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May 31, 2010

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RE: Postdoctoral researcher in the COCA research project.

Dear Laurent Gourvès and Fanny Pascual,

My name is Niall Murphy and I am applying for a postdoctoral position with the "Combinatorial Optimization with Competing Agents" (COCA) project. I defended my Ph.D. thesis in Computer Science in March of 2010 (supervisor Damien Woods, examiners Petr Sosík and Philippe Moser). For the past four years I have been simplifying complex systems using my knowledge of computational complexity theory, graph theory, combinatorial observations, and clever algorithms. This experience and expertise makes me an ideal candidate to join the COCA research project.

My research is driven by curiosity about the world and how it works. I consider the study of computation to be tightly connected with the natural sciences. For example, studying abstract complex systems composed of individual agents teaches us much about many different naturally occurring systems from physics to economics. My aim is to use computational complexity theory to evaluate physical phenomena so as to deepen our understanding of computation and to push back the boundaries of what we consider "tractable" problems.

A major part of my research is about efficiently simulating relatively complex, biologically inspired, parallel models of computation known as P-systems (also known as Membrane systems). As an example, some P-systems can that can generate an exponential amount of information are conjectured to be unable to solve problems in the class NP. I have made significant progress on proving this conjecture (which has been open for 5 years) and have proved that several restrictions of the model can solve no more than the problems in P using combinatorial arguments [5] and by extracting a graph reachability problem [11].

Graph reachability problems were the key to proving my most significant result to date, that uniform and semi-uniform families of computing devices are

not equal. While a *uniform family* of computing devices (such as Boolean circuits) is composed of devices which solve all problem instances of a certain size, a *semi-uniform family* has a different device to solve each problem instance. Using my knowledge of graph reachability problems I proved that semi-uniform families of the system characterise the complexity class known as NL [2, 6, 7] (these systems were previously thought to characterise P). Surprisingly, the uniform families of this same system are extremely weak, solving a tiny set of problems (at most AC^0) [9, 13]. This result has implications for many models of computation, both natural (neural networks, molecular and DNA computers, tile assembly systems computing systems, optical computers and cellular automata) and also "classical" systems such as Boolean circuits and branching programs.

I enjoy challenging myself and working on things outside of my area of expertise. At present I am applying my knowledge of parallel complexity theory to extract 3D information from digital holograms. I have taken this opportunity to learn image processing and also topology by collaborating with Pedro Real-Jurado of the "Computational Topology and Applied Mathematics" group in Seville who have some interesting techniques for extracting dimensional information from images. I enjoy solving problems with others, I am currently collaborating with a colleague in Milan on a conjecture of mine regarding the Polynomial Hierarchy [3, 15].

I love explaining both my work, and science in general, to others. Apart from the usual conference presentations, I take every opportunity to present my research in seminars. As a postgraduate student I also presented several talks on natural computing (aimed at the general public) in my university's annual biology student symposium, the "Whittaker Awards".

To keep up with the latest developments in computer science I am subscribed to several community mailing lists, the weblogs of prominent researchers and maintain correspondence with researchers around the world. I receive digests of the latest publications from the arXive, AMS journals, Springer, and Elsevier.

I am excited by the opportunity to work with such an eclectic group. I am especially thrilled by the chance to work in algorithmic game theory which is growing in importance every year. I am confident that my unique point of view, which blurs the line between problems and the machines that solve them, is of great value to the group and will quickly produce interesting new results.

Please find attached my Curriculum Vitae and list of publications. Do not hesitate to contact me for any clarifications or further information. I hope to hear from you soon.

Yours Faithfully,

Niall Murphy

Journal Papers

[1] Niall Murphy, Thomas J. Naughton, Damien Woods, Beverley Henley, Kieran McDermott, Elaine Duffy, Peter J. M. van der Burgt, and Niamh Woods. Implementation of a model of physical sorting. *International Journal of Unconventional Computing*, 4(8):3–12pp, 2008.

[2] Niall Murphy and Damien Woods. A characterisation of NL using membrane systems without charges and dissolution. *Natural Computing*, 2010. (Invited) *In review.* A much improved version of [6].

[3] Antonio E. Porreca and Niall Murphy. First steps towards linking membrane depth and the Polynomial Hierarchy. *Romanian Journal of Information Science and Technology*, 2010. Invited to a special issue. *In review.* Journal version of [15].

Conference Papers

[4] Niall Murphy, Thomas J. Naughton, Damien Woods, Beverley Henley, Kieran McDermott, Elaine Duffy, Peter J. M. van der Burgt, and Niamh Woods. Implementations of a model of physical sorting. In *From Utopian to Genuine Unconventional Computers*, pages 79–99. Luniver Press, 2006.

[5] Niall Murphy and Damien Woods. Active membrane systems without charges and using only symmetric elementary division characterise P. In *WMC 2007 Revised Selected and Invited Papers*, volume 4860 of *LNCS*, pages 367–384. Springer, 2007. (For a more recent version see [12]).

[6] Niall Murphy and Damien Woods. A characterisation of NL using membrane systems without charges and dissolution. In *Unconventional Computation 7*, volume 5204 of *LNCS*, pages 164–176. Springer, 2008.

[7] Niall Murphy and Damien Woods. On acceptance conditions for membrane systems: characterisations of L and NL. In *The Complexity of Simple Programs 2008*, volume 1, pages 172–184. EPTCS, 2009. arXiv:0906.3327v1 [cs.CC] (For a more recent version see [12]).

[8] Niall Murphy and Damien Woods. Uniformity: Uncovering the frontier of parallelism. In *Proceedings of the 10th Workshop on Membrane Computing*, pages 556–560, 2009. (Invited).

[9] Niall Murphy and Damien Woods. Uniformity conditions in natural computing. In *Proceedings of DNA16*, 2010. To appear, an older version is available [13].

[10] Niall Murphy, Damien Woods, and Thomas J. Naughton. Bio-computation using holliday junctions. In *4th Conference on the Mathematical Foundations of Computer Science and Information Technology (MFCSIT)*, pages 317–320, Cork, Ireland, August 2006.

[11] Damien Woods, Niall Murphy, Mario J. Pérez-Jiménez, and Agustín Riscos-Núñez. Membrane dissolution and division in P. In *Unconventional Computation 8*, volume 5715, pages 262–276, 2009.

Thesis

[12] Niall Murphy. *Uniformity conditions for membrane systems: Uncovering complexity below P.* PhD thesis, National University of Ireland Maynooth, 2010.

Technical Reports

[13] Niall Murphy and Damien Woods. The computational complexity of uniformity and semi-uniformity in membrane systems. In *Proceedings of the 7th Brainstorming Week on Membrane Computing: Volume 2*, pages 73–84, 2009.

[14] Niall Murphy, Damien Woods, and Thomas J. Naughton. On the computational complexity of photosynthesis. Technical Report NUIM-CS-TR-2005-03, Department of Computer Science, National University of Ireland Maynooth, Ireland, September 2005.

[15] Antonio E. Porreca and Niall Murphy. First steps towards linking membrane depth and the Polynomial Hierarchy. In *Proceedings of the 8th Brainstorming Week on Membrane Computing*, 2010.

Journal Papers in preparation

[16] Niall Murphy and Damien Woods. Active membrane systems without charges and using only symmetric elementary division characterise P. 201? *In preparation* Improved version of [5] see [12] for a more recent version.

[17] Niall Murphy and Damien Woods. On acceptance conditions for membrane systems: characterisations of L and NL. 201? *In preparation.* Improved version of [7] see [12] for a more recent version.

Curriculum Vitae : Niall Murphy

http://www.cs.may.ie/~nmurphy

Date of birth: 9th June 1983
Nationality: Irish

Goal:

A postdoctoral position in a world class research group that uses computer science to learn about the physical world.

Career:

- *Post-doctoral researcher, Science Foundation Ireland.*
  March 2010 – August 2010
  Digital Hologram Image Processing
  http://www.digitalholography.eu

- *Visiting Researcher.*
  October 2008 – present
  Research Group on Natural Computing, University of Seville, Spain
  http://www.gcn.us.es

- *Ph.D. National University of Ireland Maynooth*.
  September 2005 – October 2009 (oral exam March 2010)
  "Uniformity conditions for membrane systems: Uncovering complexity below P"
  http://www.cs.may.ie/~nmurphy

- *Software developer - IBM Lotus Dublin Software Lab.*
  September 2004 - September 2005
  Developed Workplace Managed Client applications and development tools.
  http://www.alphaworks.ibm.com/tech/wmctoolkit
  Mentored new interns.

- *IBM Extreme Blue Internship, Lotus Dublin Software Lab.*
  June 2004 - September 2004
  http://www.ibm.com/extremeblue
  Worked in a team to automatically translate VB6 projects to Java.

- *B.Sc. Computer Science & Software Engineering (1st Class), NUI Maynooth,*
  September 2000 - July 2004.
  Final Project: Java simulation of a super-Turing optical model of computation.

Tuition and teaching assistant:

- *Theory of Computation:* Tutor, provided & demonstrated solutions to problem sets.
  - Formal Languages, automata, Turing machines, computability, complexity, NP completeness.
- *Introduction to Computer Science:* Tutor, provided & demonstrated solutions to problem sets.
  - Formal languages, regular expressions, context-free grammars, finite automata, push-down automata; and basic programming.
- *Functional Programming:* Head demonstrator, provided & explained solutions to problem sets.

Awards:

- Nominated for Best Student Paper award DNA 16, 2010
- Postgraduate scholarship: IRCSET - Embark Initiative, 2005 – 2009 (http://www.ircset.ie/)
  A very competitive funding programme for Ph.D. students from all fields of Science and Engineering.
- Earned highest possible annual bonus in IBM 2005
- Extreme Blue internship, IBM - 2004 (http://www.ibm.com/extremeblue)
  A competitive international competition to prototype new technologies for IBM
- First class honours Bachelor's degree, NUI Maynooth, 2004

Research projects:

- "Real 3D – Digital holography for 3D and 4D real-world objects' capture, processing, and display" http://www.digitalholography.eu (contract researcher).

Reviewing:

- International Journal of Unconventional Computation
- Complexity of Small Programs 2008
- Unconventional Computation 2007

Edited Volumes:

- The Complexity of Simple Programs, 2008. EPTCS volume 1 and Cork University Press

References

- **Damien Woods** (Thesis Supervisor) woods@caltech.edu
  Senior Postdoctoral Scholar in Computer Science, Division of Engineering & Applied Science, California Institute of Technology, CA, USA.
- **Petr Sosík** (Thesis examiner) petr.sosik@fpf.slu.cz
  Associate Professor, Silesia University Opava, Czech Republic.
- **Thomas J. Naughton** (Thesis Supervisor , Current Employer) tomn@cs.nuim.ie
  Senior Lecturer , Department of Computer Science, National University of Ireland Maynooth , Ireland.