MSc Independent Engineering Scholarship (IES) Proposal

Personal Details

1	Family Name	Durbridge
2	Other Names	Simon
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4	Award Title	MSc Audio engineering
5	Proposed Supervisor	Dr. Adam Hill

NOTES: You can paste material into this form if you wish and expand the sections but the proposal must not exceed 8 pages in length overall, excluding the risk assessment record and the ethics form attached at the end of this proposal. All sections of the risk assessment and ethics form should be completed.

Dissertation Proposal

6 **Proposed Title**

The Application of Time Domain Acoustical Modelling Methods for Very Large Problems

What is the rationale for the proposed IES?

7 **Background**

The use of acoustic modelling has expanded from theatre and concert hall design using scale models, through to large format loudspeaker system deployment, environmental noise studies, virtual reality, and video game auralization using innovative simulation tools[1], [2].

Time domain numerical methods for acoustic simulation have benefits over geometric and frequency domain wave methods. Specifically, time domain numerical methods allow simulations to produce direct and contiguous[1] outputs, while including acoustic behaviour that is not inherent in geometric methods such as room modes[3]. Further, this performance is relatively insensitive to the number of sound sources and receivers in the simulation, unlike geometric and frequency domain wave methods that require separate calculations for multiple parameters across the domain of interest.

However, using time domain numerical methods such as the finite difference time domain (FDTD) method, require doing a significant number of calculations on large sets of data. Applying these methods to very large simulations may not allow for feasible calculation times[2]. The Pesudo-spectral time domain (PSTD) and Sparse finite difference time domain (SFDTD) methods may provide a significant increase in calculation speed when compared with a general second-order FDTD implementation[4], [5].

Implementing and optimising PSTD and SFDTD kernels for large simulations may provide a basis on which real time performance could be obtained in further work.

[1] Audio samples recorded in time

8	**Aims** • To implement time domain acoustic modelling methods on very large problems • To determine if these methods present significant improvements in calculations times when compared to a general method
9	**Objectives** • To implement a pseudo-spectral time domain method engine for 2D • To implement a locally sparse finite difference time domain method for 2D • To implement a generic second order finite difference time domain method for 2D • To develop a method for indexing large data sets into smaller sets • To benchmark both ‘fast’ methods against the generic method for a simple test problem
10	**Plan of work** • Develop a series of Matlab ‘kernel’ functions for FDTD, SFDTD and PSTD simulation • Prove that the results from these kernels is accurate when implemented on a large simulation, by comparing with results of other calculations for the same domain • Develop surrounding code to perform simulations using these kernel • Improve the performance of these kernels with the appropriate code profiling and parallelisation tool • Evaluate performance of the algorithms and suggest areas for improvement, relating to performance speed, with a focus on getting closer to real time simulation

Constraints that may restrict the success of the work

11	**Foreseeable constraints** Time

Identifiable risks to the successful completion of the work

12	**Foreseeable risks** None

Resources you envisage utilising to help complete the work

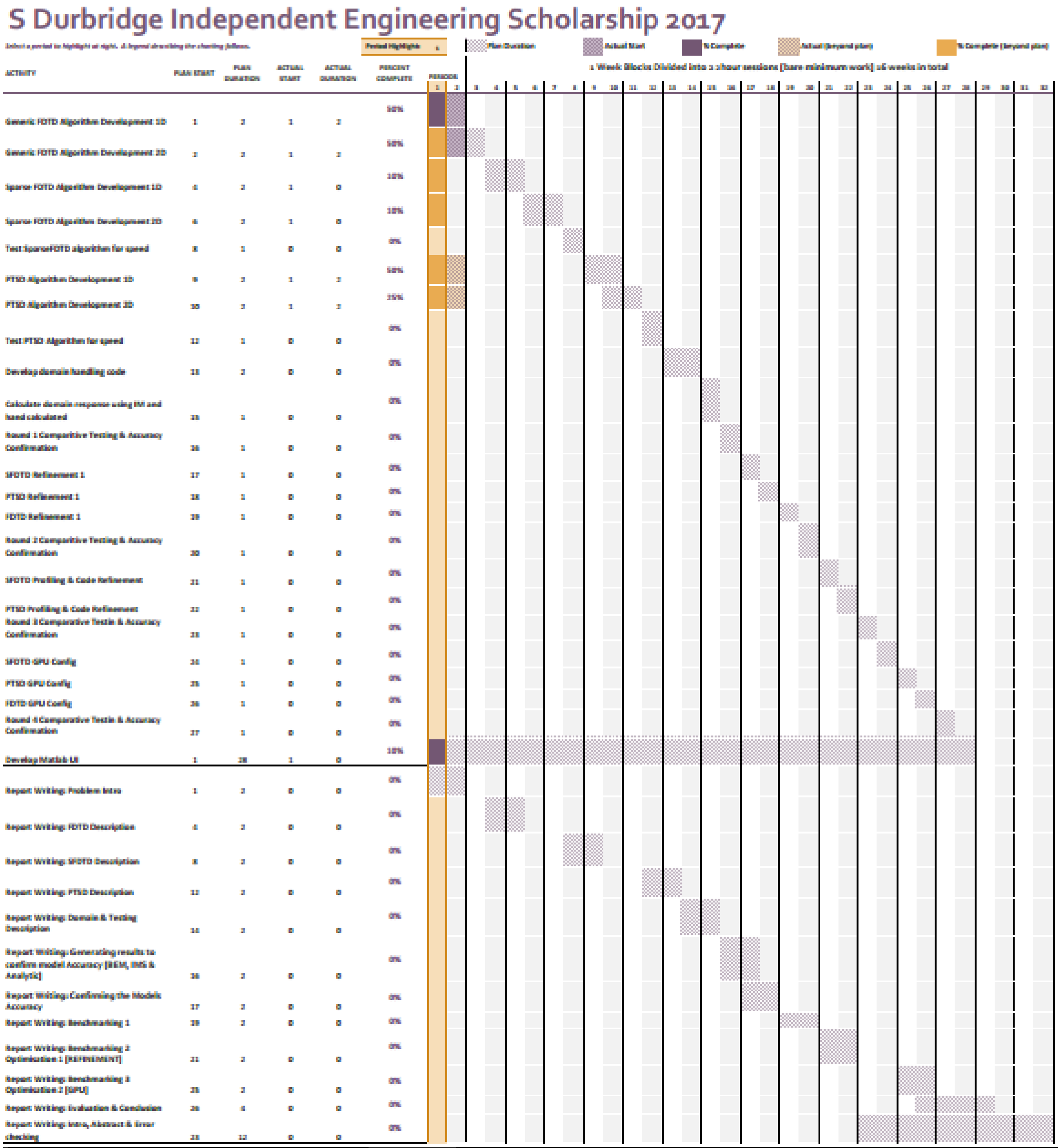
13	**Textbooks** Wave and Scattering Methods for Numerical Simulation S. Bilbao Wiley, 2004 Master Handbook of Acoustics Alton, Everest. F McGraw-Hill, 2009
14	**Journals** Journal of the Acoustical Society of America http://asa.scitation.org/journal/jas Journal of the Audio Engineering Society http://www.aes.org/journal/ Applied Acoustics http://www.sciencedirect.com.ezproxy.derby.ac.uk/science/journal/0003682X
15	**Electronic (internet)** Library of the Acoustical Society of America http://asa.scitation.org/ E-Library of the Audio Engineering Society http://www.aes.org/e-lib/ University of Derby E Library http://www.derby.ac.uk/campus/library/ Digital Audio Effects E Library http://www.dafx.de/
16	**Laboratory equipment and software** Computer running MATLAB with: Code Profiler DSP System Toolbox Signal Processing Toolbox Parallel Computing Toolbox Audio Systems Toolbox

Anticipated cost

17	**Please enter all costs. Brief Description or explanation.** (£150 maximum)	Cost
	NVidia GeForce GTX 1060 graphics card – Nvidia graphics card with large number of CUDA cores. The Matlab Parallel Computing Toolbox has inherent CUDA support, allowing for improvement of data processing speed via GPU parallelism with minimal code adaptation.	83.00
	Mathworks Matlab & Simulink Student Software Maintainance Resubscription with parallel computing toolbox and Audio Systems Toolbox	67.00

Gantt chart

Please find an easily seen version of the Gantt chart in the supporting documentation. The chart is split into 16 weeks with 2 sessions per week, to represent the absolute minimum work time required per task (single blocks of between 4 and 8 hours).



Has the IES been agreed with the proposed supervisor? Yes

Explain, if your answer is No…………………………………………………………………………

SUBMISSION: The completed proposal must be submitted electronically by 11.59 pm on Monday 6th Feb 2017.

Record of Risk Assessment

Assessment Reference	***SDIES_01***

Activity assessed	**IES: The Application of Time Domain Acoustical Modelling Methods for Very Large Problems**
Persons who may be affected by the activity	**Simon Durbridge**

SECTION A : Initial Assessment Overview

Consider the activity or work area and identify if any of the hazards listed below are significant.

1	Fall of person		7	Machinery		13	Electricity		19	Substances		25	Drowning	
2	Fall of objects		8	Tools/Equipment		14	Noise or Vibration		20	High Pressure		26	Psychological effects	
3	Tripping/Slipping		9	Mobile work equipment		15	Hot / Cold Surfaces		21	Fire/ explosion		27	Human error	
4	Manual handling operations		10	Mechanical lifting equipment		16	Workstation – layout / space	x	22	Lighting		28	Violence	
5	Repetitive work	**x**	11	Display screen equipment	x	17	Radiation		23	Confined space		29	Peripatetic / lone working	
6	Housekeeping / waste material		12	Sharp objects		18	Temperature / weather		24	Buildings & glazing		30	Other(s)	

SECTION B : Second Stage Assessment

S = Severity

For each hazard identified in Section A complete Section B

L = Likelihood

Hazard No.	Hazard Description	EXISTING CONTROL MEASURES	S	L	RESIDUAL RISK
11	**Prolonged exposure to computer screen**	**Periodic break away from computer**	**1**	**2**	**Tolerable Risk**
5	**RSI Through keyboard and mouse use**	**Periodic break away from computer, with appropriate ancillary/rehab exercises**	**1**	**2**	**Tolerable Risk**
16	**Damage to computer equipment through excess mess and dust**	**Use waste paper/plastic bin, and regularly de-dust computer components**	**1**	**1**	**Trivial risk**
No. of Section B Continuation sheets used:					

Assessor(s)	**S. Durbridge, Dr Adam Hill**			Signed	S Durbridge
Date of Assessment	**6/2/2017**	Revision No.	**1**		

Request for ethical approval for students on taught programmes

Please complete this form and return it to your supervisor as advised in your module handbook. Feedback on your application will be via your supervisor or co-ordinator.

Your Name:	**Simon Durbride**
Student ID:	**100242305**
Unimail address:	s.durbridge1@unimail.derby.ac.uk
Other contact information	
Programme name and code	**MSc Audio Engineering (MH6AB)**
Module name and code	**Independent Engineering Scholarship (7EJ998)**
Name of supervisor	**Dr. Adam Hill**
Name of co-ordinator	**Dr. Ahmad Kharaz**

Title of proposed research study

The Application of Time Domain Acoustical Modelling Methods for Very Large Problems

Supervisor Comments

Are the ethical implications of the proposed research adequately described in this application?	Yes ☒	No ❑	
Does the overall study have low, moderate or high risk in terms of ethical implications?	Low ☒	Moderate ❑	High ❑
Does the study method describe a process of research that is ethically sound?	Yes ☒	No ❑	

Signatures

The information supplied is, to the best of my knowledge and belief, accurate. I clearly understand my obligations and the rights of the participants. I agree to act at all times in accordance with University of Derby Policy and Code of Practice on Research Ethics:
http://www.derby.ac.uk/research/ethics-and-governance/research-ethics-and-governance

Signature of applicant	**Simon Durbridge**
Date of submission by applicant	06/02/2017
Signature of supervisor	
Date of signature by supervisor	

For Committee Use *Reference Number (Subject area initials/year/ID number)…………………..*

Date received……………… Date approved …………… Signed………………………

Comments

1. What is the aim of your study?

- To implement time domain acoustic modelling methods to very large problems
- To determine if these methods present significant improvements in calculations times when compared to a general method

What are the objectives for your study?

- To implement a pseudo-spectral time domain method engine for 2D
- To implement a locally sparse finite difference time domain method for 2D
- To implement a generic second order finite difference time domain method for 2D
- To develop a method for indexing large data sets into smaller sets
- To benchmark both ‘fast’ methods against the generic method for a simple test problem

2. Explain the rationale for this study (refer to relevant research literature in your response).

The use of acoustic modelling has expanded from theatre and concert hall design using scale models, through to large format loudspeaker system deployment, environmental noise studies, virtual reality, and video game auralization using innovative simulation tools[1], [2].

Time domain numerical methods for acoustic simulation have benefits over geometric and frequency domain wave methods. Specifically, time domain numerical methods allow simulations to produce direct and contiguous[2] outputs, while including acoustic behaviour that is not inherent in geometric methods such as room modes[3]. Further, this performance is relatively insensitive to the number of sound sources and receivers in the simulation, unlike geometric and frequency domain wave methods that require separate calculations for multiple parameters across the domain of interest.

However, using time domain numerical methods such as the finite difference time domain (FDTD) method, require doing a significant number of calculations on large sets of data. Applying these methods to very large simulations may not allow for feasible calculation times[2]. The Pesudo-spectral time domain (PSTD) and Sparse finite difference time domain (SFDTD) methods may provide a significant increase in calculation speed when compared with a general second-order FDTD implementation[4], [5].

Implementing and optimising PSTD and SFDTD kernels for large simulations may provide a basis on which real time performance could be obtained in further work.

3. Provide an outline of study design and methods.

- Develop a series of Matlab ‘kernel’ functions for FDTD, SFDTD and PSTD simulation
- Prove that the results from these kernels is accurate when implemented on a large simulation, by comparing with results of other calculations for a reference domain
- Develop surrounding code to perform simulations using these kernel
- Improve the performance of these kernels with the appropriate code profiling and parallelisation tools
- Evaluate performance of the algorithms and suggest areas for improvement, relating to performance speed, with a focus on getting closer to real time simulation

4. Research Ethics

Does the proposed study entail ethical considerations No

(please delete as appropriate) If you are unsure please seek advice before submitting this form.

If ‘No’ provide a statement below to support this position.
If ‘Yes’ move on to Question 5.

Please note: PROPOSALS INVOLVING HUMAN PARTICIPANTS MUST ADDRESS QUESTIONS 5 - 11.

[2] Audio samples recorded in time

5. Please provide a detailed description of the study sample, covering selection, sample profile, recruitment and if appropriate, inclusion and exclusion criteria.
6. Are payments or rewards/incentives going to be made to the participants? Yes ☐ No ☐ **If so, please give details below.**
7. Please indicate how you intend to address each of the following ethical considerations in your study. If you consider that they do not relate to your study please say so. **Guidance to completing this section of the form is provided at the end of the document.**
8. Are there any further ethical implications arising from your proposed research? Yes ☐ No ☐ **If your answer was no, please explain why.**
9. Have / do you intend to request ethical approval from any other body/organisation? Yes ☐ No ☐ **If 'Yes' – please give details**
10. What resources will you require? (e.g. psychometric scales, IT equipment, specialised software, access to specialist facilities, such as microbiological containment laboratories).
11. What study materials will you use? (Please give full details here of validated scales, bespoke questionnaires, interview schedules, focus group schedules etc and attach all materials to the application)
Which of the following have you appended to this application? ❑ Focus group questions ❑ Psychometric scales ❑ Self-completion questionnaire ❑ Interview questions ❑ Other debriefing material ❑ Covering letter for participants ❑ Information sheet about your research study ❑ Informed consent forms for participants ❑ Other (please describe)

References

[1] H. Schmalle, D. Noy, S. Feistel, G. Hauser, W. Ahnert, and J. Storyk, "Accurate Acoustic Modeling of Small Rooms," *Audio Eng. Soc.*, 2011.

[2] J. Van Mourik and D. T. Murphy, "Hybrid Acoustic Modelling of Historic Spaces Using Blender," no. c, 2014.

[3] J. Van Mourik and D. Murphy, "Geometric and wave-based acoustic modelling using Blender," *AES 49th Int. Conf. Audio Games*, pp. 1–9, 2013.

[4] J. A. S. Angus and A. Caunce, "A GPGPU Approach to Improved Acoustic Finite Difference Time Domain Calculations," *128th Audio Eng. Soc. Conv.*, 2010.

[5] S. Durbridge, "An Introduction of Time Domain Numerical Methods for Faster Acoustic Modelling," Derby, 2016.