



## Synthetic Handwritten Text Data Generation using Deep Learning

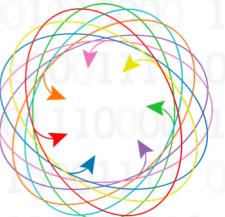
Raghav Bali

13 - 16 November 2019

Bengaluru



# About Me



Senior Data Scientist



Author

# Slides & Code

- Github: [https://github.com/raghavbali/handwritten text dhs av 2019](https://github.com/raghavbali/handwritten_text_dhs_av_2019)



SCAN ME

# Agenda

- Why Generate Handwriting
- Overall Setup
- Exploring the dataset
- Quick Demo
- Network Architecture
- Gaussians
- Training & Prediction
- Experiments
- References

# why generate handwriting

- realistic handwritten content

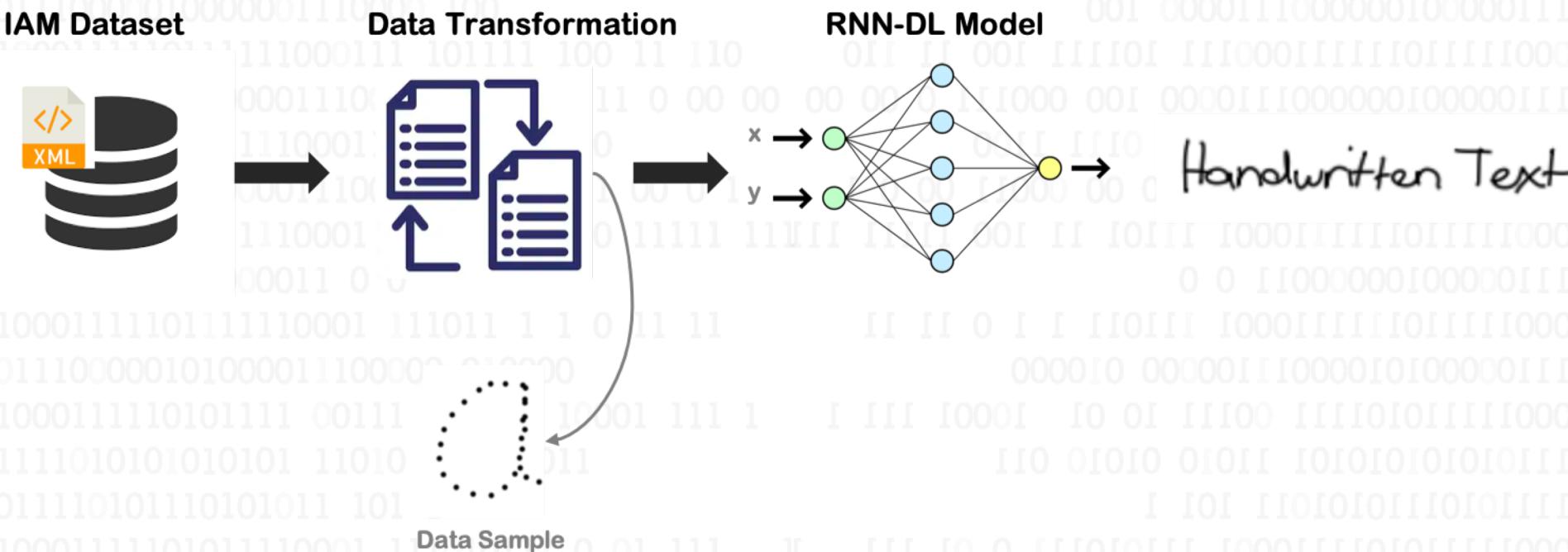
## • To Understand Data Generation Processes

This has multiple advantages such as :

- capability to model more complex problems (like speech synthesis)
- capability to design models which generalize better

- synthetic datasets

# Overall Setup



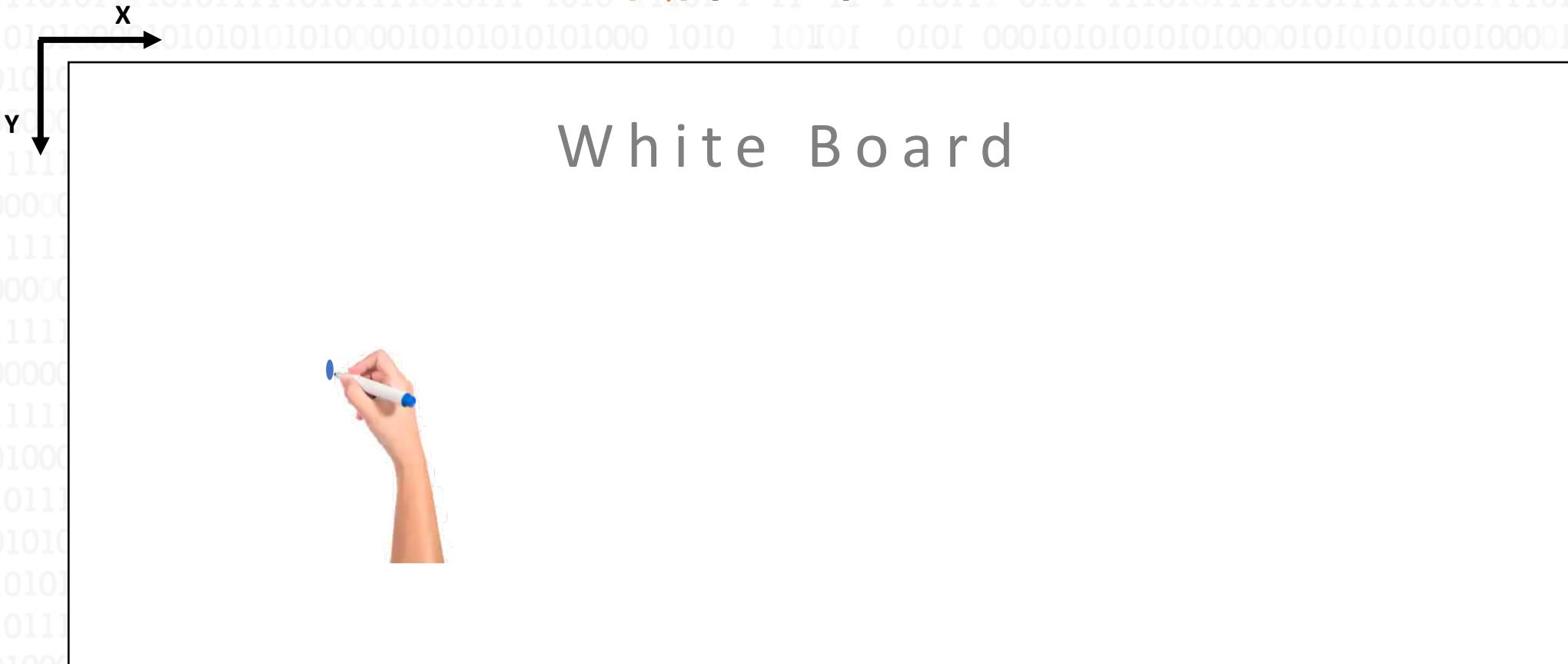
# Exploring the Dataset

- Pen Trajectories (x,y) coordinates
- IAM Online Handwriting Dataset :
  - 10k Samples
  - 200+ Contributors
  - Unconstrained Written Samples

```
<?xml version="1.0" encoding="ISO-8859-1"?>
<WhiteboardCaptureSession>
  <General>
    <Form id="c04-244z" writerID="10102" saveTime="14818006.33"/>
    <CaptureTime time="13:10:46.330" year="2004" month="10" dayOfMonth="27" dayOfWeek="3"/>
    <Setting location="IAM university of Berne (CH)" producer="Marcus Liwicki (liwicki (at) iam.unibe.ch)" system="eBeam System 3 YCap 1.0"/>
  </General>
  <Transcription>
    <Text>
      The film covered a
      wide aspect of the
      British scene, ranging
      from pubs, the Eton
      wall game, to the
      European Common Market.
      It was left to reporter
      Sevareid to make the
      strongest criticisms.
    </Text>
    <TextLine id="c04-244z-01" text="The film covered a">
      <Word id="c04-244z-01-01" text="The">
        <Char id="c04-244z-01-01-01" text="T"/>
        <Char id="c04-244z-01-01-02" text="h"/>
        <Char id="c04-244z-01-01-03" text="e"/>
      </Word>
```

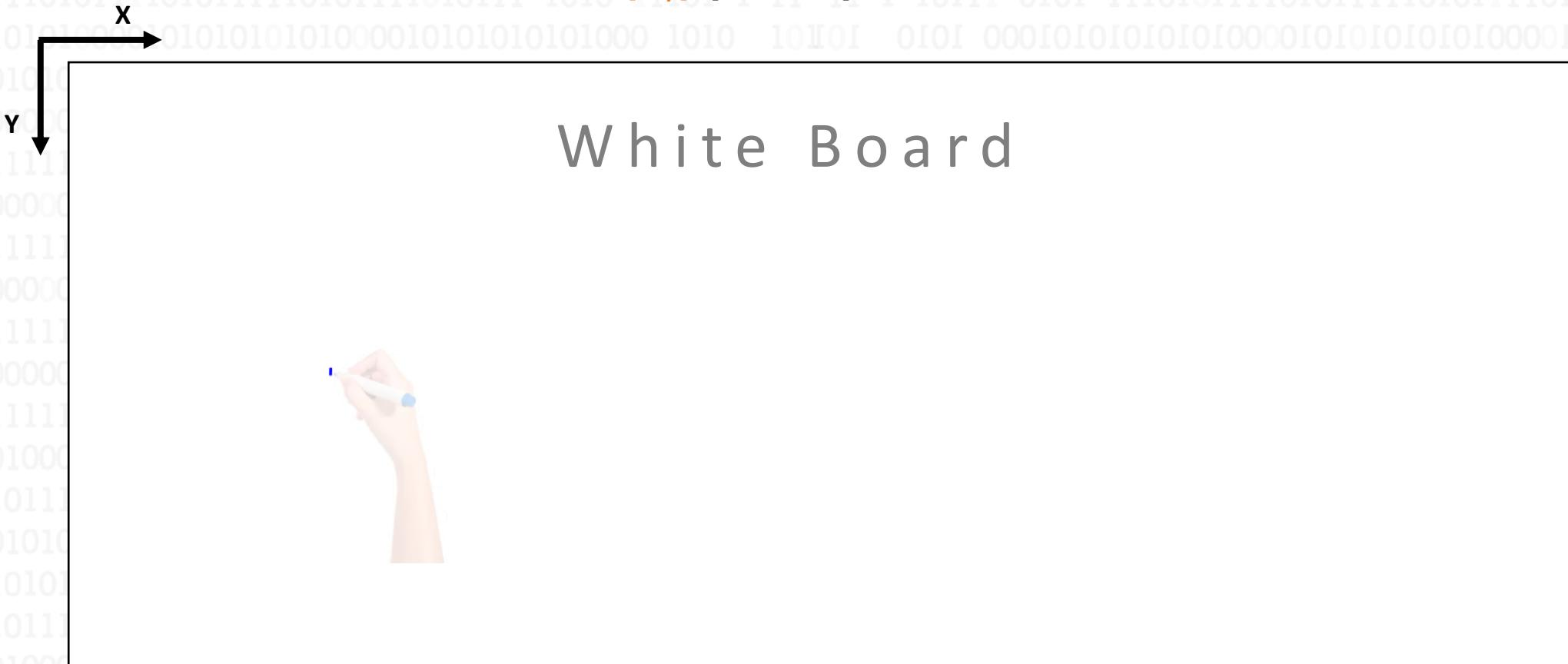
# Quick Demo

Text to be Generated : A Move to Stop Mr. Gaitskell  
[x,y]: [207,371]



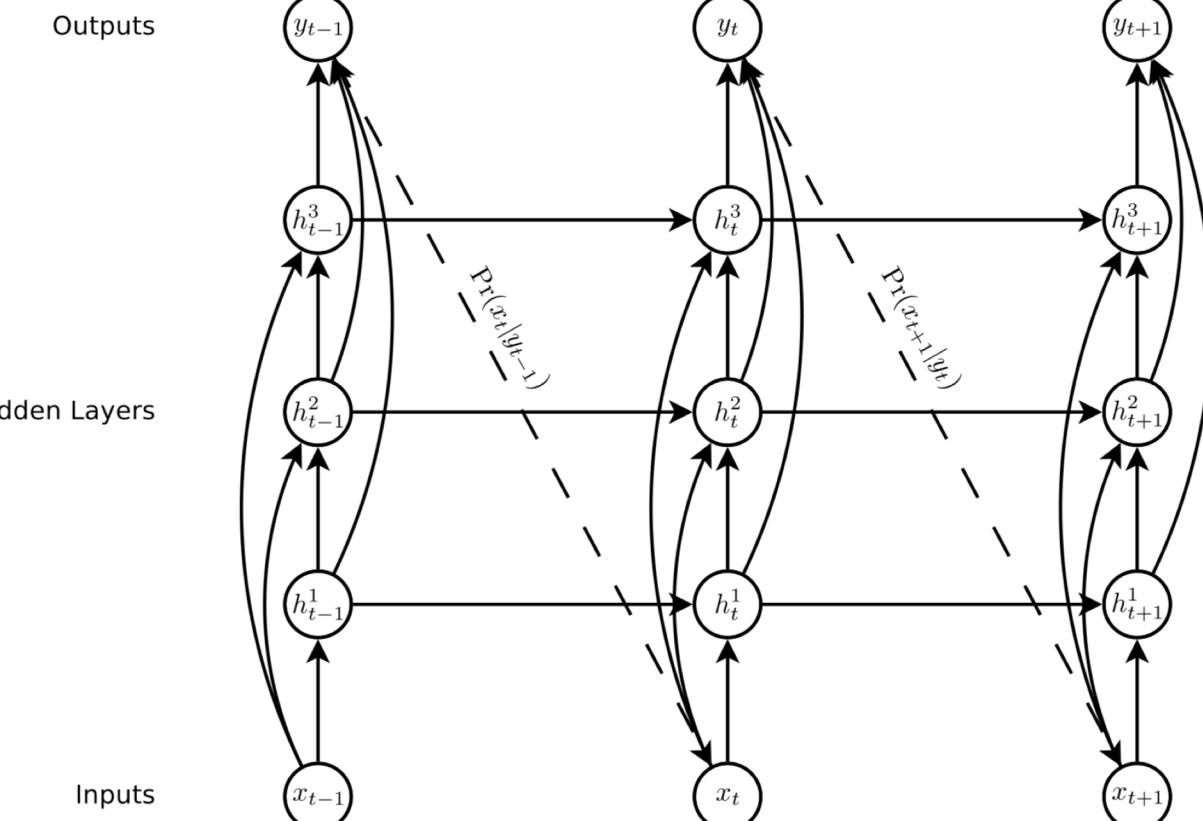
# Quick Demo

Text to be Generated : A Move to Stop Mr. Gaitskell  
[x,y]: [207,371]



# Network Architecture

- LSTMs
- Skip Connections
- Mixture Density Networks



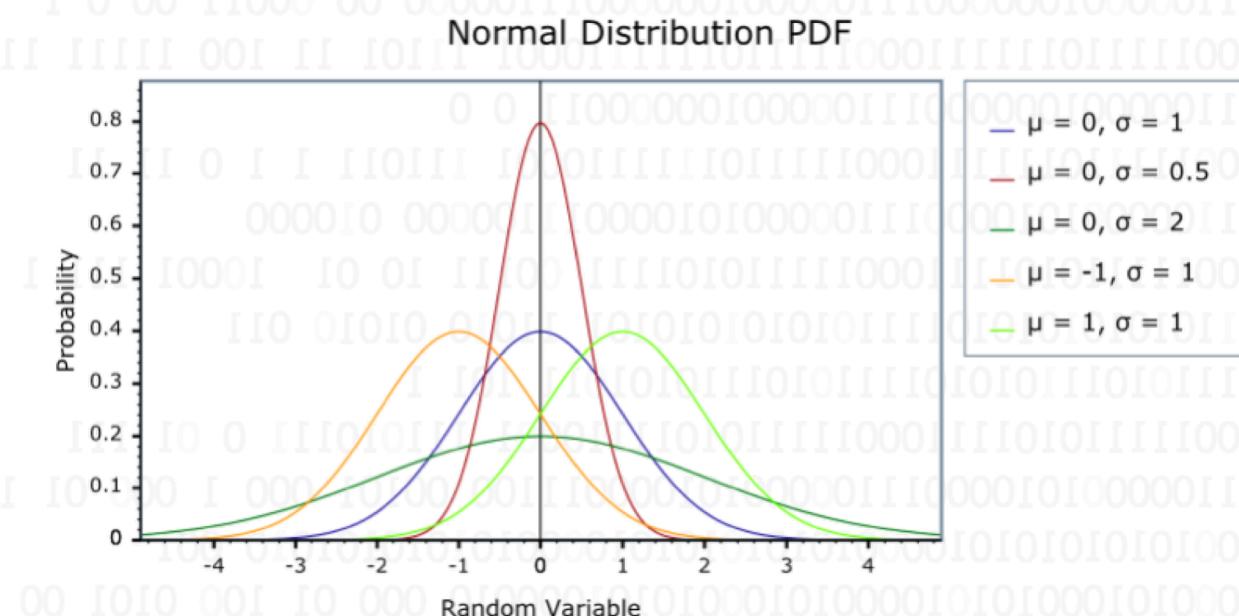
# Gaussian Distributions



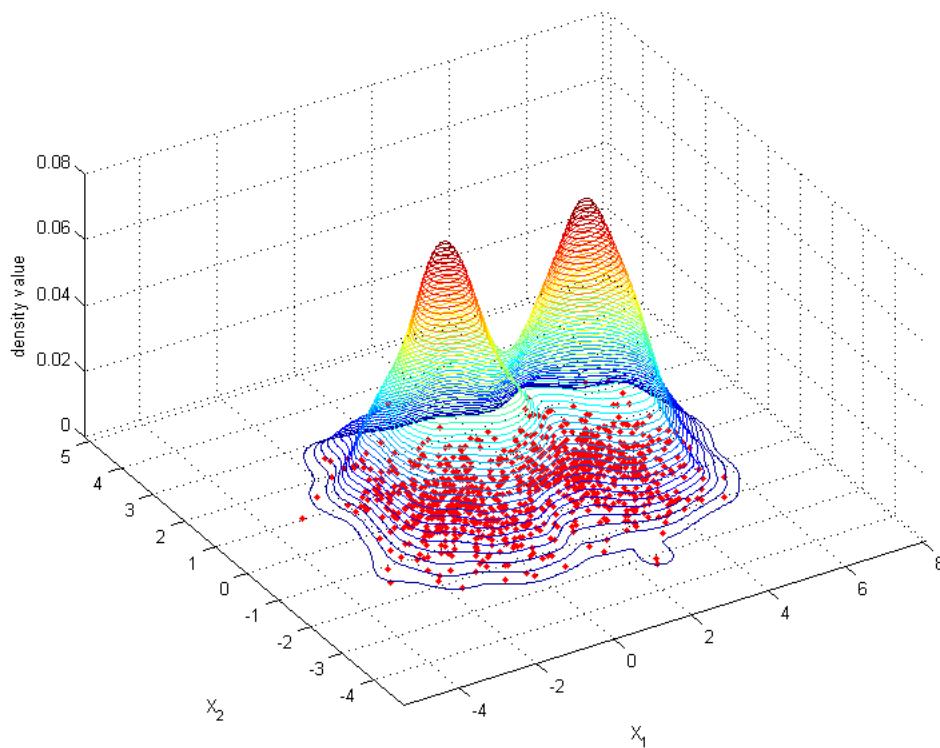
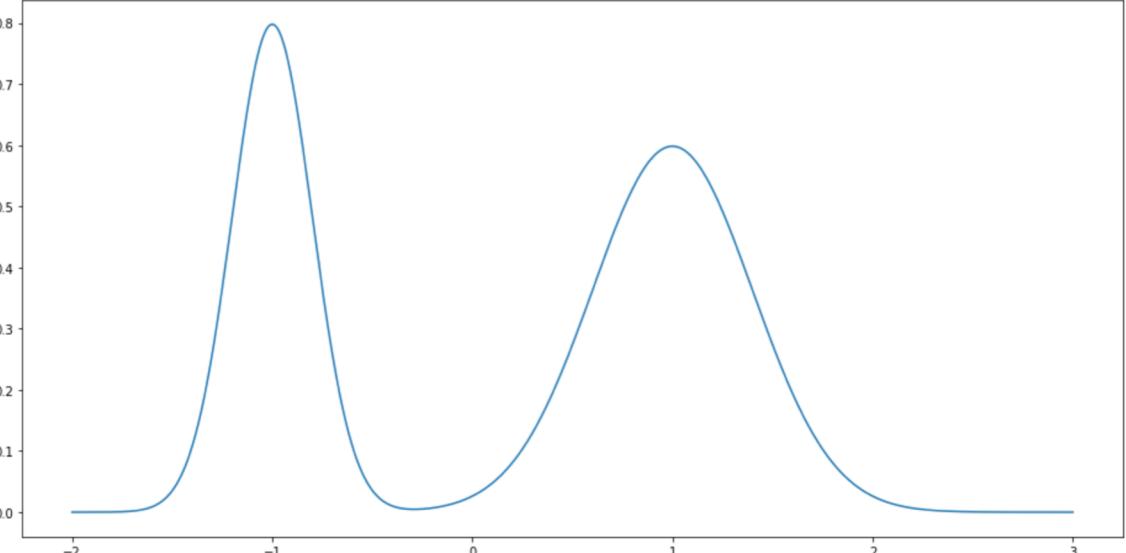
# Gaussian Distributions

- Also known as :
  - Normal Distribution
  - Bell Curve
- Central Limit Theorem?
- Notation:  $[X \sim N(\mu, \sigma^2)]$
- Probability Density:

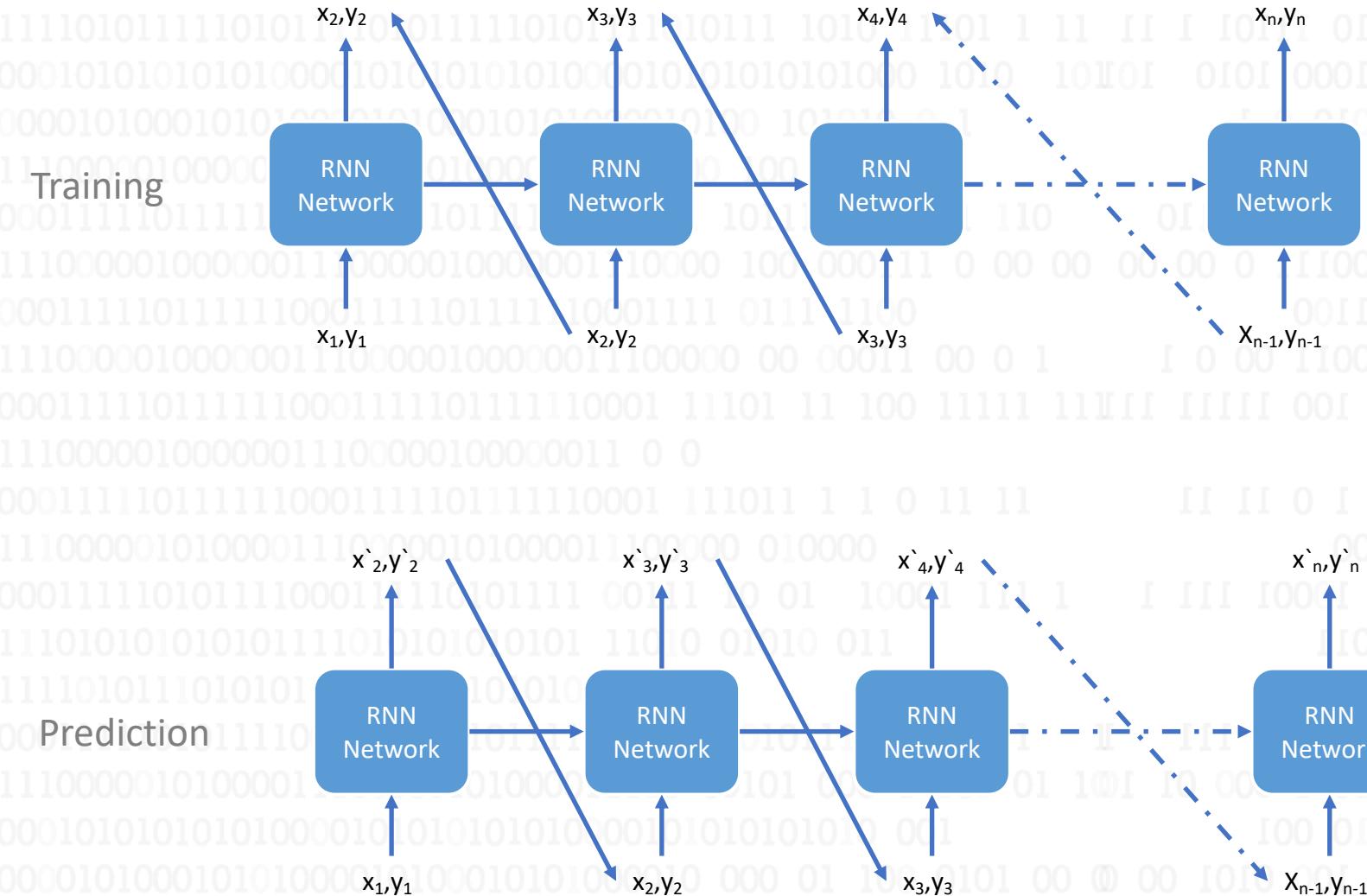
$$f(x) = \frac{1}{\sqrt{2\pi}\sigma_X} e^{-\frac{(x-\mu_X)^2}{2\sigma_X^2}}$$



# Gaussian Mixtures



# Training & Prediction



$$P(x) = \pi_t P(x_t | x_{1:t-1})$$

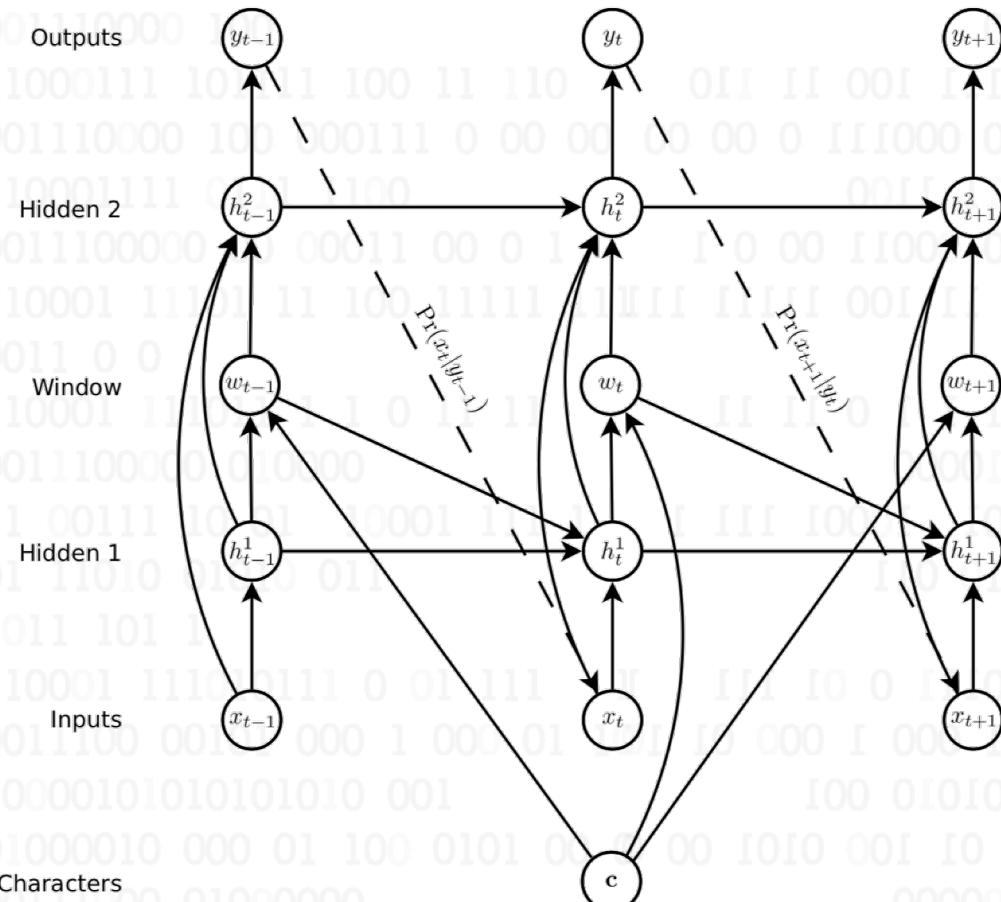
# Experiments

- Online Experiments
  - Less Comprehensive Characters/Words
  - Inconsistent Handwriting Style
  - Some Characters make sense

After my understanding Google there .  
They made another 'bepesknes' the  
main theme of 'hyp Wordits'  
see Boung a. The accent was fa

# Experiments

- Handwriting Synthesis: Tell model what to write



# ATTENTION



# Experiments

- Handwriting Synthesis: Tell model what to write
  - Biased Experiments
    - Bias the variance of Gaussians for style consistency

0 when the samples are biased towards more probable sequences  
0.1 they get easier to read  
0.5 but less diverse  
1 until they all look  
10 exactly the same  
10 exactly the same  
10 exactly the same

# Experiments

- Handwriting Synthesis: Tell model what to write
  - Primed Experiments
    - Bias network towards specific writing styles

she looked closely as she

when the network is primed  
with a real sequence

+ he samples mimic

the writer's style

# References

- [Generating Sequences with RNNs, Alex Graves](#)
- [Neural Machine Translation by Jointly Learning to Align and Translate, Bengio et al](#)
- [Attention Is All You Need, Vaswani et al](#)
- [Handwriting Generation Demo](#)
- [Chapter3, Hands on Transfer Learning, Dipanjan Sarkar, Raghav Bali, et al](#)
- [LSTM, Chris' blog](#)
- [Four Experiments in Handwriting with a Neural Network, distill.pub](#)
- [Mixture Density Networks, Hardmaru/Otoro's Blog](#)
- [Keras MDN](#)
- [Tensorflow Probability](#)



Thank you!

