ECE 8890 Neural Network Final Project

Ensemble Generative Adversarial Networks for Anomaly Detection

Wenlong Wu

Advisor: Derek Anderson, James Keller

University of Missouri

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Overview and Motivation

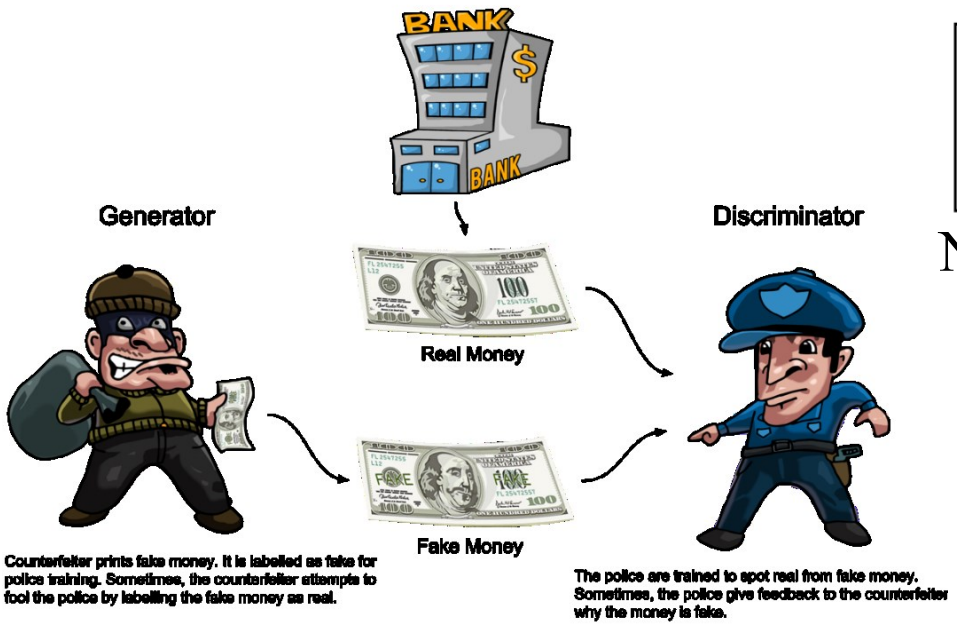
Generative Adversarial Network (**GAN**) is a powerful framework to learn generative model and has been achieved a great success on image generation, image super-resolution and etc.

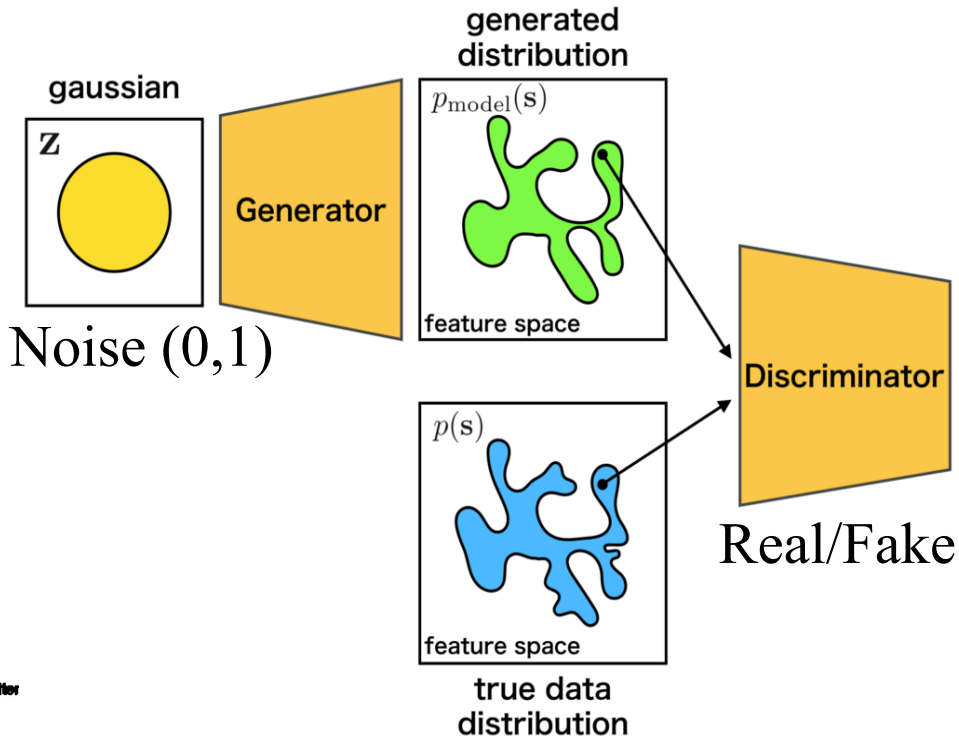
However, the GAN algorithm is mostly used on image datasets to learn the distribution of images nowadays [1]. Few research has been done on structure / tabular data to model the high-dimensional data distribution.

In this project, the GAN is used to **model data distribution on structure/tabular data** and to **detect potential outliers** that is out of data distribution.

Which image do you think is REAL?

Methodology: GAN





- Two networks competing with each other.
- **Discriminator** D tries to distinguish between real samples and samples generated by **Generator** G.
- G tries to "fool" D.
- G will learn to generate samples similar to real data.

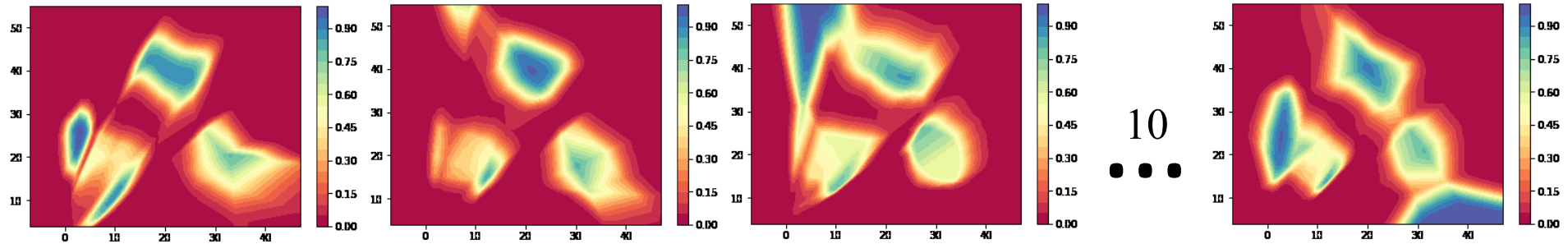
D and G plays two-player minimax game with value function V(G, D):

$$\min_{G}\max_{D} V(G,D) = E_{x\sim p_{data}}[\log D(x)] + E_{x\sim p_z(z)}[log(1 - D(G(z)))]$$

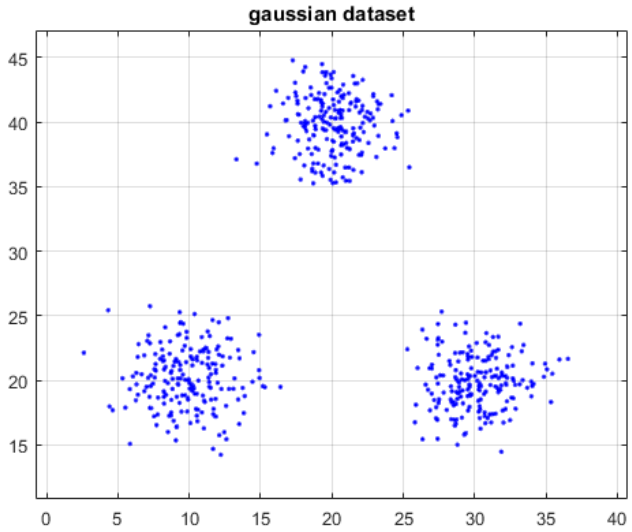
Methodology: Ensemble GAN

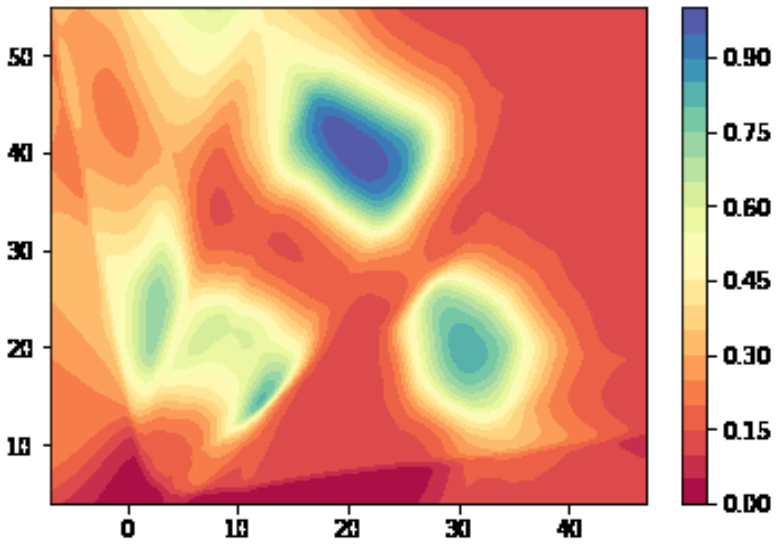
Single GAN

Red area is not in data distribution for sure;
Blue area is likely to be in data distribution, but not for sure.



Ensemble (mean)

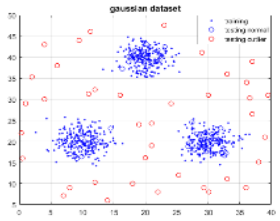
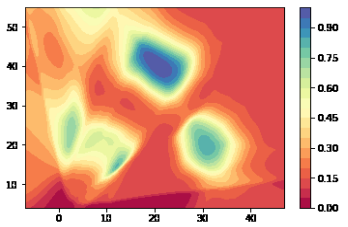
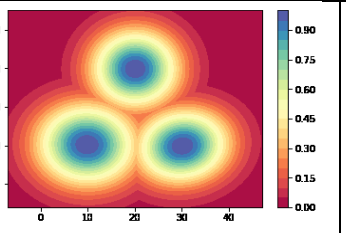
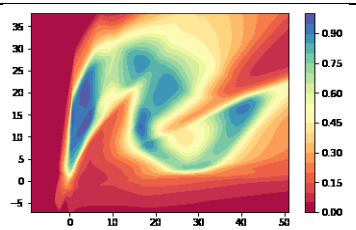
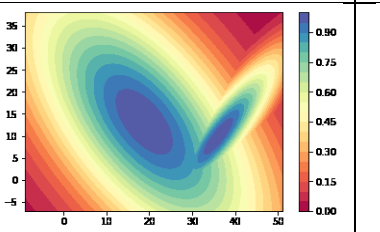
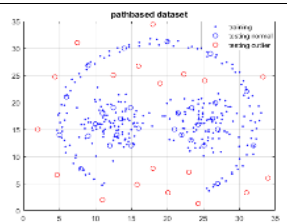
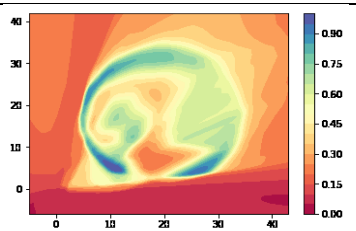
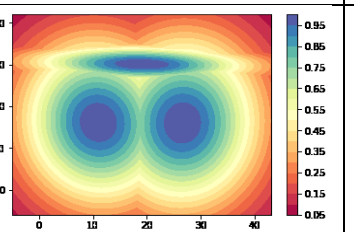
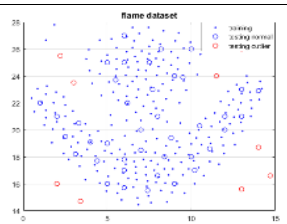
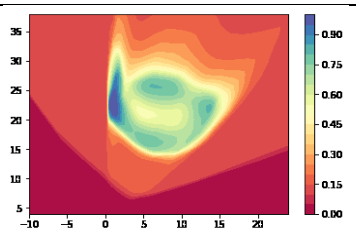
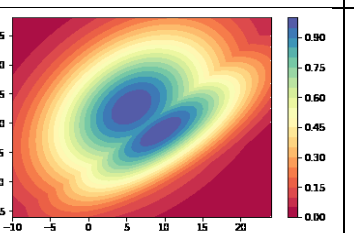




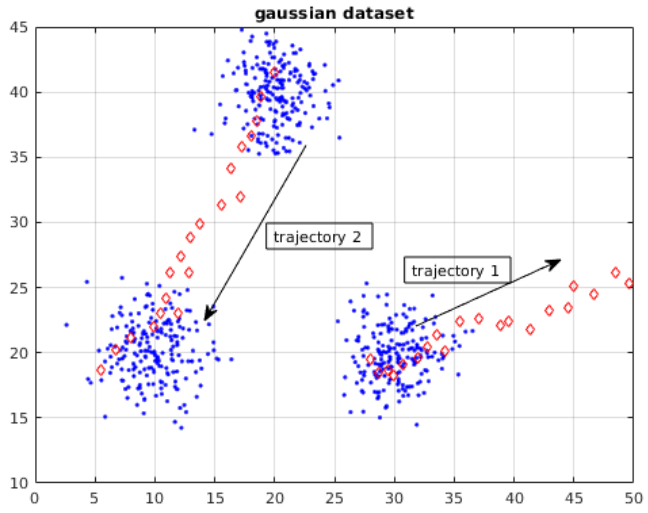
Ensemble GAN

Fuzzy integral ensemble?

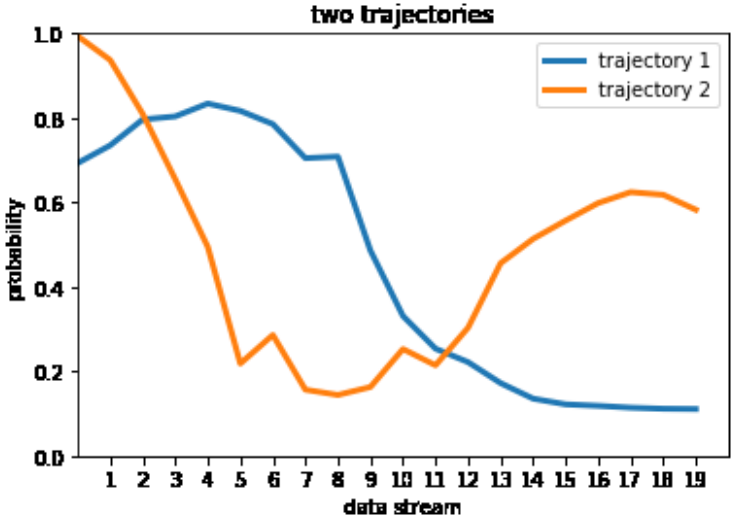
Experiments: model data distributions

	Ensemble Generative Adversarial Net		Gaussian Mixture Model	
Datasets	Data distribution	Test	Data distribution	Test
Gaussian					
Jain					
Pathbased					
Flame					

Experiments: trajectory analysis



	Ensemble GAN			GMM		
DATASET	Precision	Recall	F1	Precision	Recall	F1
Gaussian	0.92	0.95	0.94	1.00	1.00	**1.00**
Jain	0.84	0.80	**0.82**	0.70	0.90	0.78
Pathbased	0.83	0.80	**0.82**	0.82	0.70	0.76
Flame	0.76	0.70	**0.73**	0.68	0.60	0.64



Trajectory 1:
-- Goes from cluster center to outside;
Trajectory 2:
-- Goes from one cluster to another cluster.

Summary and Future Work

- GAN has the ability to model data distribution:
  - Generator G learns to generate samples similar to real data
  - Discriminator D learns to distinguish between real and fake data
- Ensemble GAN performs better at modeling data distribution than the single GAN and the GMM;
- Ensemble GAN can serve as a base model for anomaly detection.

- Fuzzy integral ensemble can be used in the future;
- Ensemble GAN can be developed in data stream processing mode.

References

[1] Brock, Andrew, Jeff Donahue, and Karen Simonyan. "Large scale gan training for high fidelity natural image synthesis." arXiv preprint arXiv:1809.11096 (2018).
[2] https://dzone.com/articles/working-principles-of-generative-adversarial-netwo
[3] http://cs.joensuu.fi/sipu/datasets/