Bruno Gavranović

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Computer Science student interested in the intersection of category theory and machine learning

Experience

Strongly Typed
Zagreb, Croatia

Backend Haskell developer — *Sep. 2018. - Present*

- Backend developer working on a fleet-management system for restaurant delivery
- Working on delivery optimization, integration with SQL and various web services, compositional pseudonymization, logging

Petnica Summer School of Machine Learning
Petnica, Serbia

Invited speaker, Mentor — *2017.,2018.*

- Held a lecture and workshop on Generative Adversarial Networks
- Mentored several teams in implementing various neural network architectures

TakeLab (Text Analysis and Knowledge Engineering Lab)
Zagreb, Croatia

Master student under the supervision of assoc. prof. dr. sc. Jan Šnajder — *Sept. 2015 - present*

- Research laboratory specializing in Natural Language Processing, Machine Learning and Text Analytics
- Completed several projects as a part of the university curriculum

Projects

Framework for automatic differentiation
Zagreb, Croatia

Open source project — *Mar. 2017. - Jan. 2018.*

- Developed an efficient, general TensorFlow-like framework for backpropagation in Python
- Implemented dynamic computational graphs, higher order derivatives, tensor differentiation and more

Reimplemented a dozen of state of the art deep learning papers and frameworks
Zagreb, Croatia

Highlights include — *Feb. 2017. - Present*

- **Backprop as Functor**: Haskell implementation of a category-theoretic formulation of neural networks
- **Differentiable Neural Computer**: DeepMind's 2016 Nature paper, neural network architecture capable of learning algorithms
- **Generative Adversarial Networks**: DCGAN, Wasserstein GAN, CycleGAN and others
- **Decoupled Neural Interfaces**: a novel approach to distributed training of networks

Education

Faculty of Electrical Engineering and Computing, University of Zagreb
Zagreb, Croatia

Master studies, Computer Science — *2016. - present*

Undergraduate studies, Computer Science — *2013. - 2016.*

Additional education, awards & recognition

2018. **Presentation,** 2nd Symposium on Compositional Structures,*Compositional Deep Learning* — *Glasgow, UK*

2018. **Participant,** Applied Category Theory workshop — *Leiden, Netherlands*

2017. **AI Grant finalist,** Reducing research debt by clearly communicating ideas in deep learning

2012. **Honorable mention,** 6th International Olympiad on Astronomy and Astrophysics — *Rio de Janeiro, Brazil*

Knowledge & Abilities

Technical skills

- **Programming:** Haskell, Python, Java, Idris, SQL, C
- **Other:** reading research papers, linux, git, vim, zsh, PyTorch, TensorFlow

Languages

- English (C1.1), Spanish (B1), Croatian (Native)

Interests & Activities

Interests Category Theory, Optimizing workflow, Self-improvement, Piano, Guitar

Misc. Alumni of BEST (Board of European Students of Technology)

Member of the winning team in the Red Bull Gravity Challenge — *Zagreb, 2015.*

Jan Šnajder
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Zagreb, 30 January 2019

RE: Letter of recommendation for Mr Bruno Gavranovic

Dear ACT2019 organizers,

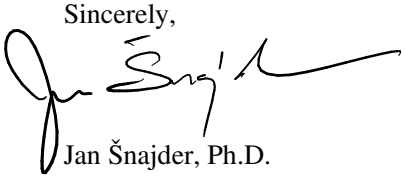
I am writing this letter in support of Mr Bruno Gavranovic's application to ACT2019. I am basing my assessment on my experience as a teacher, a supervisor to over one hundred bachelor and master level students of Computer Science, and a supervisor to ten PhD students.

I have known Bruno for three years now in my capacity as his teacher and supervisor at the Faculty of Electrical Engineering and Computing, University of Zagreb. During that time, Bruno took four of my classes: Artificial Intelligence, Machine Learning, Text Analysis and Retrieval, and Programming in Haskell course, all of which are rather comprehensive and demanding. He performed excellent on all four courses. Bruno is currently finishing his master studies in Computer Science under my supervision, with expected graduation in June 2019.

About two years ago, Bruno developed a keen interest in deep learning, and joined us on our internal seminars to present and discuss state-of-the-art papers in the field. At about the same time, he completed my Programming in Haskell course, where we mentioned in passing the links between functional programming and Category Theory. Bruno seems to have been intrigued by that short exposition, and since embarked on a self-study in Category Theory. Subsequently, he became interested in the links between deep leaning and Category Theory, and has been studying this topic on his own for about a year now. The result of his endeavor is a research paper which Bruno submitted to this year's International Conference on Machine Learning (currently under review), where he reformulated a small portion of deep learning in terms of Category Theory.

The above activities and results are a clear demonstration of Bruno's proactiveness, motivation, and keen interest in the field of Category Theory and its applications. The fact that he – completely on his own – came to the idea of applying Category Theory to deep learning, and managed to articulate his ideas in a research paper which he submitted, is a definite proof of his research potential. I therefore consider Bruno an ideal candidate for your school, and wholeheartedly recommend him for ACT2019. If you should require any additional information, please feel to contact me.

Sincerely,



Jan Šnajder, Ph.D.
Associate Professor

Bruno **Gavranović**

Computer Science student at University of Zagreb ·

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January 30, 2019

Application for the Applied Category Theory 2019 School

Brief statement of interest

Hi! I'm Bruno and I'm a Computer science student at the University of Zagreb, at Faculty of Electrical Engineering and Computing. At the moment I'm finishing the last year of my master studies and I'm expecting to graduate in June this year.

I'm certain beyond any doubt that I want to be studying nature's machinery using the most universal language possible. I'm interested in understanding and designing large-scale systems while carefully managing their complexity and emergent behaviour. Category theory seems like the best language we have so far to do those things.

I've been falling down the rabbit hole of both functional programming and category theory for the past year and a half. I'm mostly self-taught and I'm trying to seize every opportunity to learn from excellent researchers.

During my master studies I've been focusing on understanding the fundamental principles behind various types of neural networks. Together with category theory endeavours, this culminated with me giving a talk at SYCO2 on *Learning functors using gradient descent* and very recently with my submission to the International Conference of Machine Learning on the same topic.

How can this school help me in my career? How can this school contribute to my research goals?

I'm currently 24. I have about 50-60 years more of using various compositional constructions in my research. Learning and internalizing these categorical structures as early as possible will enable me to recognize them in various processes (physical, biological, digital) I will surely encounter in that time and use them to, hopefully, solve some real-world problems. ACT school has the potential to catalyse that process and enable me to meet and network with people who are interested in the same things.

I'm especially interested in two topics: David Spivak's topic on autopoietic organizations and Bartosz' topic on profunctor optics. Both of these sound very intriguing and and relate to my interests in the both the short and the long run. The school could push me in the right direction by allowing me to communicate with the experienced mentors, learn how to approach and solve this kinds of problems.

Other required information

Relevant background in CT or any of the specific project areas.

I have a rudimentary knowledge in CT, which mostly comes from reading "Seven Sketches in Compositionality", "Category theory for Programmers" and watching Bartosz' Youtube lectures on both Haskell and Category theory.

To give a sense of my knowledge, I feel I can comfortably talk about: categories, functors, natural transformations, limits (terminal objects, products, pullbacks, equalizers) and the corresponding duals, adjunctions, monoidal categories, quotient categories, monads, enriched categories and functor categories. I also have a very rudimentary understanding of 2-categories.

I'm also employed as a Haskell developer; I have a solid understanding of functional programming in practice. I'm comfortable using monads, lenses and type-level programming. I'm also experimenting with programming with dependent types in Idris.

The date you completed or expect to complete your Ph.D and a one-sentence summary of its subject matter.

I'm still finishing my master studies. My master thesis is still not formally specified, but it will be on the topic of *Compositional Deep Learning*. I hope to continue the work I've presented at SYCO2 and understand what compositional structures exist in various neural network architectures.

Order of project preference:

1. Toward a mathematical foundation for autopoiesis
2. Traversal optics and profunctors
3. Formal and experimental methods to reason about dialogue and discourse using categorical models of vector spaces
4. Complexity classes, computation, and Turing categories
5. Partial evaluations, the bar construction, and second-order stochastic dominance
6. Simplifying quantum circuits using the ZX-calculus

To what extent can you commit to coming to Oxford (availability of funding is uncertain at this time).

I can fully commit to coming to Oxford.

Sincerely,

Bruno Gavranović