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An explanation of any relevant background

My background in category theory comes, in the first instance, from my time in Cambridge's Part III Maths course. There I learned the basics by taking Peter Johnstone's course in the subject. In the year after Part III, I learned about higher category theory on my own largely from reading Tom Leinster's *Higher Operads, Higher Categories* and using this knowledge to explore topics covered on the n-Category Café. This interest was one of the reasons I applied to do a PhD in applying category theory to the realm of computational complexity. In my current research, category theory is central, with a special class of comonads being the focus of my work. I also keep up to date with developments in higher category theory by attending the weekly category theory seminar here in Cambridge.

Alongside this I have a good knowledge of complexity and computability theory (pertinent to Pieter Hofstra's project) through a number of graduate and undergraduate courses here at Cambridge (including Part III Logic and Quantum Computing courses and Part II Logic & Set Theory and Formal Languages and Automata.) In addition, the logic and algorithms group (and reading circle) in my department has given me opportunities to develop my knowledge of complexity theory, and in the last few months I have studied dichotomy results in CSPs and given talks on complexity of Graph CSPs and Holant problems.

Expected PhD Completion: 2021-21

PhD Topic: Investigating the novel connection between logic, algorithms and category theory provided by Dawar and Abramsky's k-Pebbling Comonads and attempting to construct from this a general algebraic framework for transferring algorithmic complexity bounds between Graph Isomorphism and Constraint Satisfaction Problems

Order of project preference:

1. Pieter Hofstra: *Complexity classes, computation, and Turing categories* **(strong preference)**
2. Miriam Backens: *Simplifying quantum circuits using the ZX-calculus*
3. David Spivak: *Toward a mathematical foundation for autopoiesis*

Commitment to coming to Oxford: I can commit to coming, even without funding. I live in Cambridge (which is a gruelling but cheap bus ride away) and I have contacts to stay with in Oxford.

Interest Statement for ACT2019 School

I've been interested in the field of ACT and the surrounding community since I started learning category theory and have, since then, been keen to get involved in something such as the Adjoint School. Having started a PhD this year in which I aim to apply category theory to problems in logic and algorithms, I think I would benefit a lot from taking part this year.

In particular, I believe the main benefits of my taking part in this programme would be learning about a key piece of theory with similar aims to my current research, deepening my knowledge of category theory itself and meeting people working in ACT with whom I could learn from and collaborate with in the future.

Firstly, the subject of the Pieter Hofstra's project for the Adjoint School is something which I am very interested in learning about. Turing Categories are a promising attempt at capturing computability and complexity in categorical terms and this is directly complementary to my proposed research which uses category theory to analyse certain algorithms for CSP and Graph Isomorphism. Participating in this project would thus give me an important and hopefully fruitful new perspective on my own work.

Secondly, as a first year PhD student, I would benefit a lot from the opportunity to learn more in general about category theory. In particular, as my activities in the department and with my supervisor so far have largely focused on the logic and finite model theory aspects of my research and I would benefit from working on a category theory project.

Finally, the Adjoint School represents an excellent opportunity to join a community of researchers who are working on applying category theory across science and engineering. As this is an area I hope will be central to my career, this network of colleagues and potential collaborators would be an excellent source of inspiration and motivation for my work.

ADAM Ó CONGHAILE

St. Catharine's College, Cambridge
ac891@cl.cam.ac.uk

EDUCATION

Computer Laboratory, University of Cambridge
PhD in Computer Science (1st Year) *October 2018 - Present*
Topic: Comonadic Constructions in Finite Model Theory
Supervisor: Prof. Anuj Dawar

Department of Mathematics, University of Cambridge
MMath in Mathematics (Part III) *June 2017*
Result: Distinction
Courses in: Logic, Category Theory, Quantum Computation

BA in Mathematics *June 2016*
Result: 1st (Part IA), 2.i (Parts IB, II)

Coláiste Chiaráin Community School, Leixlip, Ireland
Leaving Certificate (625/625 points) *June 2013*

FUNDING & AWARDS

3+ Years EPSRC Grant: For research proposal written with Anuj Dawar. *2018*

Christ's College Graduate Scholarship: For outstanding exam performance in MMath. *2017*

Christ's College Scholarship: For outstanding exam performance in BA. *2014*

Honourable Mention, International Maths Olympiad *2013*

Irish National Team Member for Maths, Science and Linguistics Olympiads. *2010-13*

RESEARCH ACTIVITIES

Project on Applying Category Theory to Finite Model Theory *October 2018 - Present*
with Anuj Dawar & Samson Abramsky

- Investigating coKleisli categories of game comonads and their relationship to finite variable logics.
- Searching for new proofs of homomorphism preservation theorems using a category-theoretic perspective

Reading Group on Complexity of CSPs *October 2018 - Present*
with Computer Lab Logic & Algorithms Group

- Studied algebraic methods used to prove upper and lower bounds for complexity of Constraint Satisfaction Problems, through weekly paper readings and presentations.
- Gave hour-longs talks on Algebraic Results in Digraph CSPs and The Complexity of Holant Problems.
- Wrote notes on topics presented and gained insight into recent success in CSP Dichotomy Theorems.

OTHER ACTIVITIES & EXPERIENCE

Academia Undergrad supervisor, VP of The Archimedean's (2016), assistant editor of Eureka (2015)
Industry 12 months working for start-up applying algorithmic game theory to auction design.
Hobbies Amateur actor and mid-distance runner, avid reader and cook, speaker of Irish and French.

Gmail **Applied Category Theory <act2019school@gmail.com>**

Adam ó Conghaile

1 message

Anuj Dawar <anuj.dawar@cl.cam.ac.uk> Mon, Jan 28, 2019 at 1:33 PM
Reply-To: anuj.dawar@cl.cam.ac.uk
To: act2019school@gmail.com

I am writing in support of the application by my PhD student, Adam ó Conghaile, to take part in the ACT 2019 school.

Adam is a first-year PhD student who is working on a project aimed at developing the ideas first proposed in my joint work with Samson Abramsky (at LICS 2017). This paper aimed to apply category-theoretic methods to the study of some standard constructions in finite model theory and descriptive complexity. When we wrote the paper, we felt that there is scope for synergy in the two fields, especially in understanding the methods of finite model theory in a more abstract setting. There is a lot more to be done in this area and I was very fortunate to find, in Adam, a student interested in taking this further. Adam has the ideal background in Category theory, having studied it as part of his course in Part III Mathematics at Cambridge, and obtained a distinction.

Adam has been working with me since the beginning of October and I have not been disappointed. He has very quickly mastered large swathes of the literature in finite model theory and he has been teaching me category theory at the same time. I feel that he is already ready to start making research contributions.

The school in Applied Category Theory would be an ideal setting for Adam to develop his knowledge and skills in the subject further. The project on Turing Categories intersects particularly well with his research project. Adam is a very able, enthusiastic and dedicated student and I know he will make a great contribution to the course if he is afforded the chance.

Please do let me know if you require any further information from me.

Best wishes,
-Anuj Dawar.

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