Summer ML Triggers

Week 3 Report

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Part 1

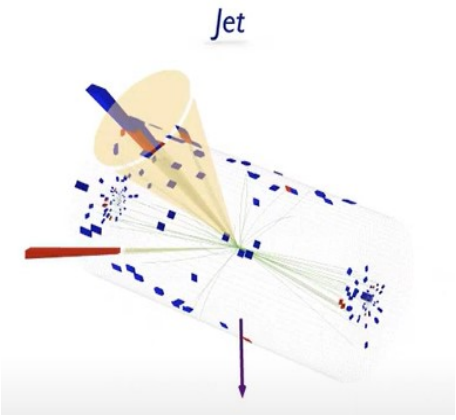
Paper Reading

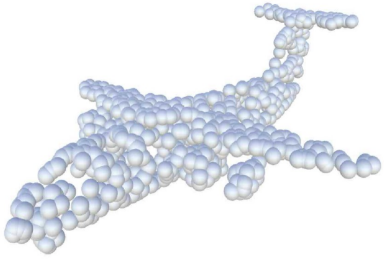
ParticleNet: Jet Tagging via Particle Clouds

Content:

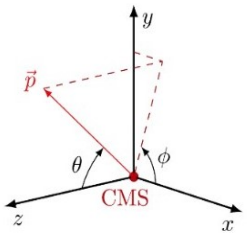
- This paper represented jet as particle clouds instead of image-based or particle-based. And model jet events as point clouds which widely used in spatial dataset. Then the author implement Dynamic Graph Convolutional Neural Network (DGNN) for graph-based dataset and achieved better accuracy than CNN.
- I will use elements of our own dataset to introduce both the theoritical and computer-based content of this paper. Also, I will customize our own neural networks ParticleNetLite++.

Represent as a particle cloud ?

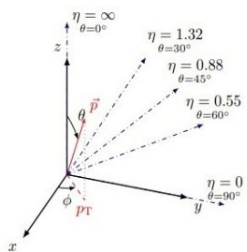




pseudorapidity-azimuth space



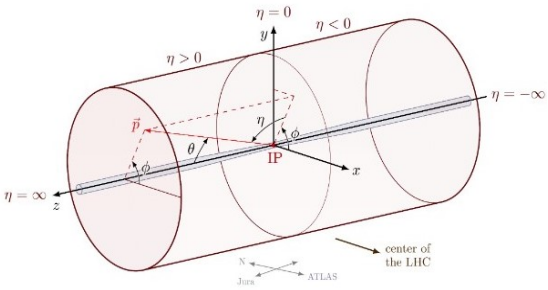
$$\eta \equiv -\ln\left[\tan\left(\frac{\theta}{2}\right)\right]$$



$$\phi \in [0, 2\pi]$$
$$\eta \in (-\infty, +\infty)$$

pT: momentum (energy)

pseudorapidity-azimuth space



offer sufficient background to represent event as a graph

Construct Graph-based Dataset

```
[b'Particle.fUniqueID'
 b'Particle.fBits',
 b'Particle.PID',
 b'Particle.Status',
 b'Particle.IsPU',
 b'Particle.M1',
 b'Particle.M2',
 b'Particle.D1',
 b'Particle.D2',
 b'Particle.Charge',
 b'Particle.Mass',
 b'Particle.E',
 b'Particle.Px',
 b'Particle.Py',
 b'Particle.Pz',
 b'Particle.P',
 b'Particle.PT',
 b'Particle.Eta',
 b'Particle.Phi',
 b'Particle.Rapidity',
 b'Particle.T',
 b'Particle.X',
 b'Particle.Y',
 b'Particle.Z']
```

Converting dataset

First, to facilitate comparison with CNN, we select three elements ϕ, η, pT from our delphes dataset.

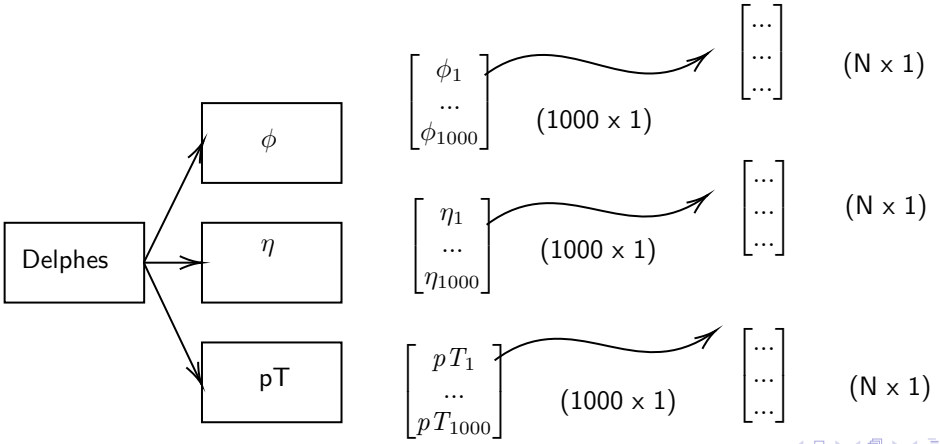
Then, we can define two inputs of Neural Network:

Coordinates: (ϕ, η)

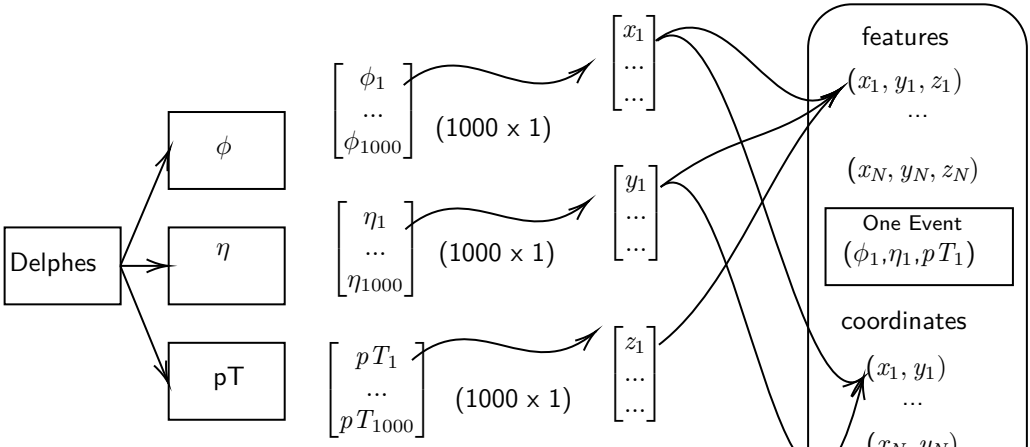
Features: (ϕ, η, pT)

Construct Graph Dataset

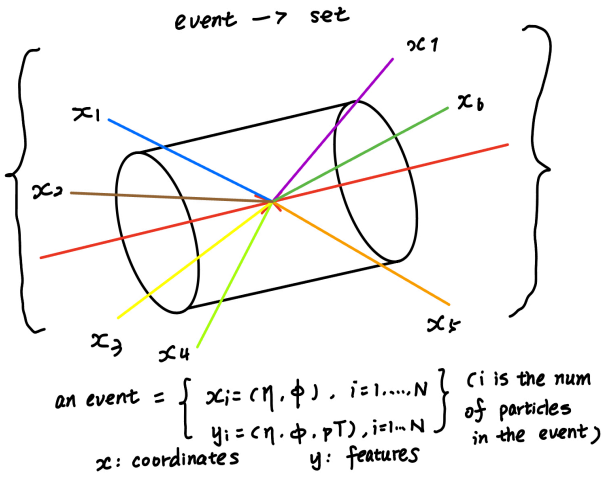
Each of three elements ϕ, η, pT has 1000 events and each event contains different numbers of information which represents particles. (Notice: The number N is not identical.)



Construct Graph Dataset

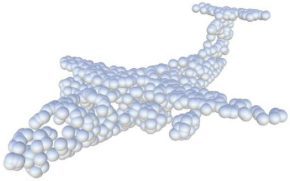


Event as a Set

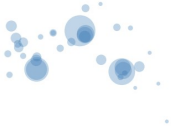


- An event is a set of particles in the space.
- Particle clouds are generally created by clustering a large number of particles measured by the particle detectors.

Point cloud vs Particle cloud

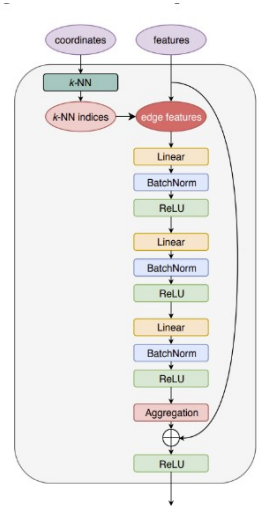


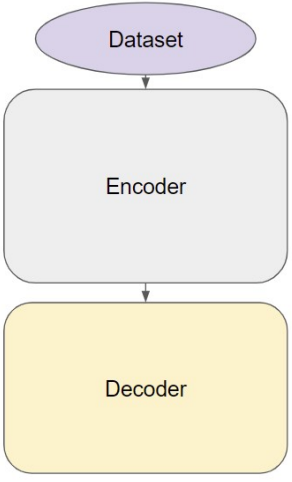
- Point cloud
  - points are intrinsically unordered
  - primary information:
    - 3D coordinates in the xyz space

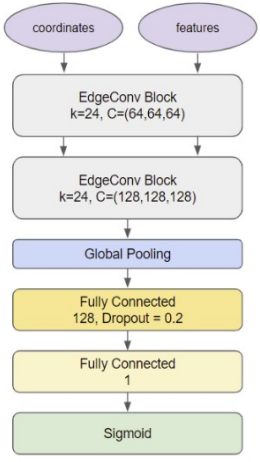


- Particle cloud
  - particles are intrinsically unordered
  - primary information:
    - 2D coordinates in the η-φ space
  - but also additional “features”:
    - energy/momenta
    - charge/particle type
    - track quality/impact parameters/etc.

ParticleNetLite++

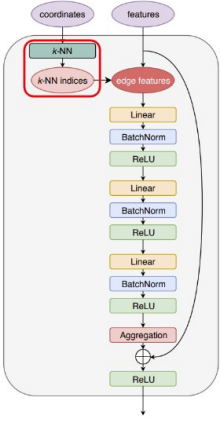






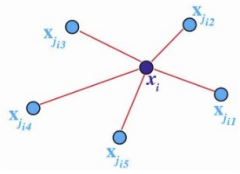
ParticleNetLite++

EdgeConv



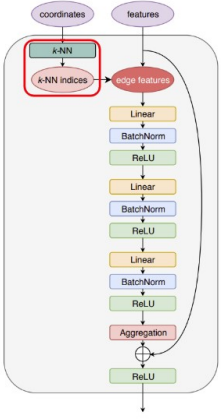
K-Nearest-Neighbors

- Goal: To make every particle and his k neighbors as a graph.



ParticleNetLite++

EdgeConv



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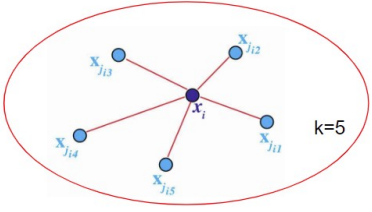
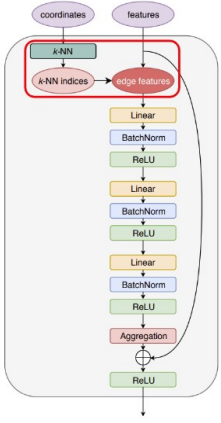
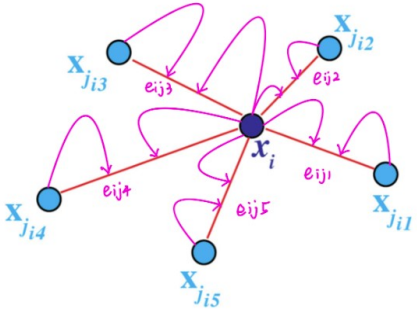


ParticleNetLite++

EdgeConv

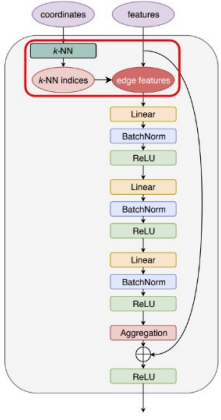


- Use particle features to update the edge features



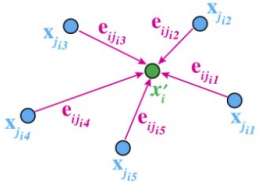
ParticleNetLite++

EdgeConv



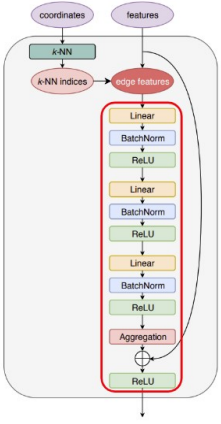
- Use edge features to update particle features

$$x_i' = \square_{j=1}^{k} h_\Theta(x_i, x_{i_j})$$

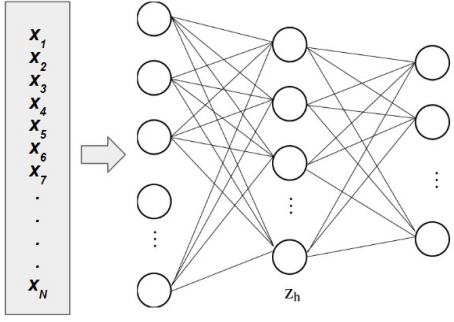


ParticleNetLite++

EdgeConv

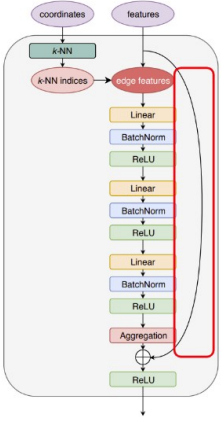


Updated Dataset



ParticleNetLite++

EdgeConv



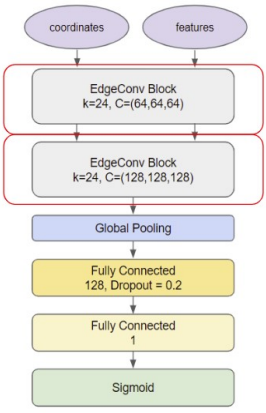
Skip Connect

With the deepening of the number of deep network layers:

- gradient disappearance,
- gradient explosion,
- overfitting
- consumption of computing resources.

ParticleNetLite++

Why Dynamic?

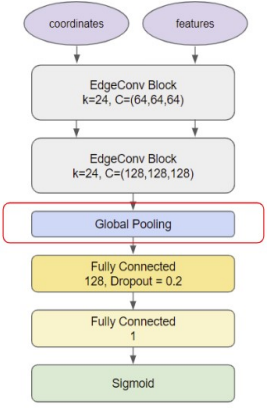


pseudorapidity-azimuth space

Euclidean space

ParticleNetLite++

Global Pooling



With Global pooling reduces the dimensionality from 3D to 1D.

(phi, eta, pT)

Therefore Global pooling outputs 1 response for every feature map. This can be the maximum or the average or whatever other pooling operation you use.

(sum, median, mean, average. maximum, operation)

Tasks

- Implement code of ParticleNetLite++
- Perform experiments
- Set up testing standards and visualise
- Reparameterization