Hyperbolic Neural Networks

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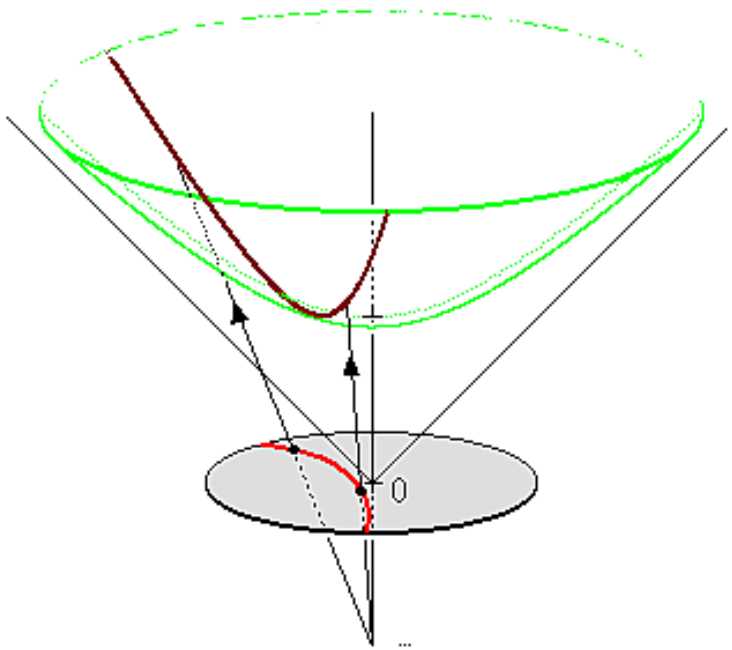
Preliminaries



Hyperboloid $\{(\xi, \tau) : \ \tau^2 - \|\xi\|^2 = R^{n+1}\}$ is isometric to Poincare ball of radius R.

Cool facts about

Facts about negative curvature:

1. Trees of constant branching factor are spaces of negative curvature and can be embedded in a Poincare ball
2. Volume grows exponentially with distance from ball center
3. Geodesics and barycentres are unique

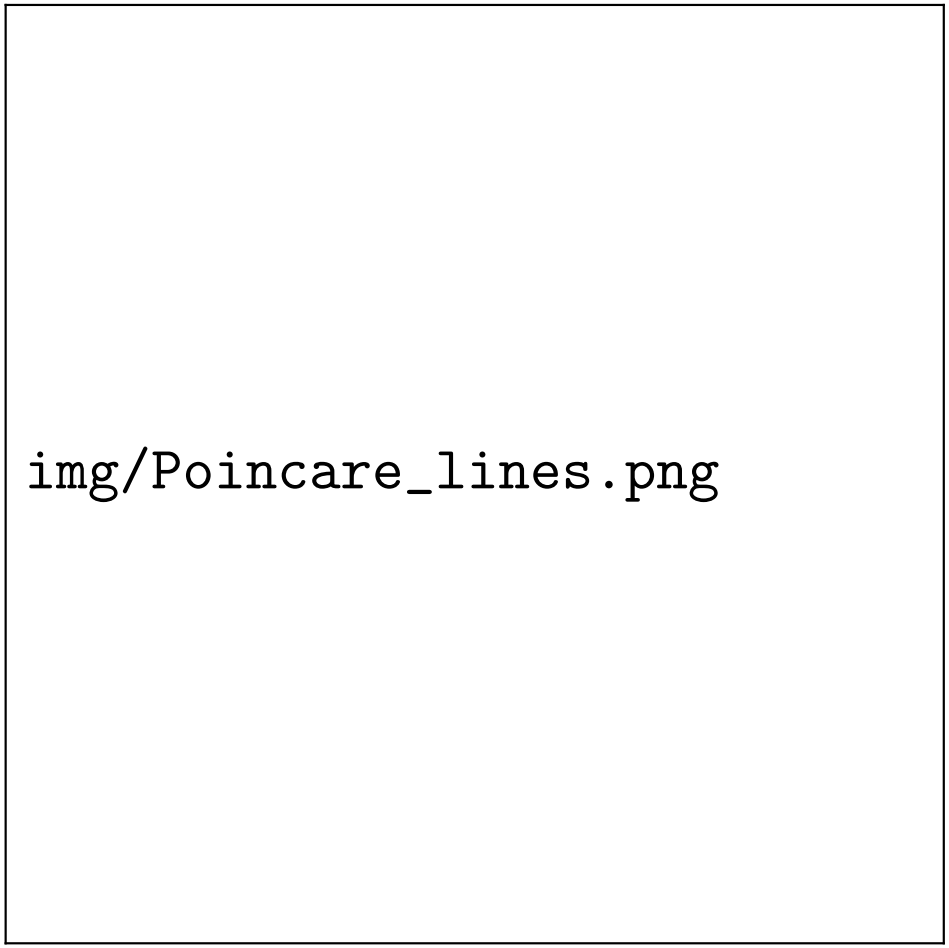


Figure: Embedding example: Poincare Model

Hyperbolic spaces in the wild

Bright papers from Facebook showed that hyperbolic spaces are good for language models

Utilizing Embeddings

Further accounting for negative curvature of text and graph embeddings, Octavian-Eugen Ganea propose Hyperbolic RNNs.

Challenges:

- Hyperbolic RNN cell – how to mimic Euclidian math in hyperbolic space?
- Parameters on the Poincare Disc – how to perform SGD?

TLDR [1]: do logmap-update-expmap (cf. Gyrovector spaces and Riemannian optimization)

[1] We got but 15 minutes

Challenges

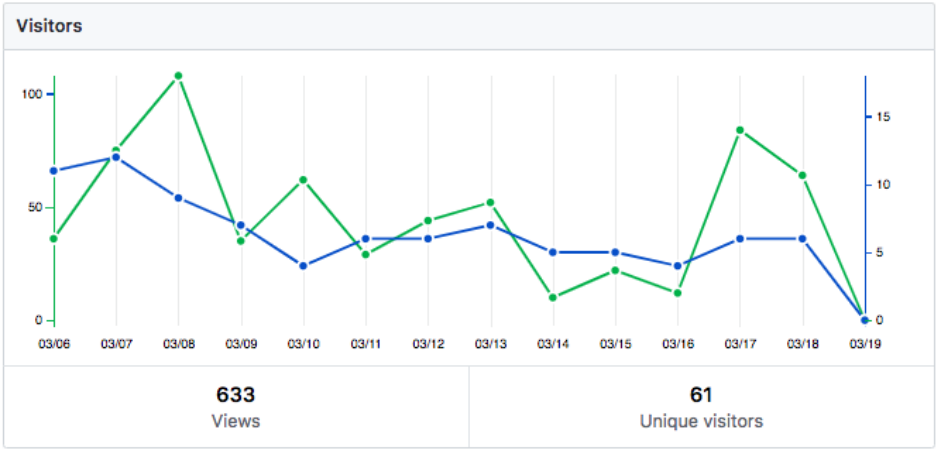
- Authors' code: `tensorflow`
- Our tool of choice: `pytorch`
- No Riemannian optimization out of the box
- No optimized implementation for hyperbolic rnn
- Training is numerically unstable with `float32`

Evaluation on toy data:

- Vocabulary size: 100
- Sentences are short
- Train/Validation/Test set: 50k/10k/10k examples
- Takes a day of training or even more to obtain good results

Our contribution: Geoopt & Hyperbolic GRU

We started an open source project Geoopt. Our contributers include folks from Facebook Research and Skoltech. We already got cited in http://hyperbolicdeeplearning.com and some other media



Referring sites

Site	Views	Unique visitors
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hyperbolicdeeplearning.c...	23	5
openreview.net	18	6
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Pull Requests	48	8
Poincare ball model by fer...	40	6
geoopt/geoopt at master	31	14
Normal sampling by Code...	28	4
Stargazers	19	2

github.com/geoopt/geoopt

geoopt

pypi v0.0.1 | docs passing | build passing | coverage 87% | code style black | chat on gitter

Manifold aware `pytorch.optim`.

Unofficial implementation for "Riemannian Adaptive Optimization Methods" ICLR2019 and more.

Installation

Make sure you have pytorch>=1.0.0 installed

There are two ways to install geoopt:

1. GitHub (preferred so far) due to active development

```
pip install git+https://github.com/geoopt/geoopt.git
```

Geoopt

The major part of Skoltech project was devoted to implement and document a **Poincare ball model for Geoopt**. It already allows to use Adam, Amsgrad, SGD, Nesterov optimization methods.

Current status:

- **Implementation:** 100% test coverage for Poincare math

- **Documentation:** waiting a review from Facebook/Skoltech. Preview available here: `https://geoopt.readthedocs.io/en/Poincare/extended/Poincare.html`

Plans:

- Continue the project, **new contributors are welcome!**

Our Hyperbolic GRU in pytorch

Hyperbolic GRU was another part of our Skoltech project. Available at `https://github.com/ferrine/hyrnn`

Status:

- Same API as native pytorch GRU:
  - Variable sequence length
  - Multilayer
- Reproduced authors' results
- `RAdam` performs better than `RSGD`

Plans:

- Test coverage for Hyperbolic GRU
- Learn pytorch-cpp to optimize its runtime
- Adapt for `float32`