Workshop proposal: Applied Category Theory

January 19, 2017

1 Organizers

1. John Baez (math)
2. Bob Coecke (physics and linguistics)
3. Brendan Fong (dynamical systems)
4. Aleks Kissinger, main contact (computer science)
5. Joshua Tan, main contact (computer science)

2 Scientific case

2.1 Scientific background

Category theory was developed in the 1940s to translate ideas from one field of mathematics, e.g. topology, to another field of mathematics, e.g. algebra. More recently, category theory has become an unexpectedly useful and economical tool for modeling a range of different disciplines, including programming language theory [**?**], quantum mechanics [**?**], systems biology [**?**], complex networks [**?**], database theory [**?**], and dynamical systems [**?**].

A category consists of a collection of objects together with a collection of maps between those objects, satisfying certain rules. Topologists and geometers often use categories as mathematical workspaces, while pure category theorists study them as their own mathematical structures. In computer science and physics, many categorical constructions (e.g. topoi, or Stone duality, or compact closed categories) are used to give a formal semantics of domain-specific phenomena (e.g. recursive types [**?**], or automata [**?**], or quantum protocols [**?**]).[1] In the applied category theory community, a long-articulated vision understands categories as mathematical workspaces for all sciences, not just topology and geometry [**?**]. While it is too early to say whether this vision will bear fruit,

[1] The categorical semantics is often preferable to set- or type-theoretic semantics in some way: for example, compact closed categories have an elegant graphical language in terms of string diagrams.

we do believe that category theory has the potential to bridge *specific* different fields, and moreover that developments in such fields (e.g. dynamical systems) can be transferred successfully into other fields (e.g. systems biology) *through* category theory.

Most extant applications of category theory outside of pure mathematics have used categories to *model* some phenomena, in the tradition of formal semantics. It is another, further step to use category theory as a *medium* for knowledge representation and integration, in the sense of a mathematical workspace. We believe... this is the future? ... this approach has been underrepresented? ... this topic has been largely unexplored? ... the difference is largely psychological, like the difference between classical and modern geometry? ... cited in early examples, like Baez's 'rosetta stone' [**?**]? ... is the language just convenient for manipulation, or are there real *theorems* that go between fields?

2.2 More on precedence

Dagstuhl?

2.3 Specific challenges and outcomes

This workshop will bring together both theorists and practitioners from a wide variety of disciplines to work on new applications of category theory in (1) dynamical systems and networks, (2) systems biology, and (3) cognition and AI, with a special focus on developing a community of early-stage researchers in applied category theory, and on fostering fresh dialogue between researchers working in different applications.

Some of the specific challenges and outcomes we wish to address include:

1. Computability: BRENDAN

2. Pedagogy: despite the flexibility and expressiveness of categorical tools in mathematics and computer science, the perceived difficulty of category theory has hindered wider acceptance of the formalism. As a consequence, many researchers in different communities share the feeling of under-exploitation of the potentialities of category theory to their areas of interest. We plan on addressing this problem over the tutorial weekend, and through the organization of the "Kan Extension Lab".

Other challenges, specific to each application area, include ??? (dynamical systems), ??? (dynamical systems), ??? (systems biology), and ??? (cognition and AI).

Our workshop will be considered a success if it results in joint research between researchers specializing in different applications (e.g. physics and biology, or economics and AI) or in research that carries over techniques from one application domain of category theory to another, and if the workshop introduces new people into the field.

2.4 Connection to the Dutch research community

ALEKS: in the Dutch applied category theory community... this would be Bart + Aleks at Nijmegen.

3 Program

3.1 Workshop week

The workshop highlights three particular applications of category theory: (1) to dynamical systems and networks, (2) to systems biology, and (3) to cognition and AI. While there will be a short introductory lecture for each application domain, the afternoons will intermix all three applications by focusing on common techniques (Monday and Wednesday), computational tools (Tuesday), common problems (Thursday morning), and common goals (Thursday afternoon) across all three.

3.2 Timetable

Time	Monday	Tuesday	Wednesday	Thursday	Friday
9:00 - 9:30	Arrival at Lorentz				
9:30 - 10:00		Systems Biology (Krivine)	Cognition and AI (Coecke)	?	
10:00 - 10:30	Welcome			?	
10:30 - 11:30	Dynamical Systems (Baez)			?	?
11:30 - 12:15		Discussion	Discussion	Discussion	Discussion
12:15 - 2:00	Lunch	Lunch	Lunch	Lunch	Lunch
2:00 - 3:00	Sheaves (Abramsky)	Comput-ation (?)	Monoidal (?)	???	???
3:00 - 3:45	Discussion	Discussion	Discussion	Discussion	Discussion
3:45 - 4:45			Boat trip and dinner		
4:45 - 5:30	Wine and cheese				

Each working day will include one keynote lecture during the morning that sets the stage for the day, followed by a "lightning round" of four 15-minute talks that delve into specific aspects of content in the keynote lecture. For example, on Tuesday, there will be a survey lecture by Jason Morton on computational category theory, followed by talks on ???, ???, and ???. These will be followed by four additional 15-minute talks in the early afternoon, which will present active areas of research in these topics. Each morning and afternoon will be closed by a problem session or an extended coffee break.

Overview:

3.3 Tutorial weekend

Immediately prior to the workshop, we will organize a 3-day weekend of tutorials targeted at graduate students and postdocs, though we envision more senior researchers who wish to broaden their horizons will also be interested in attending.

To supplement the tutorial weekend, we will host an online "Kan Extension Lab" for graduate students prior to the workshop, whose participants will then be invited to speak at either the tutorial weekend or at the workshop itself. The output of the Extension Lab will be published in a special issue of ???.

4 Participants

The estimated number of participants is 55. At the time of writing of this proposal, the planned workshop already has ?? confirmed participants with affiliations in the Netherlands, the UK, the US, and [...].

Confirmed participants for tutorial weekend: ??.

Junior/senior ratio: ??.

1. First Last (Affiliation), prof/PhD/postdoc, subject of expertise
2. Samson Abramsky (Oxford), prof, computer science
3. John Baez (UC Riverside), prof, math
4. Bob Coecke (Oxford), prof, computer science
5. Brendan Fong (MIT), postdoc, computer science
6. Joshua Tan (Oxford), PhD, computer science
7. ... [copy over from spreadsheet when complete.]

5 Factsheet

A separate factsheet has been attached to this application.

6 Budget

A separate budget has been attached to this application.