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Simulation of Wave Propagation using Graph-Theoretical Algorithm

We simulate the wave propagation through various mediums using graph-theoretical path finding algorithm. The mediums are discretized to the square lattices, where each node is connected up to its 4th nearest neighbors. The edge connecting any 2 nodes is weighted by the time of flight of the wave between the nodes, which is calculated from the Euclidean distance between the nodes divided by the average velocity at the positions of those nodes. According to Fermat's principle of least time, wave propagation between 2 nodes will follow the path with minimal weight. We thus use path finding algorithm to find such a path. We apply our method to simulate wave propagation from a point source through a homogeneous medium. By defining a wavefront as a contour of nodes with the same time of flight, we obtain a spherical wave as expected. We next investigate the wave propagation through a boundary of 2 mediums with different wave velocities. The result shows wave refraction that exactly follow Snell's law. We finally investigate time of flight of wave propagation through an inhomogeneous medium where the wave velocity depends on the angle between the direction of propagation and radial direction from a pole. This is a simple model of wave propagation through a wood. The results agree well with the measurements in sample wood disks. The advantage of our method is on its simplicity and straightforwardness. In all above simulations, the same simple path finding code is used, regardless of the complexity of wave velocity model of the mediums. We expect that our method can be useful as an educational tool to demonstrate the wave propagation through arbitrary medium. The method can be used also in practice when an investigation of wave propagation in a complex medium is needed.

Authors: KETTHONG, Kanyaporn (Kasetsart University); JINUNTUYA, Noparit (Kasetsart University); PULPIROM, Sarita (Kasetsart University); CHOMKOKARD, Sakchai (Kasetsart University); WONGKOKUA, Wiwat (Kasetsart University); RIANTHAKOOL, Laddawan (Kasetsart University); PRASANAI, Khanchai (Kasetsart University); NA TAKUATHUNG, Chakrit (Kasetsart University)

Presenter: KETTHONG, Kanyaporn (Kasetsart University)

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