Question being addressed

Location of acoustic system according to the conditions of the space plays an important role in the proper sounding of the system. Arbitrary location of sound sources and neglect of features of this premises as a rule, leads to a significant distortion of the original sound track.

Acoustic systems placed in an enclosed space acoustically interact with the wall structures. This causes a negative acoustic effects.

Computer modeling provides ample opportunities for interaction with investigation object. Purposes of acoustic modeling software are important observation and manipulation the properties of sound sources in order to perform computer-based experiments in concert hall / living room / office area geometry. This class of software is used to predict the acoustic conditions within spaces (premises, offices etc). Walls, partitions and furniture objects directly influence the acoustic characteristics of the closed spaces. Visualization of sound wave propagation gives a better representation of their behavior in a given space.

There are a lot of works in this field. For example, the technology and software: EAX, DirectSound3D, Impulse Modeler. Also Intel Corp. has researches in this field, one of their work is ”Interactive geometric sound propagation and rendering”.

Despite the variety of created software, the issue remains open. Research continues to improve the methods used and the search for new ways of making.

Engineering Goals

The method in room acoustic field usually based on ray tracing, which has a lot of benefits, but there are some alternative such as lattice Boltzmann method. This is numerical method. It has some limits, such as low speed and using only in static scenes, but there are benefits of using this approach: physical simulation gives more approximated to reality model and, using this method, sound engineers are able to observe the physical processes in detail.

The main goal was to create software for acoustics exploration in spaces with complex structures of walls. It should be designed as the instrument for acoustics researchers, but also it should have a simple user interface for people interested in this area.

With this tool the user will be able to choose convenient location for the system of sound sources or plan room's geometry for good sound. Good sound implies a fact that in areas where the presence of sound if preferable, the sound volume is approximately the same and uniform, and in areas, where the presence of sound if unpreferable, this sound is absent. Computer simulations is more advantageous then real experimentations because it does need special equipment.

Also the physical model used in our program can find its application at creation of acoustic engines for computer games. Good acoustic engines are gaining in popularity, as people appreciate the detailed accuracy and credibility in computer games. As the hearing is one of the five senses of reality perception, so the audio component of a computer game should be paid no less attention than the visual.

Created software can be useful in sphere of room acoustic. Room acoustics describes how sound behaves in an enclosed space. Created model makes it possible to take into account propagation of sound in a space, wall reflections, diffraction and interference of waves. One of the features of the program – interactivity. A user can influence the system: create

waves, set objects in the room, receive information in graphs from any point in real time, etc. The set of tools helps user to explore different rooms' layouts.

Description of methods and procedures used

Lattice Boltzmann method (LBM)

LBM is a class of computational fluid dynamics methods for fluid simulation. Also it can be applied in acoustics.

LBM discretizes geometry of field's objects, divides the space into cells. Each cell - a group of particles. At each iteration of the algorithm the mass transfers between cells in discrete directions. Each cell has a single-particle distribution functions (SPDF) for each discrete direction - the probability of flight in this direction by randomly chosen particle.

Selected model is D2Q9: two-dimensional space with 9 SPDF directions (8 vectors to neighboring cells + 1 zero vector).

At each iteration, the substance transfers between neighboring cells, in accordance with the kinetic equation and the collision integral.

Density in the cell is calculated as the sum of all single-particle distribution functions of the cell. Condition for the existence of sound waves - the presence of an elastic medium.

As mentioned above, the space is divided into cells. A cell can either be of a solid object, reflecting or absorbing waves or elastic medium, the conducting of the wave.

Algorithms