Geometric structures in machine learning

MLRG summer, 2021
Geometric structures exist everywhere

Non-Euclidean Observations

- Images

Painting  Sculpture  Embroidery
Geometric structures exist everywhere

Natural Science

- Black holes (general relativity)
- Elementary particles (particle physics)
- Planetary motion (classical mechanics)
- Organic compounds (chemistry)
Why use Geometric structures?

Geometric methods are more efficient
Why Geometric structures?

Geometric priors are encoded in many useful NNs (e.g., CNN, RNN, GNN)
Challenges

Difficulties of exploiting geometric structures

- Unawareness (less fashionable)

- non-standard math for ML (time investment)

- Few practical implementations (examples in low-dimensions)
The goal of this MLRG

Learn some basics of geometric structures and how to exploit them in ML

Basics:

Optimization on manifolds (sub-topic 1)

Information geometry (sub-topic 2)

Geometric deep learning (sub-topic 3)

8 meetings (2 meetings for the basics, 6 meetings for related papers)

Pick at least one paper from each subtopic
Basics: (I will cover the basics of manifolds and information geometry)

Geodesic Convex Optimization
https://arxiv.org/abs/1806.06373

An elementary introduction to information geometry

Geometric Deep Learning: Grids, Groups, Graphs, Geodesics, and Gauges,
https://arxiv.org/abs/2104.13478,
https://www.youtube.com/watch?v=w6Pw4MOzMuo (Presenter ?)
Picking Presenters

Related papers

Sub-topic 1

Manifold optimization


Picking Presenters

Sub-topic 2

Information geometry

[1] Natural Wake-Sleep Algorithm,

[2] Quantum Natural Gradient,

[3] NGBoost: Natural Gradient Boosting for Probabilistic Prediction,
Picking Presenters

Sub-topic 3

Geometric deep learning


Schedule

July 7    Introduction
July 14   Basics of geometric DL (graph, group) [Nick]
July 21   Basics of manifolds [Wu]
July 28   Optimization [Fred]
August 4  Wake-Sleep [Christian]
August 11 Something (Momentum or Quantum) [Victor]
August 18 NGBoost (Wilder)
August 25 GCNNs (Emmanuel)
September 1 : AntiCancer [Betty]