use a multi-point multipole expansion if you wish. A complication is that you must find multiple points inside the mesh. However, a simplification is that you can hardcode low-order basis functions, e.g., dipoles.

Gotchas: A couple things to pay attention to: (1) don't place sources too close to the surface mesh, or you are effectively collocating on a near-singular source model. (2) make sure that your surface mesh is sampled sufficiently finely to resolve the wavelengths used by your basis functions, e.g., simply collocating at mesh vertices requires the mesh to be uniformly sampled, and sufficiently fine, which may not be the case for your specific frequencies.

1.2 Transfer Runtime

At runtime you need to evaluate the transfer at the listener's position in the object's frame of reference. You will need to evaluate the multipole basis functions sufficiently quickly in order to do this well. In practice, you need not evaluate the transfer at audio rates, and can in practice get away with a few hundred Hz evaluation rates. You can lag the evaluation position, and in that way linearly interpolate the evaluated transfer pressure values along the trajectory. If your system is too slow, then you can use fewer multipole expansion coefficients until it runs in real time.

Generate video results for each of the HW2 modal objects to demonstrate that the system works reasonably.

Compare the results you obtain before/after adding acoustic transfer to demonstrate the effect.

2 What to Submit

You should submit (1) your code, (2) a short 1-page write-up on your findings, (3) image and video captures demonstrating your results, and the proper functioning of your system/implementation. Upload your final submission as a zip file to Canvas (`http://canvas.stanford.edu`).

References

JAMES, D. L., BARBIČ, J., AND PAI, D. K. 2006. Precomputed acoustic transfer: Output-sensitive, accurate sound generation for geometrically complex vibration sources. In *ACM Transactions on Graphics (TOG)*, vol. 25, ACM, 987–995.

ZHENG, C., AND JAMES, D. L. 2009. Harmonic fluids. *ACM Transactions on Graphics (TOG) 28*, 3, 37.

ZHENG, C., AND JAMES, D. L. 2010. Rigid-body fracture sound with precomputed soundbanks. 69.