

Language Processing on Quantum Hardware with DisCoPy

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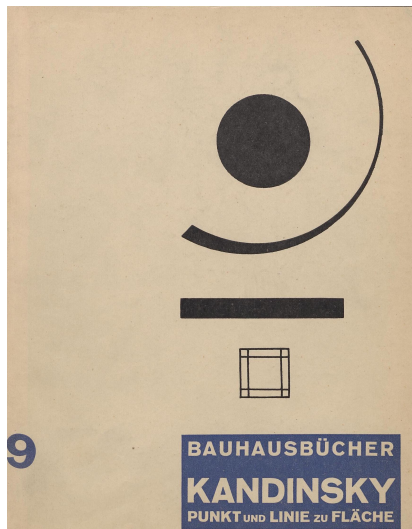
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September 16th, PyData Berlin

Outline

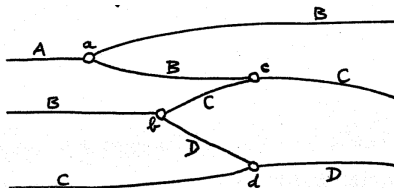
0. What is a diagram? From the point of view of...
 - ▶ Geometry
 - ▶ Algebra
 - ▶ Data
1. What can you do with it? Apply functors!
 - ▶ Natural language semantics
 - ▶ Quantum circuit evaluation
2. Demo time!
 - ▶ Classical simulation with `jax.numpy`
 - ▶ Proof-of-concept experiments with IBMQ
3. The future
 - ▶ Towards a quantum advantage for NLP

What is a diagram? “Point and line to plane”



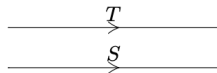
PLANAR DIAGRAMS AND TENSOR ALGEBRA

André Joyal and Ross Street
September 1988



What is a diagram? An arrow in a monoidal category.

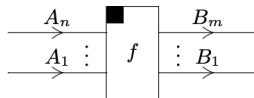
Tensor product $S \otimes T$



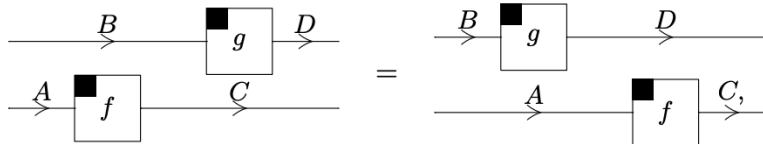
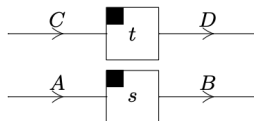
Unit object I

(empty)

Morphism $f : A_1 \otimes \dots \otimes A_n \rightarrow B_1 \otimes \dots \otimes B_m$



Tensor product $s \otimes t$



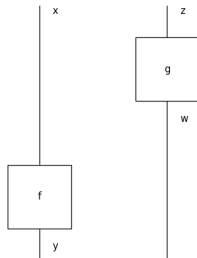
P. Selinger, *A Survey of Graphical Languages for Monoidal Categories*

(arXiv:0908.3347)

What is a diagram? DisCoPy's core data structure.

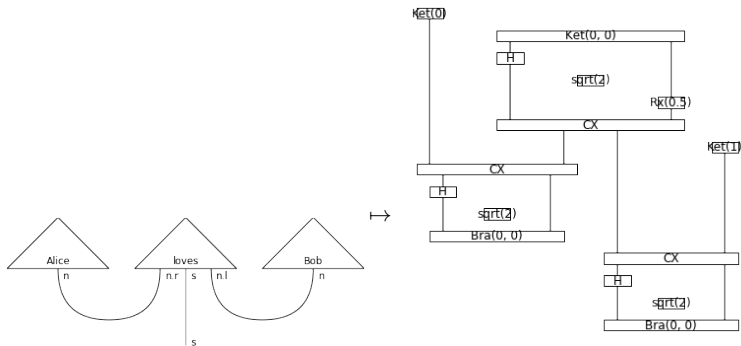
```
class Ob(name)
class Ty(x_1, ..., x_n)
class Box(name, dom, cod)
class Layer(left, box, right)
class Diagram(dom, cod, boxes, offsets, layers=None)
```

```
1  from discopy import *
2  x, y, z, w = Ty('x'), Ty('y'), Ty('z'), Ty('w')
3  f, g = Box('f', x, y), Box('g', z, w)
4  diagram = Id(x) @ g >> f @ Id(w)
5  assert diagram == Diagram(
6      x @ z, y @ w, boxes=[g, f], offsets=[1, 0])
7  assert diagram.normal_form() == f @ g
8  diagram.draw()
```

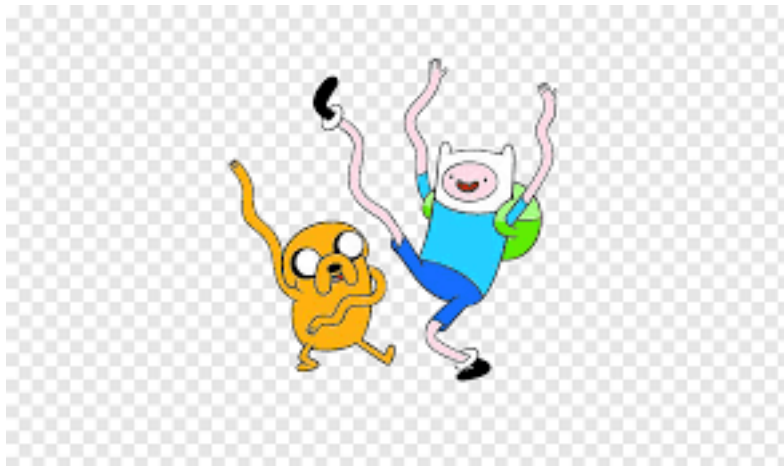


What can you do with it? Apply functors!

```
class Functor(ob, ar, ob_factory=None, ar_factory=None)
```



Demo time!



<https://github.com/oxford-quantum-group/discopy>