COMPARATIVE ANALYSIS OF TWO ACOUSTIC SIMULATION SOFTWARE

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ABSTRACT

In this work, firstly a comparative analysis of the acoustic simulation programs RAYNOISE and ODEON was carried out. Secondly, the influence of the modeling accuracy on the convergence was analyzed. For the first objective, the same model was simulated with both programs. For the second objective, four geometric models of a room with different degrees of precision were generated, varying from 40 surfaces for the simplest model to 1,497 surfaces for the more complex model. Questions such as time for calculation, stability and power of the complex models, diffusion processing, convergence in the results, user interface facilities, etc. were analyzed.

1 INTRODUCTION

Room acoustics is a scientific field in continuous development. Great progress has been made in the knowledge and applications of this science in the last half century. That is due both to the extensive investigation accomplished in the field of physiological acoustics and to the development in computation tools for the simulation of acoustic responses. The high power and the relatively low cost of computers has led to simulation software replacing the scale models used until recently. A comparison between two of the most popular simulation acoustic software-Raynoise (3.0) and Odeon (4.0)- will be carried out.

2. RAYNOISE and ODEON: COMPARATIVE ANALYSIS

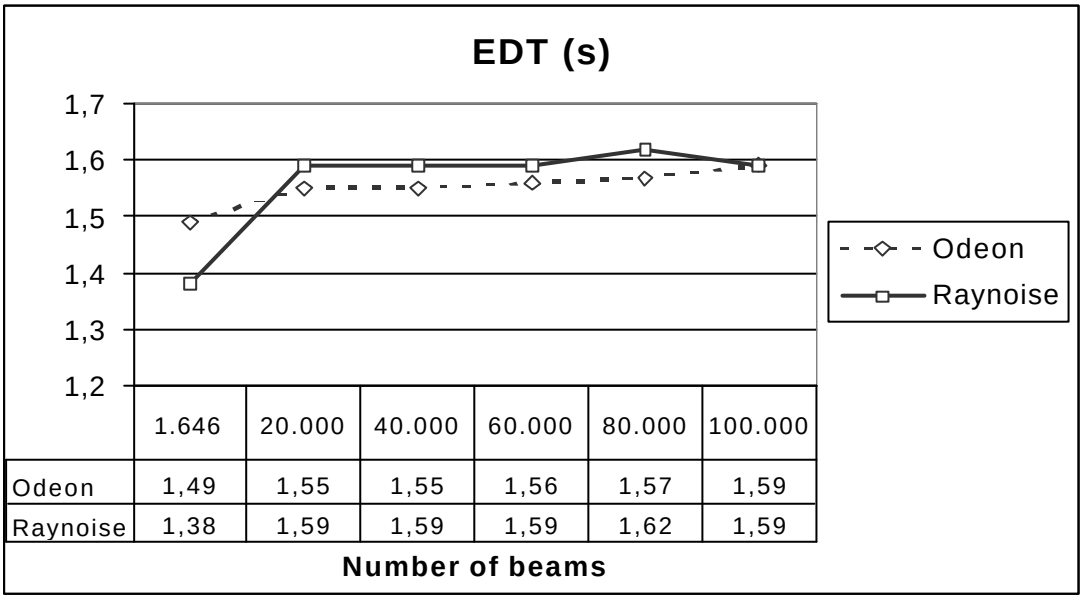
Raynoise can process with the Conical Beam Method (CBM) as well as with the Triangular Beam Method (TBM). It combines the advantages of both. A single algorithm adjusts on the one hand the exponential increase time of calculation of the image sources and on the other hand the low precision of the algorithm of beam tracing. With regard to diffusion, it combines deterministic and statistic methods. Odeon works with two types of algorithms. One for the first reflection and the other one for the rest. The user can establish both when to close and when to change the algorithm. Odeon uses a slightly modified algorithm of the image sources for the first reflections since it takes into account the size of the sources. Once the moment of closure of the first method-number of reflections- is surpassed a second source with directivity according to Lambert's law is created each time a beam is reflected on a surface. This strategy does not

produce an exponential increase in the number of reflections-as might have been expected in real rooms- but maintains the same reflection density during the calculation without increasing the calculation time. In order to correct it a process of evenness in reverberation curves is applied, Furthermore this method includes the diffusion effect in the reflections.

One of the advantages of the method of ray tracing used by Odeon is that is possible to obtain a reasonable number of reflections in a receiver-necessary to obtain reliable results- with a small number of beams. This reduces the necessary calculation time.

2.1 Number of beams

Five simulations were carried out for each program, varying the number of beams from 20,000 to 100,000. Furthermore an extra simulation with the number of beams recommended by Odeon (1,646) was carried out. The maximum number of reflections was fixed at 50. There isn't meaningful difference between results obtained from both programs and both offer a rapid convergence (see figure 1). Due to the special algorithm of ray tracing used by Odeon the number of required beams are fewer than those required by Raynoise though always above those suggested. The main difference between both programs is the computation time. The same simulation is approximately ten times quicker in Odeon than in Raynoise.

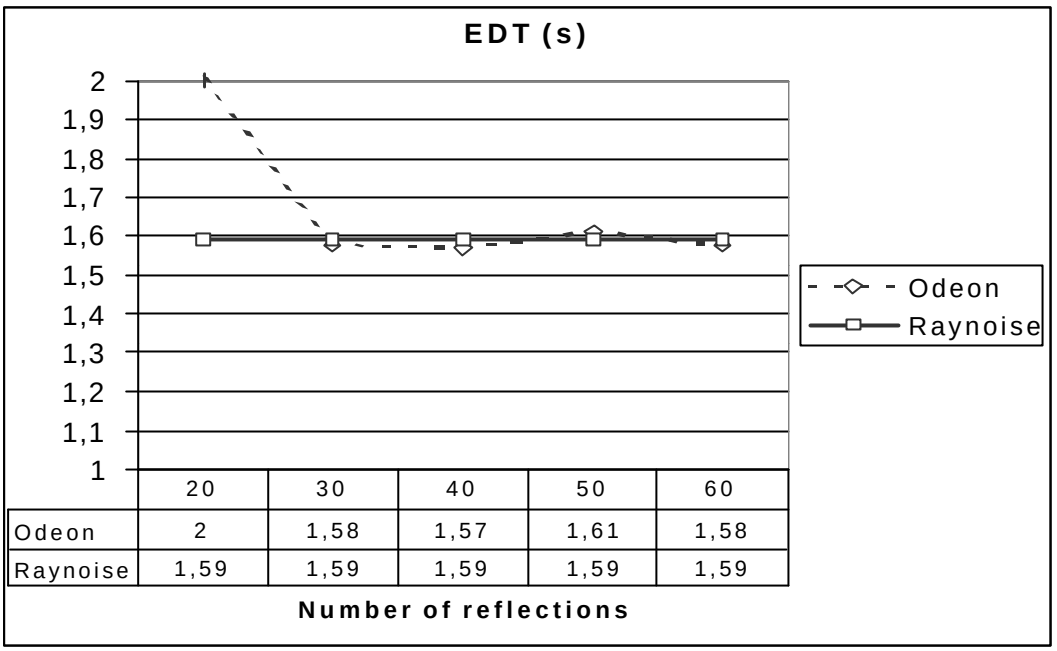


	1.646	20.000	40.000	60.000	80.000	100.000
Odeon	1,49	1,55	1,55	1,56	1,57	1,59
Raynoise	1,38	1,59	1,59	1,59	1,62	1,59

Fig.1 Values for Early Decay Time versus number of beams.

2.2 Number of reflections

Five simulations for each program were carried out by ranging the number of reflections from 20 to 60. The number of beams was fixed at 50,000 for all simulations. Figure 2 shows the convergence of EDT versus number of reflections. Results are constant for Raynoise. Algorithms of ray tracing in Raynoise are much more dependent on the number of beams than on the number of reflections.

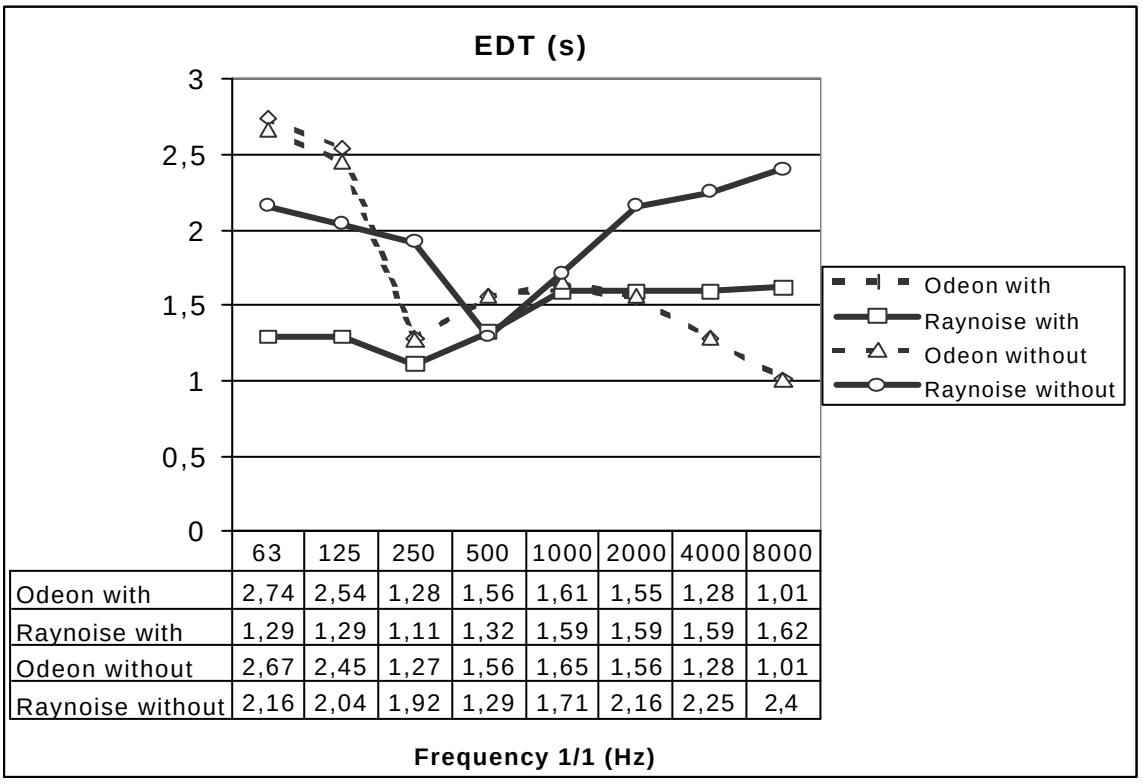


	20	30	40	50	60
Odeon	2	1,58	1,57	1,61	1,58
Raynoise	1,59	1,59	1,59	1,59	1,59

Fig. 2 Values for Early Decay Time versus number of reflections.

2.3 Diffusion

Results obtained from both programs with and without diffusion coefficients are shown in figure 3. Noticeable differences can be observed in Raynoise. Such differences are higher at low and high frequencies, whereas Odeon offers similar results for all frequencies with and without diffusion coefficients.



	63	125	250	500	1000	2000	4000	8000
Odeon with	2,74	2,54	1,28	1,56	1,61	1,55	1,28	1,01
Raynoise with	1,29	1,29	1,11	1,32	1,59	1,59	1,59	1,62
Odeon without	2,67	2,45	1,27	1,56	1,65	1,56	1,28	1,01
Raynoise without	2,16	2,04	1,92	1,29	1,71	2,16	2,25	2,4

Fig. 3 Values for Early Decay Time with and without diffusion.

3. TIME PROCESSING VERSUS MODELLING ACCURACY

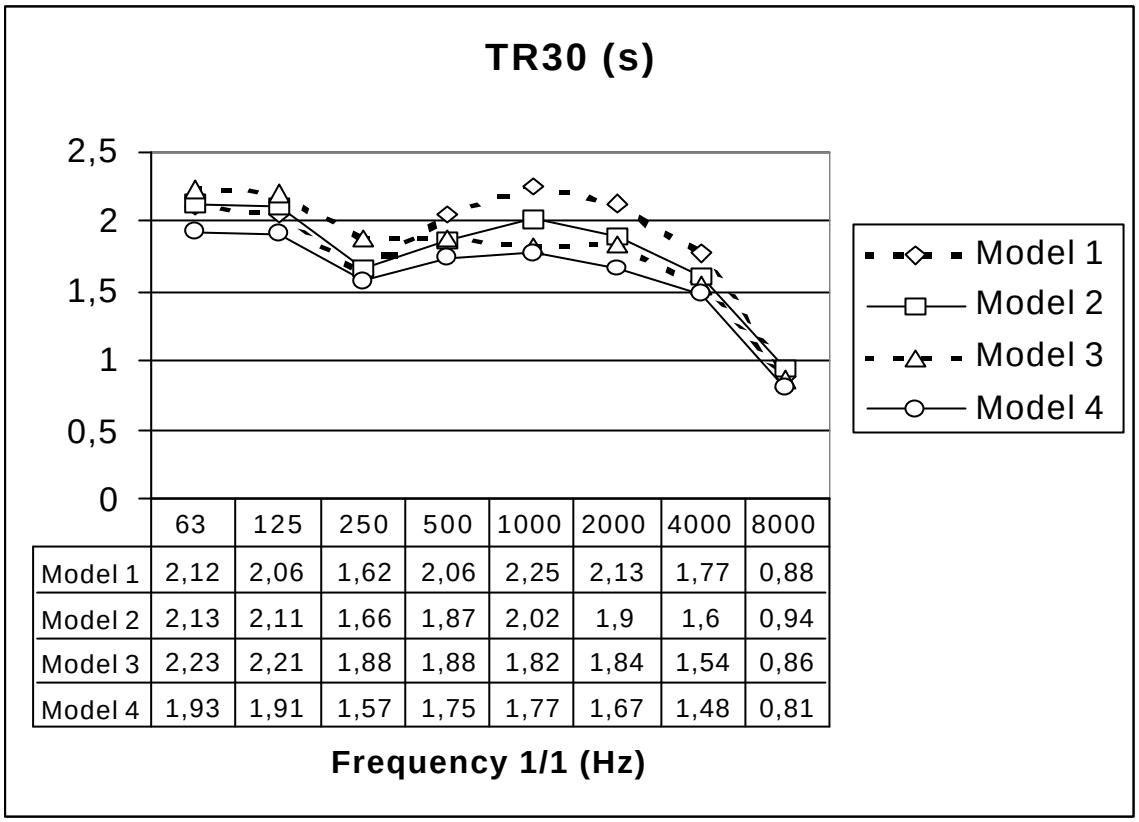
Most of the required time to carry out a study of room acoustics by computer simulation is spent on generating the geometric model. Experience in simulating can imply a considerable reduction in the time used for the simulation of a room. As a general rule, one may expect a greater precision on the results obtained according to the accuracy of the model. However it is very useful to know the characteristics of the program. When it comes to carrying out a simulation, the most important concern is to know the size of the surfaces areas in the room. Geometric acoustic laws consider all the surfaces as infinite-in comparison with wavelengths- in the calculation of the reflected energy. This limitation is considered differently by programs which consider, for instance, diffraction algorithms, minimum size of the surface to be taking into account, etc. An accuracy simulation implies a great increase in time not only to draw the model but also for the subsequent computer processing. It is a matter for the user to decide the balance between the processing time and the precision of the results.

Odeon recommends a 'reasonably large' surface size for models to simulate. It intrinsically considers a surface size limit from which it introduces an algorithm that approximates losses due to diffraction. That restriction is only applied to the first reflection. Odeon recommends avoiding very small surfaces in those parts of the room contributing strongly to first reflections. However, Raynoise does not consider any lower limit for the size of the surfaces. The main consequence of this difference between both programs is that while the processing time is approximately constant in Odeon, the corresponding time in Raynoise increases considerably according to the accuracy of the simulation. Results are shown in table 1.

Model	Number of points	Number of surfaces	Processing time (hours:minutes)	
			Odeon	Raynoise
1	84	40	0:58	0:57
2	144	82	1:03	1:08
3	488	252	1:11	2:40
4	2,408	1,497	1:21	6:22

Table 1. Comparison of processing time versus number of surfaces

The reverberation time (TR30) evaluated by Odeon for the four simulations carried out is shown in figure 4. Except for low frequencies in model 3. It seems that the more complicated the simulation is, the slower the convergence in reverberation becomes. Nevertheless, Odeon emphasizes that it is more important to simulate the geometry of the room correctly than to carry out an exhaustive simulation of each one of the surfaces. Figure 5 shows results obtained by Raynoise for EDT at 500 Hz octave band for the four simulations. The greater variation in results comes in the first and the second models.



	63	125	250	500	1000	2000	4000	8000
Model 1	2,12	2,06	1,62	2,06	2,25	2,13	1,77	0,88
Model 2	2,13	2,11	1,66	1,87	2,02	1,9	1,6	0,94
Model 3	2,23	2,21	1,88	1,88	1,82	1,84	1,54	0,86
Model 4	1,93	1,91	1,57	1,75	1,77	1,67	1,48	0,81

Fig. 4 Results obtained (TR30) from Odeon for different octave bands in the four simulations

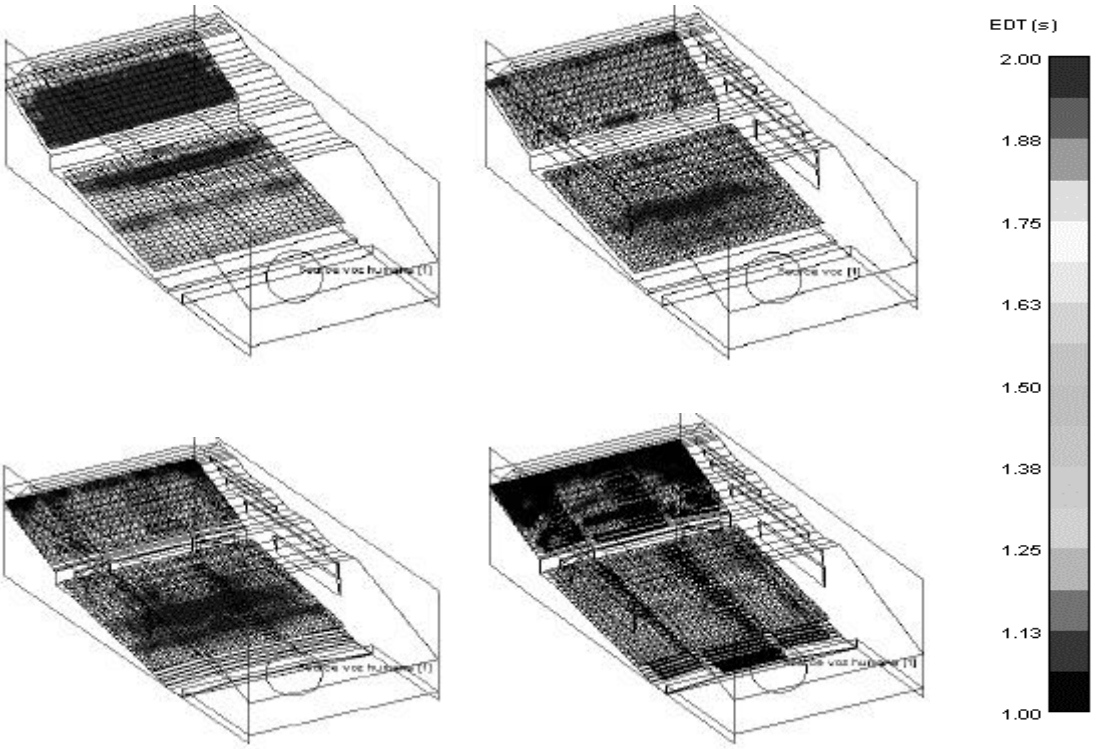


Fig. 5 Results for EDT at 500 Hz octave band from Raynoise in the four simulations

CONCLUSIONS

1. A comparative analysis of the acoustic simulation programs RAYNOISE (3.0) and ODEON (4,0) was carried out.

2. With regard to the number of beams, results obtained from both programs are very similar. Nevertheless, the processing time is substantially less in Odeon.

3. With regard to the number of reflections, results obtained from Raynoise are constant. Results from Odeon depend notably on when the number of reflections is fewer than 30. Over that figure results are constant and very similar to those obtained from Raynoise.

4. Algorithms of ray tracing in Raynoise are much more dependent on the number of beams than on the number of reflections.

5. With regard to diffusion processing, noticeable differences can be observed in the results obtained from Raynoise. Such differences are higher at low and high frequencies. Odeon, on the contrary, offers similar results for all frequencies with and without diffusion coefficients.

6. Processing time required by Raynoise increases considerably when simulations are more complicated. On the contrary, the corresponding processing time is approximately constant in Odeon.

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