Supporting Document for ACT2019 School Application

Yanying Wu

12 Jan. 2019

An explanation of my background in category theory

I haven't got any chances to learn category theory formally in a mathematical department. I got to know category theory in early 2018 and have been learning this fascinating subject by myself since then.

I have read/watched the following relevant materials:
(1) What is category theory *by Giandomenico Sica (Editor)*
(2) What is applied category theory *by Tai-Danae Bradley*
(3) An introduction to category theory *by Harold Simmons*
(4) Introduction to category theory videos [x6] *by Steven Roman*
(5) Category theory for scientists *by David Spivak*
(6) Categories for the practising physicist *by Bob Coecke et al.*
(7) Category theory for genetics *by Remy Tuyeras*
(8) Seven sketches in compositionality: an invitation to applied category theory *by Brendan Fong and David Spivak*
(9) Seven sketches in compositionality lecture videos [x21] *by Brendan Fong and David Spivak*
(10) Category theory in λC 2017 videos [x6] *by David Spivak*
(11) The Catster's category theory videos [x74] *by Eugenia Cheng and Simon Willerton*
(12) Category theory in life video *by Eugenia Cheng*
(13) Category theory for programmers videos I [x20], II [x18] and III [x14] *by Bartosz Milewski*
(14) A crash course in category theory video *by Bartosz Milewski*
(15) Applied category theory online course [77 lectures] *by John Baez*
(16) Physics, Topology, Logic and Computation: A Rosetta Stone *by John Baez*
(17) Props in network theory *by John Baez et al.*
(18) Network theory seminar videos [x5] *by John Baez*
(19) ACT2018 -- Props in network theory video *by John Baez*
(20) ACT2018 -- Towards a categorical approach to neuroscience video *by Kathryn Hess*
(21) ACT2018 -- A higher-order temporal logic for dynamical systems video by *David Spivak*
(22) Mathematical Foundations for a Compositional Distributional Model of Meaning *by Bob Coecke et al.*
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Also, I tried but felt a bit too hard to digest/finish the following:
(a) Categories for the working mathematicians *by Saunders Mac Lane*

(b) Category theory in nLab
(c) Picturing Quantum Processes: A First Course in Quantum Theory and Diagrammatic Reasoning *by Bob Coecke and Aleks Kissinger*

About my PhD degree
I got my PhD degree on 6th of Jan., 2013.
The subject was a study of neural circuit mechanism underlines reversal learning in *Drosophila.*

Order of project preference
(1) David Spivak: Toward a mathematical foundation for autopoiesis
(2) Bartosz Milewski: Traversal optics and profunctors
(3) Mehrnoosh Sadrzadeh: Formal and experimental methods to reason about dialogue and discourse using categorical models of vector spaces

My commit to coming to Oxford
Luckily for me, I live in Oxford.

A brief statement on why I am interested in the ACT2019 school
To uncover the secret of human intelligence has long been my central research interest. Holding the belief that the study on a less complex model organism may provide us with a better chance of understanding biological intelligence systematically, I spent the past 12 years doing loads of experiments in *Drosophila* labs, trying to explore the mechanisms of learning and memory in fruit-fly at different levels: from gene, neural circuit up to behaviour.

My hard work did gain us some new knowledge about learning and memory. In my PhD project I identified a pair of GABAergic neurons being critical for reversal learning and later during my postdoc research I discovered a gene which plays an essential role in long-term memory in the fly brain. However, these are only 2 small pieces of knowledge for neuroscience. And my initial ambition for a systematic understanding was almost completely unfulfilled. On the other hand, I deeply realized that even a fly's brain is far from being simple at all! In fact it contains daunting complexity beyond our limited imagination. Undoubtedly our experimental efforts will proceed, but I started to seek after something else.

For a while I hold the vague idea that we need some powerful mathematical tools to help us dealing with this incredible intricacy of the brain, and it only became clear when I got to know the existence of category theory and its amazing power from a friend doing quantum computation in early 2018. I felt like being enlightened and began to learn the subject by myself. It's a bit hard for me but I couldn't stop as I sensed category theory will be extremely useful for my biological research.

To my delight, many professional mathematicians are now taking serious efforts to make category theory accessible to the laymen like me. This new interdisciplinary field of applied category theory is blooming vigorously under their fostering. I am strongly encouraged by all these, and I am eager to join the community.

That's why I am applying for the ACT2019 school.

I am particularly interested in the project "Toward a mathematical foundation for autopoiesis" led by Dr David Spivak. As I have been studying *Drosophila* for many years, I am super curious in knowing how behavioural mereology and graphic logic could help me better understand my favourite autopoiesis organization – the fruit-fly.

Yanying Wu, PhD

Email: yanying.wu@cncb.ox.ac.uk

Education

2006 ~ 2013 **Ph.D. in Neurobiology**

Institute of Neuroscience, Chinese Academy of Sciences

1996 ~ 2000 **B.S. in Computer Science**

Fudan University, China

Work Experience

2013 ~ Now **Postdoc Research Fellow**

Centre for Neural Circuits and Behaviour (CNCB)

Department of physiology, anatomy and genetics, University of Oxford, UK

2005 ~ 2006 **Research Assistant**

Institute of Neuroscience, Chinese Academy of Sciences

2004 ~ 2005 **Software Engineer**

Intel Shanghai Software Center, China

2000 ~ 2004 **Software Engineer**

Ericsson Telecom Software Research & Development (Shanghai) Ltd., China

Research Experience

2018 **Single cell RNA-seq data analysis; implemented an deep autoencoder for dimension reduction using Keras/Tensorflow**

CNCB, University of Oxford, UK

2013 ~ 2018 **Behavior screening for long-term memory related genes in *Drosophila*, and functional characterization of the gene *unextended(uex)* using genetic, molecular and gene editing tools**

CNCB, University of Oxford, UK

2008 ~ 2012 **Neuronal mechanism of olfactory reversal learning in *Drosophila***

Institute of Neuroscience, Chinese Academy of Sciences

2006 ~ 2008 **Platform setup for *in-vivo* Ca^{2+} imaging in the fly brain**

Institute of Neuroscience, Chinese Academy of Sciences

Publications

2019 Yanying Wu, Yosuke Funato, Paola Cognigni, Oliver Barnstedt, Francisco J Arjona, Joost G. J. Hoenderop, Hiroaki Miki & Scott Waddell, ***The evolutionarily conserved magnesium transporter uex supports normal and enhanced long-term memory in Drosophila***, in preparation

2019 Irmgard U. Haussmann, Yanying Wu, Nathan Archer, Mohanakarthik P. Nallasivan, Zsuzsanna Bodi, Daniel Hebenstreit, Scott Waddell, Rupert G. Frays & Matthias Soller, ***Cap 2'-O-ribose methylation in messenger RNA is required for reward learning in Drosophila***, in preparation

2019 Yanying Wu, Christoph Treiber, Vincent Croset & Scott Waddell, ***The Drosophila mid-brain revisited, from PCA to Autoencoder***, in preparation

2012 Yanying Wu, Qingzhong Ren, Hao Li & Aike Guo, ***The GABAergic anterior paired lateral neurons facilitate olfactory reversal learning in Drosophila***, Learning and Memory, 19:478-486

2012 Qingzhong Ren, Hao Li, Yanying Wu, Jing Ren & Aike Guo, ***A GABAergic Inhibitory Neural Circuit Regulates Visual Reversal Learning in Drosophila***, Journal of Neuroscience, 32:11524-11538

Professional Skills

Experimental Biology: ·12+ years of *Drosophila* lab work

·*Drosophila* genetics

·Molecular cloning and CRISPR/Cas9 gene editing

·Basic biochemistry and immune-staining techniques

·Behavior assay of *Drosophila* olfactory learning and memory

Computer Science: ·Computer Science Major Course GPA 3.8/4.0, top 5%

·5 years of software development in leading IT companies

·Assistant tutor for course: *Python for biologists*, 2018

·National Senior C Programmer Certificate, 1997

·National C Programmer Certificate, 1994

·The first prize in Shanghai City Senior High School Program Design Contest (C language), 1995

·The first prize in Shanghai City Youth Program Design Contest (PASCAL), 1994

·Programming languages: Python/R/C/ JAVA/SQL/PASCAL

Jan 15, 2019

To whom it may concern,

My name is Li Wei. I received my Ph.D. in Computer Science from University of California, Riverside in 2006. I currently hold a position of staff software engineer at Google Inc. I am very pleased to write this letter to support Dr. Yanying Wu's application for ACT 2019 school.

I first came to know Dr. Wu in 1996 when we were both college students in the Computer Science department, Fudan University, China. We spent four years together to pursue our bachelor's degree. During this period, I was really impressed by Dr. Wu. She is one of the smartest people I ever met. She could easily solve problems that took others hours to figure out. She was always curious in learning new things, especially subjects in Computer Science and Math. She also worked very hard, spending most of her time studying in the classrooms. Most importantly, she was very kind and always happy to help. I liked her so much that we became best friends.

After graduating as a top student, Dr. Wu worked as a software engineer in Ericsson Telecom Software Research & Development (Shanghai) Ltd. and Intel Shanghai Software Center for five years. Deep down in her heart, she felt intrigued in understanding human intelligence. She decided to follow her heart, quite her well-paid job, go back to school to pursue a Ph.D. in Neurobiology. I can't even imagine how hard it is to go back to school after working for five years, not to mention that she also switched the major completely from Computer Science to Neurobiology. However, Dr. Wu did it! Her story was legendary and well known.

Now Dr. Wu is a post-doc at Oxford University, doing research in neuroscience. She is looking for powerful mathematical tools to help her research. She feels that the topics in ACT 2019 school will be extremely useful. I believe that if you give her the opportunity, she will participate in the learning actively, and she will be able to apply them to her research to make even bigger impact. She has my strongest support to get admitted to ACT 2019. Please do not hesitate to contact me if you require any further information.

Best Regards,
Li Wei