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Técnicas Avançadas de Análise de Dados
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CALORIMETRY WITH DEEP LEARNING: PARTICLE SIMULATION AND RECONSTRUCTION FOR COLLIDER PHYSICS

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Seomara Félix, 2017253011

The images present in this presentation are taken from the article in question.

INTRODUCTION

A calorimeter is na experimental apparatus that measures the energy of particles. Most particles enter the calorimeter and intiate a particle shower, depositing their energy, which is then collected, and measured.

The particle identification analyses requires extremely detailed and precise simulations of detector data and a large amount of computing resources.

With the improvement and development of future accelerators and detectors, the data volume will increase posing a variety of technological and computational challenges.

PROPOSED SOLUTION

END-TO-END PARTICLE RECONSTRUCTION

A network for end-to-end particle reconstruction, receiving as input a particle shower and acting both as a particle identification algorithm and as a regression algorithm for the particle's energy

GENERATIVE MODEL

A generative adversarial network (GAN) for simulating particle showers, designed to return calorimeter-cell voxelized images like those generated by GEANT4.

GENERATIVE MODEL

Generative Adversarial Networks (GAN):

- Generator
- Discriminator

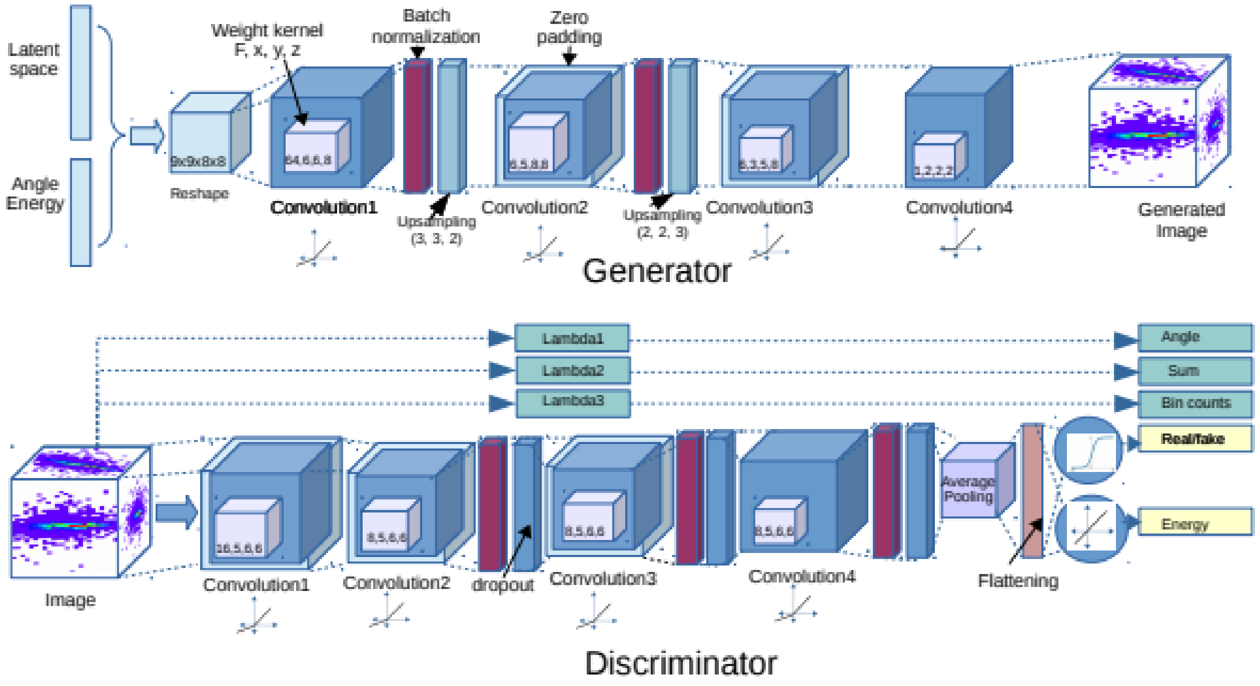


Fig. 1 - 3DGAN architecture

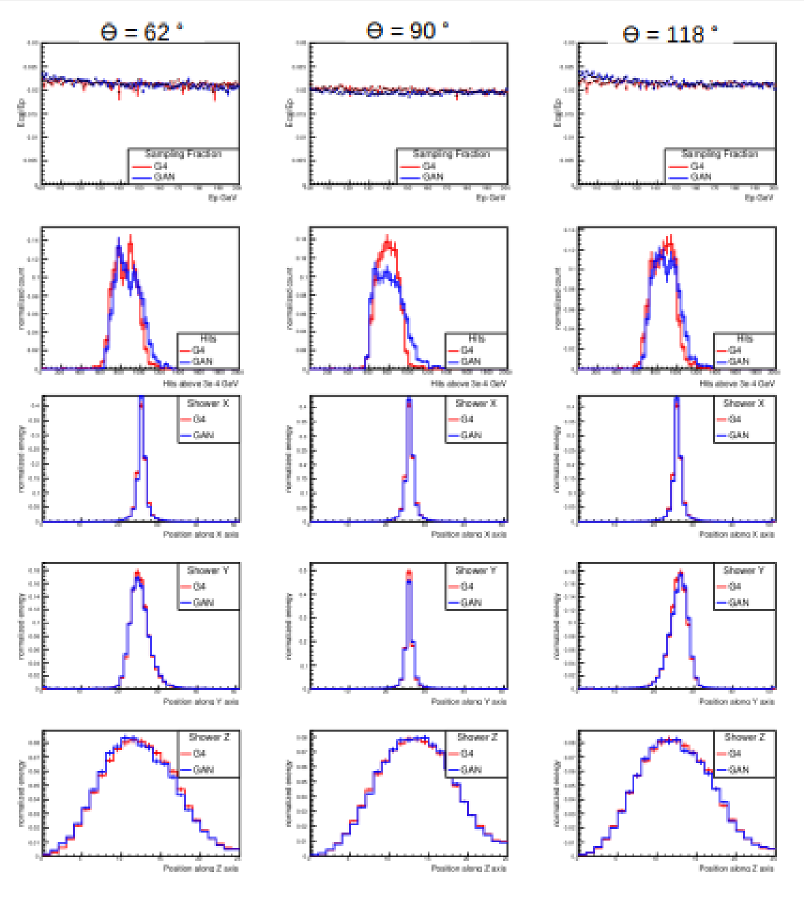


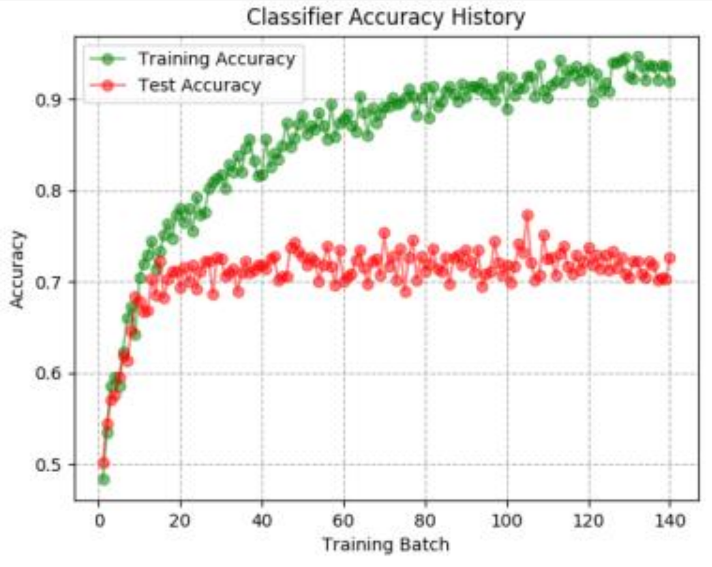
Fig. 2 - GEANT4 vs GAN

GENERATIVE MODEL

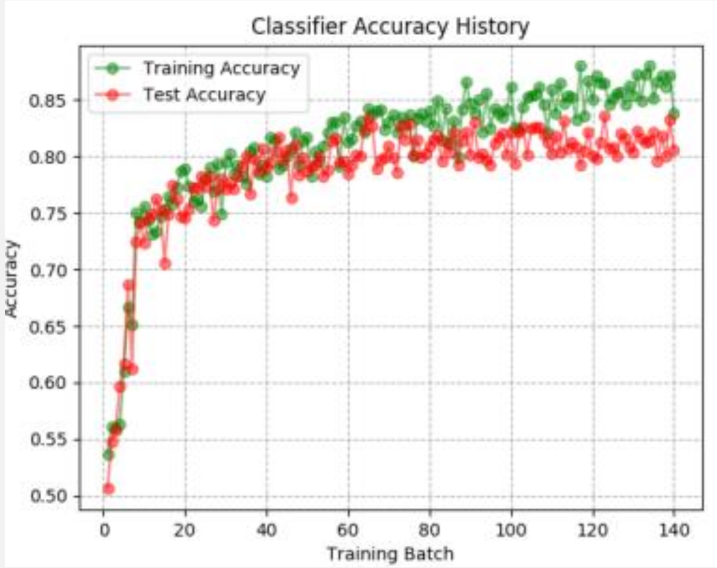
- The agreement is very good, and 3DGAN is able to mimic the way the energy distributions changes with incident angle.
- The GAN model represents a potential simulation speedup of over 4,000 times when compared to GEANT4.

END-TO-END PARTICLE RECONSTRUCTION

Dense Neural Network, DNN



3D convolutional network (CNN)



Network based on GoogLeNet (GN)

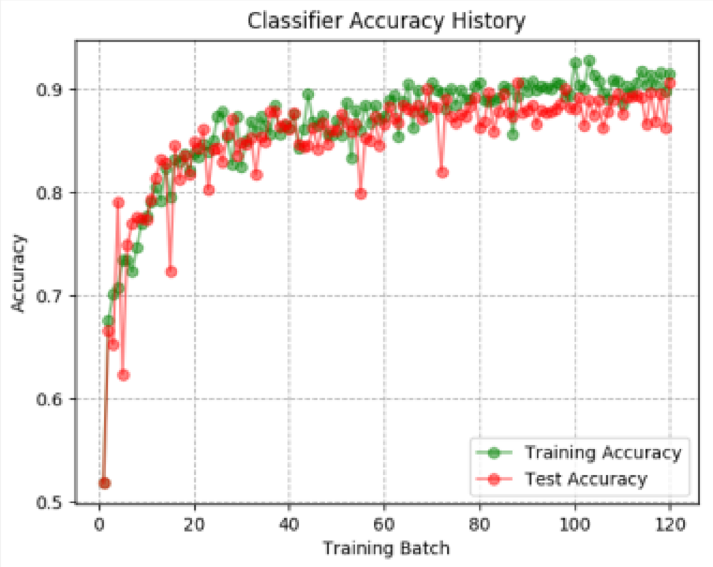
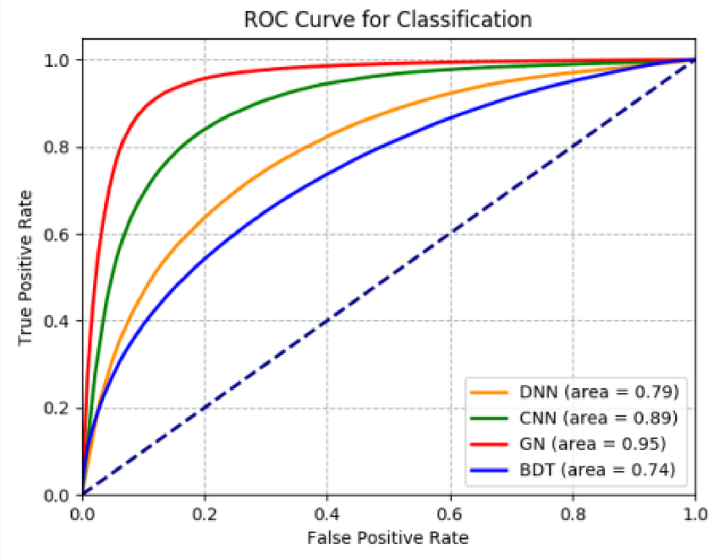


Fig. 3 - Training curves for the best hyperparameters

END-TO-END PARTICLE RECONSTRUCTION

To analyse the classification performance, the ROC curves were design. Two classification tasks were compared:

Photons γ vs neutral pions π^0



Electrons e vs charged pions $\pi^\pm$

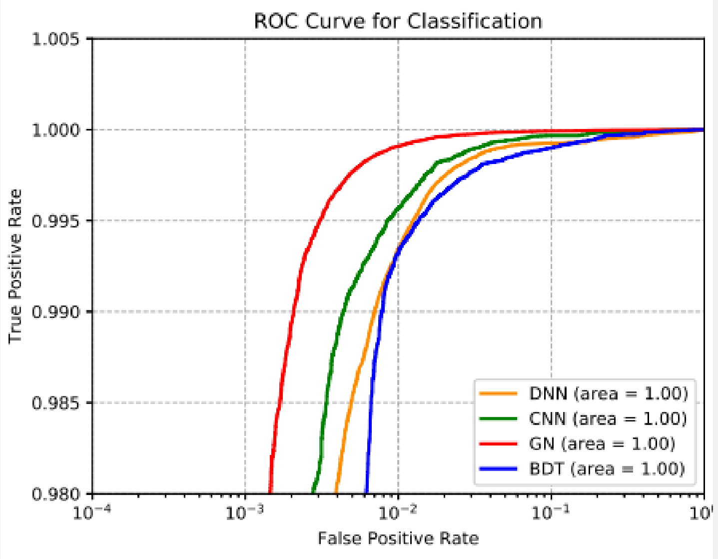
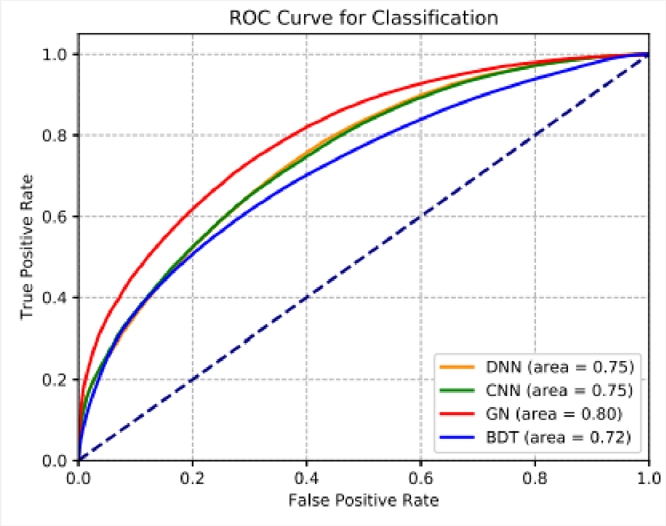


Fig. 4 – ROC curves for classification performance

END-TO-END PARTICLE RECONSTRUCTION

To visualize how the calorimeter data would look with a coarser detector (ATLAS and CMS detectors), the contents of each event were linearly extrapolated to a different calorimeter geometry, using the "resampling" process.

ATLAS geometry



CMS geometry

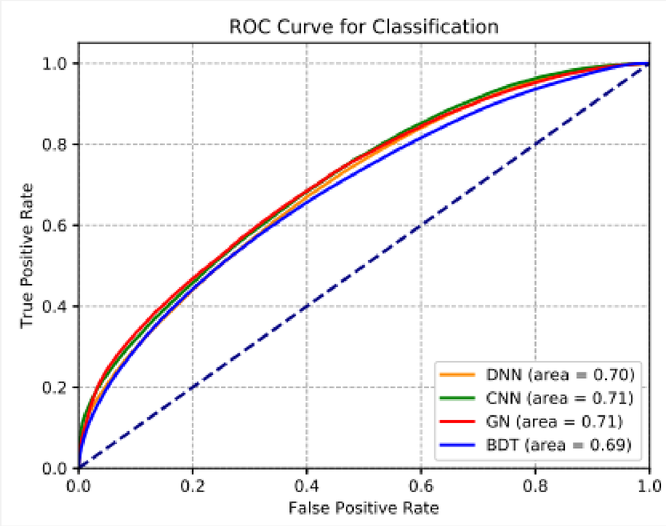


Fig. 5 - ROC curves for the ATLAS and CMS geometries

CONCLUSION

The purpose of the study, which was to preserve the accuracy of more traditional techniques while reducing the computing time and resources, was accomplished.

Deep learning techniques can outperform traditional techniques in tasks such as particle shower simulation and particle reconstruction in a calorimeter.

The computing time and resources required for these tasks can be drastically reduced.