Application to ACT2019 school

Tiago João Páscoa Costa
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During my masters, I had some courses in Functional Analysis, Topology, Measure Theory, and elementary set theory. Recently I began studying category theory on my own, with the purpose of eventually using it as a means to study the interaction between behaviour and brain activity. In particular, how the architecture of a network is transposed into function. I expect to finish my PhD by 2023.
I have funding for flights and stay if no fellowships become available.

Order of preferred projects:

1) Toward a mathematical foundation for Autopoiesis

2) Formal and Experimental methods to reason about dialogue and discourse using categorical models of vector spaces

3) Partial evaluations, the bar construction, and second-order stochastic dominance

4) Complexity classes, computation, and Turing categories

5) Traversal optics and profunctors

6) Simplifying Quantum circuits using the ZX – Calculus

Statement of Purpose

To whom it may concern,

I began my studies in Biochemistry. When I was finishing my bachelors degree, I felt that a more fundamental understanding of Biology required me to improve my quantitative skills. With the idea of approaching biochemistry from a formal perspective, I went on to study mathematics. During my masters in mathematics, I was able to explore several problems in different fields such as stochastic differential equations, and more applied ones like epidemiology, and environment macroeconomics.

One of the questions that most fascinated me was how the nervous system is able to perform such diverse and complex functions. Motivated by these thoughts and spurred by my new found passion for mathematics, I applied to a PhD in Neuroscience at the Champalimaud Center for the Unknown with the goal of working with Gonzalo de Polavieja and Alfonso Renart.

During the first year I worked in modeling collective behaviour in fish with deep reinforcement learning and on auditory decision making. Working on those projects allowed me to think more profoundly about the interaction between behaviour and brain activity, and lead me to study the way in which different aspects of the architecture of biological and artificial neural networks are related to their function.

Eventually I discovered the works of Robert Rosen, and quickly became fascinated with how elegant was his solution of using categories to solve the problem of the infinite regress. Further reading of more current applications of category theory led me to believe that this field might be essential to better understand the interaction between the behaviour of a system and organization of its corresponding parts.

Similarly to the way in which I once ventured from biochemistry into mathematics, I now think that category theory is the next step in my academic studies. As such, the ACT2019 school seems to be a perfect match to my research goals.

Looking forward to hearing from you,
Best regards,
Tiago Costa

Tiago João Páscoa Costa

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Education:

- Champalimaud Research, Champalimaud Centre for the Unknown, Lisbon
  01/2017 - Present

  INDP PhD Neuroscience Student at the Circuit Dynamics and Computation, and Collective Behaviour Laboratories, under the guidance of Alfonso Renart and Gonzalo G. de Polavieja.

- Faculty of Sciences and Technologies, New University of Lisbon,
  09/2012 - 12/2015

  MSc. In Mathematics and Applications – Numerical Analysis and Differential Equations

  - Thesis: Large Deviations Principle for stochastic flows of viscous fluids under the guidance of Professor Fernanda Cipriano PhD
    (Key words: Fluid Dynamics, Stochastic analysis, Measure Theory)

- Faculty of Sciences and Technologies, New University of Lisbon,
  09/2008 - 07/2012

  Bsc. In Biochemistry

  - Final Project: Development of an algorithm for analyzing the morphology of Protein-Protein interfaces, under the guidance of Professor Ludwig Krippahl PhD
    (Key words: Structural Biochemistry, Bioinformatics)

Professional Experience:

- Nova School of Business & Economics 12/2015 – 12/2016

  Research fellow in the project "The Economic Valuation and Governance of Marine and Coastal Ecosystem Services", under the guidance of Professor Renato Rosa PhD, and Professor Antonieta Cunha e Sá PhD.

  - Analysis of the stochastic sardines' population model with an optimal Harvest control rule.

    (key words: Recurrence Relation, Macroeconomics, Econometrics)

- Center of Mathematics and Applications, Faculty of Sciences and Technologies, New University of Lisbon, 03/2014 - 07/2015

  Research fellow in the project EXPL/MAT – CAL/0794/2013 "Game Theory and Epidemiology, under the guidance of Professor Paula Rodrigues PhD and Professor Fabio Chalub PhD.

  - Analysis of the spatial model SIR discretized, in which was introduced vaccination
    (Key words: Partial Differential Equations, Modeling in Epidemiology, Game Theory)

- Faculty of Sciences and Technologies, New University of Lisbon, 02/2015 - 07/2015

  Teaching Assistant in the course Mathematical Methods in Epidemiology,

  - Mathematical Modeling in Epidemiology.

  Head Professor, Paula Rodrigues PhD

- Faculty of Sciences and Technologies, New University of Lisbon, 09/2011 - 12/2011

  Teaching Assistant in the course, Enzyme Kinetics

  - Mathematical Modeling in Enzyme Kinetics.

  Head Professor, Teresa Moura PhD

- Plant Cells Biotechnology Laboratory – Institute of Chemical and Biological Technology, New University of Lisbon, 09/2011 - 07/2012

  Research internship in Molecular Biology under the guidance of Sofia Duque PhD.

  - Genetic Manipulation of *Medicago Truncatula* to increase resistance to water stress

Scientific Papers:

- Fernanda Cipriano, Tiago Costa, 2018. A large deviations principle for stochastic flows of viscous fluids with Irregular Drift, Journal of Differential Equations, 2018
- Pardo-Vazquez, J. L., Castineiras J., Valente M., Costa T. & Renart A., 2018. *Weber's Law is the result of exact temporal accumulation of evidence.* bioRxiv, 333559 (submitted)
- *T. Costa, R. Rosa, R. Gama, A. Cunha e Sá. Incorporation economics into fishery policies: developing integrated ecological-economics Harvest Control Rules (submitted)*
- T. Costa, A. Laan, G. de Polavieja*. Automatic Discovery of local rules for desired collective-level behavior through policy gradient learning. (in preparation)*
- F. Chalub, T. Costa, P. Patrício. Vaccination Schemes in Spatial SIR Models *(In preparation)*

Personal Skills:

Linguistics:	Portuguese – Native language English – Proficiency written and oral (106 TOEFL)
Informatics:	MS Office, LateX, Matlab/Octave, Python
Organizational:	Organizing committee of Jortec (Biochemistry), technological journeys, Faculty of Sciences and Technologies, New University of Lisbon - 2009
Hobbies:	Surfing, Rock Climbing, Playing guitar and Piano, Project Euler/Code chef

Champalimaud Foundation

Letter of recommendation for Tiago Costa

30th January 2019

I write to recommend Tiago Costa for ACT 2019. Tiago did his BSc in Biochemistry, and since has been working in applying mathematics to biological problems. He did an 'MSc in Mathematics and Applications' and he is now in our PhD programme at Champalimaud Foundation in Lisbon.

During his MSc and first year of compulsory PhD courses, Tiago has been working in several labs, giving him experience in stochastic differential equations, game theory, decision-making theory, epidemic modelling, deep learning and reinforcement learning. This work has lead to five manuscripts (one published and three submitted).

For the PhD, he needs to propose a project by June 2019, approximately. Together with me, and his other PhD supervisor (Alfonso Renart), we have been looking at which mathematics could be insightful to describe organisational principles in brain activity and behaviour. Among others, we studied the work of Rosen, Spivak and Baez, for example, and find the prospect of applying category theory very exciting.

Neither the supervisors (me and Alfonso) nor Tiago, have received formal training in category theory. We think Tiago is well positioned, given this background in both Biology and Mathematics, to learn how to apply category theory in several contexts at ACT 2019. This will have a strong impact in his PhD work, that we hope will be geared towards an effort to make applied category theory relevant for concrete behavioural and brain activity data.

For these reasons, I very strongly support Tiago Costa for ACT 2019. We can fund flights and stay if no fellowships become available.

Please, do not hesitate to contact me for more information.

Yours sincerely,

Gonzalo G. de Polavieja
PI of Collective Behavior Group, Champalimaud Neuroscience Programme
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