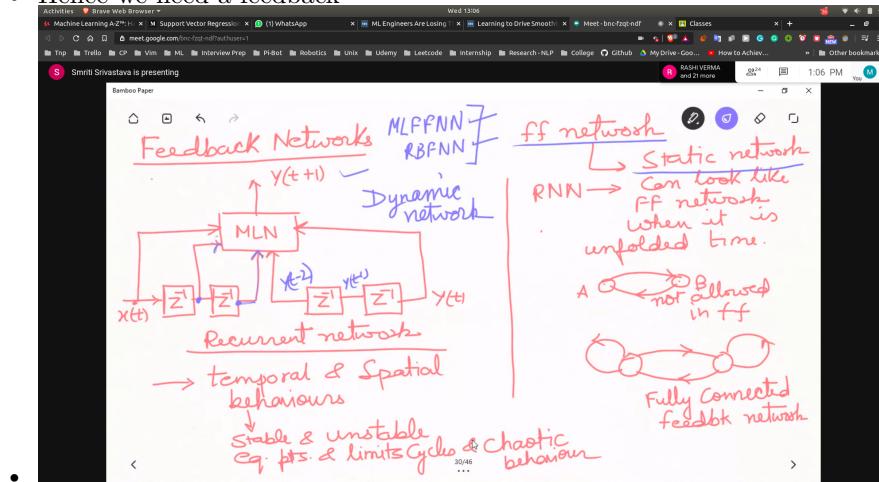


## Feedback Networks

- FF network is a static network
- So in order to have dynamic , we need feedback
- Hence we need a feedback



## Prop.

- Rich Temporal and spatial behaviours
  - because it's time stamp depends upon  $t, t-1$
- stable and unstable cycles
- mainly used for pattern recognition

## Unfolding in Time

- RNN can look like NN , when they are unfolded in time

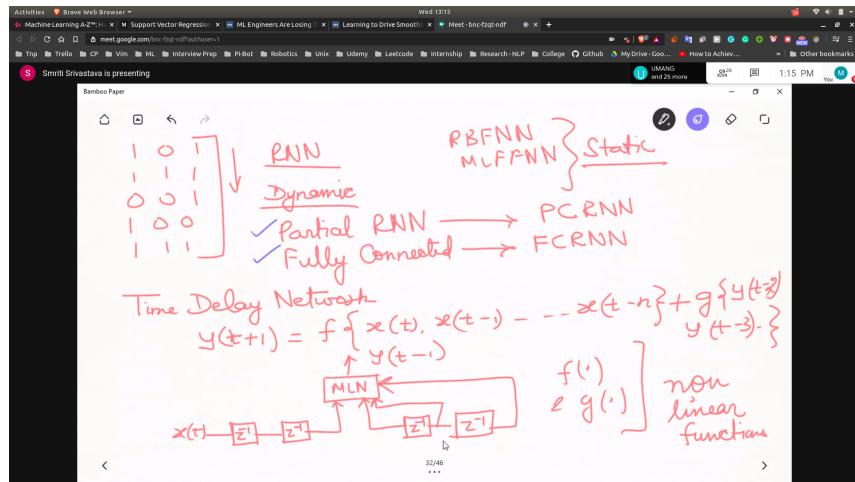
## Types

- FCRNN
- Partially Connected(PCRNN)

## Application

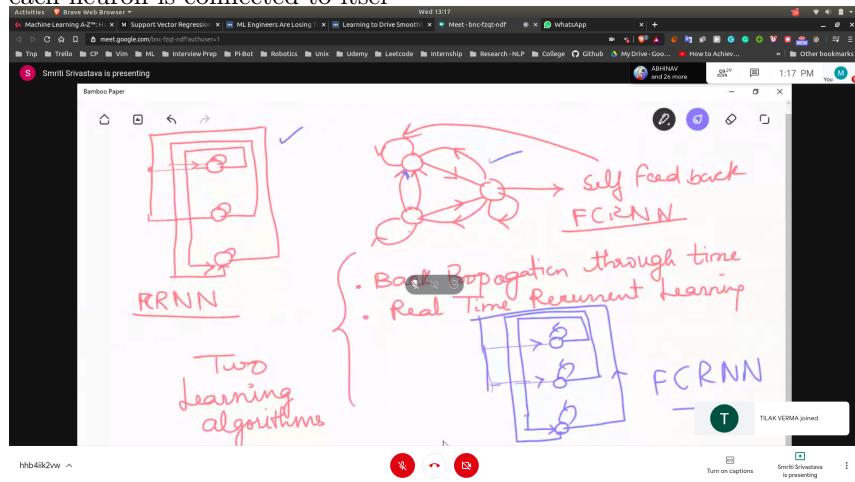
- Time Series Prediction
- Temporal Pattern recognition
  - signal classification
  - sound classification

## Time Delay Network



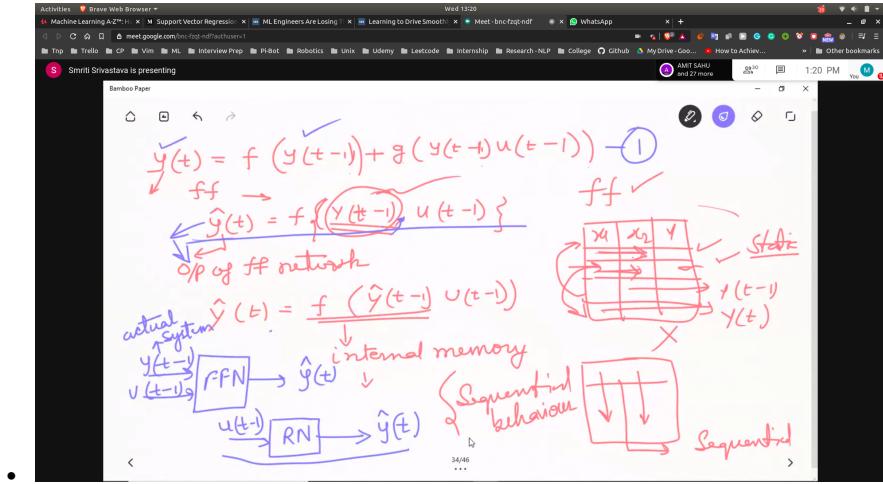
## Formation of full connected neural networks

- each neuron is connected to itself



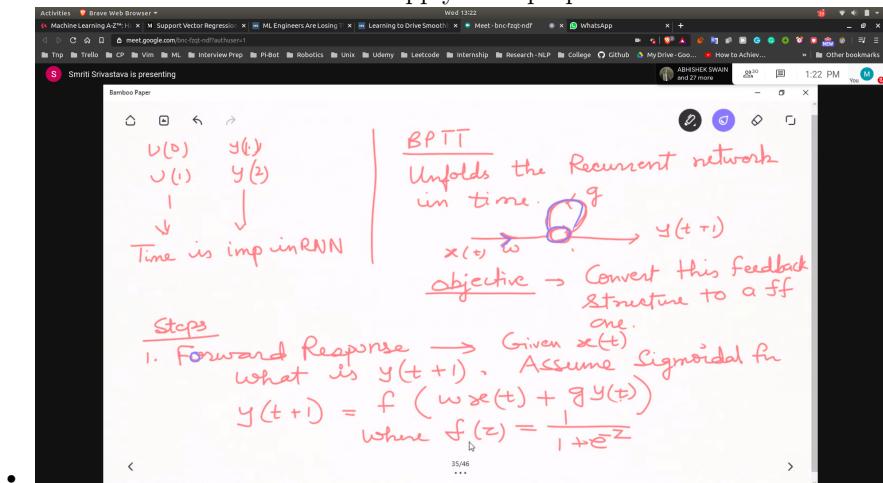
## Comp

- comparision of the NN



## Applying Back Propagation

- we roll the network in time to apply back prop



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Recursively it is

$$y(1) = f(\omega x(0) + g y(0))$$

$$y(2) = f(\omega x(1) + g y(1))$$

$$y(3) = f(\omega x(2) + g y(2))$$

Rolling of network in time

Back Propagation

$y^d \rightarrow$  desired o/p

Given  $\begin{cases} y(t+1) = f(\omega x(t) + g y(t)) \\ \text{external i/p's in Sequence} \\ x(0) \rightarrow x(1) \rightarrow x(2) \dots \\ y(0) \rightarrow \text{Initial Condition} \end{cases}$

Compute  $y(1)$ ,  $y(2)$ ,  $\dots$ ,  $y(5)$ .

$\omega$  &  $g$  are chosen same & random.

find  $y(1)$ ,  $\dots$ ,  $y(5)$  Targets  $e(1) \dots e(5)$

$$e(5) = y^d(5) - y(5)$$

$$e(4) = y^d(4) - y(4)$$

Apply BP

$y(0) \rightarrow y(1) \rightarrow y(2)$

$$y(1) = f(\omega x(0) + g y(0))$$

$$y(2) = f(\omega x(1) + g y(1))$$

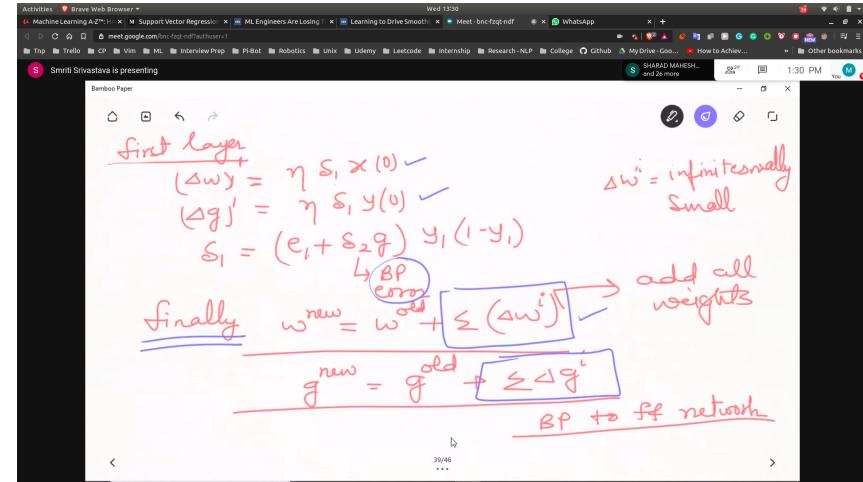
$$(\Delta\omega)^2 = \eta s_2 x(1) \rightarrow$$
 Generalized delta rule
$$(\Delta g)^2 = \eta s_2 y(1)$$

$$s_2 = e_2 \underbrace{y_2(1-y_2)}$$

$$f'(z) = \frac{df(z)}{dz} = y_2(1-y_2)$$

$$f(z) = \frac{1}{1+e^{-z}}$$

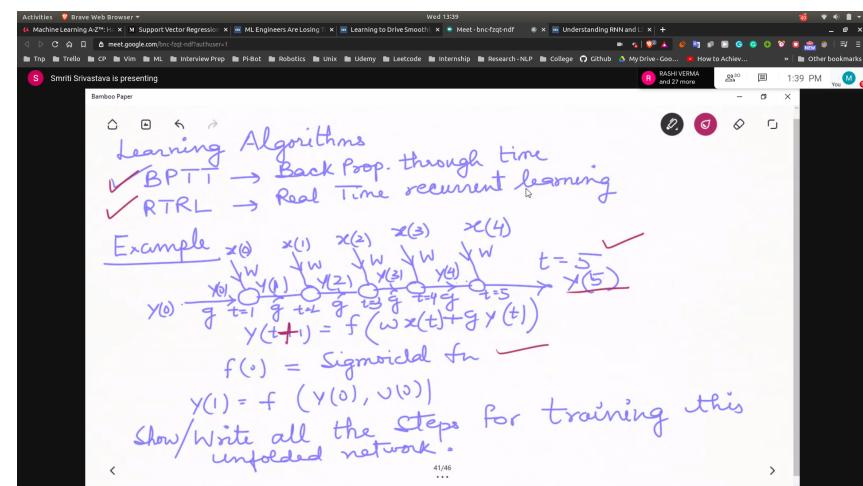
$$\text{so } f'(z) = z(1-z)$$



## 2 Learning Algo

- Back Prop Through time
- Real Time recurrent learning

### Example



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1. Calculate the response of Sequence  $y(1)$  to  $y(5)$   
given the sequence  $x(0)$  to  $x(4)$  &  $y(0)$ . ✓
2. Calculate the error  $e(5)$  ✓  

$$\Delta w^5 = \eta s_5 x(4) \quad \left. \begin{array}{l} s_5 = y(5) (1-y(5))e(5) \\ \Delta g^5 = \eta s_5 y(4) \end{array} \right\}$$
3. Compute  $e(4)$ ,  $e(3)$ ,  $e(2)$  &  $e(1)$   

$$\Delta w^4 = \eta s_4 x(3) \quad s_4 = y(4) (1-y(4)) [s_5 g + e(4)]$$

$$\Delta g^4 = \eta s_4 y(3)$$

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$$\begin{aligned} \Delta w^3 &= \eta s_3 x(2) & \Delta w^2 &= \eta s_2 x(1) & \Delta w^1 &= \eta s_1 x(0) \\ \Delta w^1 &= \eta s_1 x(0) & \Delta g^3 &= \eta s_3 y(2) & \Delta g^2 &= \eta s_2 y(1) \\ \Delta g^1 &= \eta s_1 y(0) & \text{where } s_1 &= y(1) (1-y(1)) [s_2 g + e(1)] \end{aligned}$$

update rule

$$w^{\text{new}} = w^{\text{old}} + \sum_{i=1}^5 \Delta w^i$$

$$g^{\text{new}} = g^{\text{old}} + \sum_{i=1}^5 \Delta g^i$$

System Identification / Modeling

hhb4lik2ww

Turn on captions

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