ANALYZING QUANTUM MANY-BODY SYSTEMS WITH ITENSOR AND PASTAQ

MATTHEW FISHMAN

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- Associate data scientist at CCQ, lead developer of ITensor and co-developer of PastaQ with Giacomo Torlai.
- Continuing to develop novel tensor network algorithms, with a focus on making them available as open source software.

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- We are hiring postdocs, full-time scientists, part-time and full-time software developers, interns, etc.

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- If TNs could do everything, we would not need a quantum computer! But in my opinion, it is the best general purpose tool we have right now.
- Perhaps most importantly, tensor networks are a common, general language for reasoning about quantum many-body systems (for example, quantum circuits).

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What are tensor networks?

[TODO: Show drawings of tensor networks.]

How do I install ITensor/PastaQ?

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Tutorial: One-site state basics

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using ITensors

i = Index(2)


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# Load ITensor


# 2−dimensional labeled
# Hilbert space
# (dim=2|id=510)
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```
Zp = ITensor(i)
Zp[i => 1] = 1

Zp = ITensor([1 0], i)
```

```
# Z|Z+⟩ = |Z+⟩



# Alternative syntax
```

Tutorial: One-site state basics

```
1  Zm = ITensor([0 1], i)
2  Xp = ITensor([1 1]/√2, i)
3  Xm = ITensor([1 -1]/√2, i)
```

```
# Z|Z−⟩ = −|Z−⟩
# X|X+⟩ = |X+⟩
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```

```
(Zp + Zm)/√2
(dag(Zp) * Xp)
(dag(Zp) * Xp)[]
inner(Zp, Xp)
norm(Xp)
```

```
#   Xp
#   ITensor(1/√2)
#   1/√2
#   1/√2
#   1
```

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back = "UnicodePlots"
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@visualize dag(Zp) * Xp
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# TODO: Add
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[TODO: Add GLMakie visualization.]

Future directions

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- Many ongoing projects and directions: quantum chemistry (for example UCC), real space parallel DMRG, TDVP, and TEBD, MPO compression tools, general approximate contraction techniques for unstructured networks, contracting and optimizing general tensor networks with AD, infinite MPS and tensor network tools like VUMPS and TDVP, trying out different network topologies for noisy circuit tomography, simulation and optimization.

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