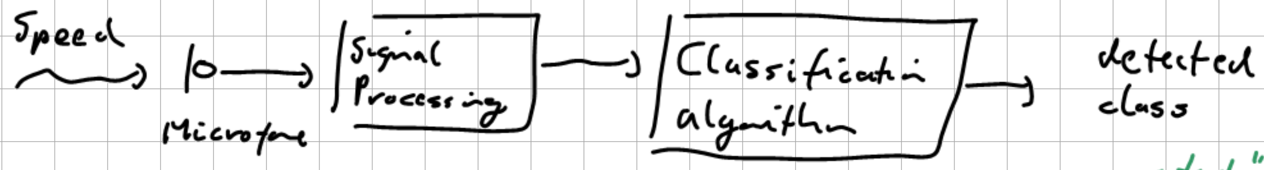
How is the Confusion matrix evaluated?



„start"
„start"

„start"
„left"

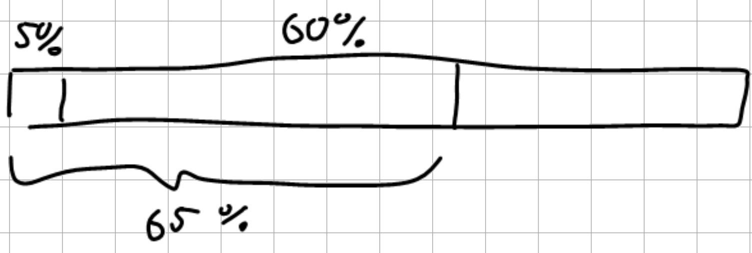
- Artificial Neural Network implemented in e.g. TensorFlow

		detected words			
		start	stop	left	right ...
	start	17		1	
	stop				
spoken words	left				
	right				
	⋮				

Random Number : 0 ... 1

False Rejection Rate : 5%

Accuracy : 60%

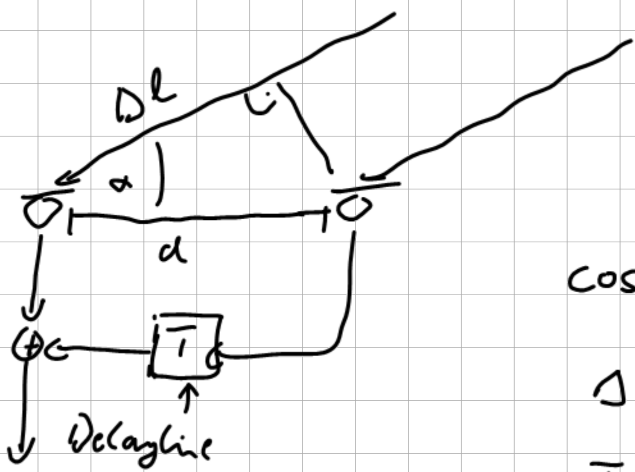


Beamforming

$\alpha = 15°$

$d = 10\ \text{cm}$

$c = 340\ \frac{m}{s}$



$$\cos\alpha = \frac{\Delta l}{d}$$

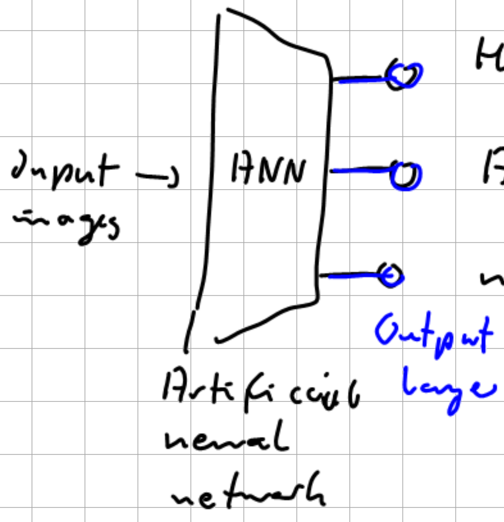
$$\Delta l = d \cdot \cos\alpha$$

$$T = \frac{\Delta l}{c} = \frac{d \cdot \cos\alpha}{c} = 284\ \mu s$$

Softmax

Assumption : 3 Classes to detect

z_j $\qquad 0 \le j < J$



Human	0.7
Animals	0.9
not living things	0.3

Softmax layer

$x_i \to y_j = f(x_i)$ $\qquad$ here: $I = 3 \quad J = 3$

$$= \frac{e^{x_j}}{\sum_l e^{x_l}}$$

$$0.7 \longrightarrow \frac{e^{0.7}}{e^{0.7} + e^{0.9} + e^{0.3}} = 0.346$$

$$0.9 \longrightarrow \frac{e^{0.9}}{e^{0.7} + e^{0.9} + e^{0.3}} = 0.422 \quad \%$$

$$0.3 \longrightarrow \frac{e^{0.3}}{e^{0.7} + e^{0.9} + e^{0.3}} = 0.232$$

$$\Sigma = 1$$

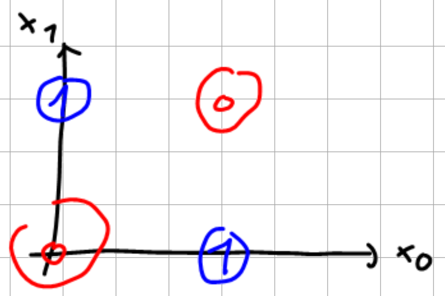
Dense layer

I Number of inputs

J Number of outputs

$$y_j = b_j + \sum_{i=0}^{I-1} w_{ji} \cdot x_i$$

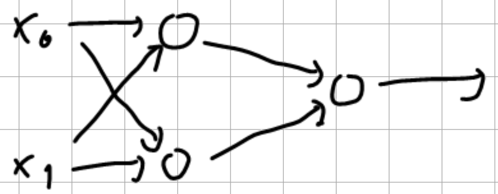
XOR : nonlinear separation :



Table

x_0	x_1	o
0	0	0
0	1	1
1	0	1
1	1	0

can be solved bey neural network:



Layer 0
- Dense
- nonlinearity, e.g.
  Sigmoid
  ReLU

Dense Layer - backward

$$y_j = b_j + \sum_{i=0}^{I-1} w_{ji} \cdot x_i$$

e.g. $y_2 = b_2 + w_{20} x_0 + w_{21} x_1 + w_{22} x_2$

$$\frac{dy_j}{db_j} = 1$$

$$\frac{dy_j}{dw_{ji}} = x_i$$

$$\frac{dy_j}{dx_i} = w_{ji}$$

$$\frac{dy_2}{dx_1} = w_{21}$$

$$\frac{dy_2}{dw_{22}} = x_2$$

$$\frac{dy_2}{dw_{20}} = x_0$$

Prove of linearity

for linearity the following must be true:

$$f(a x_1 + b x_2) = a \cdot f(x_1) + b \cdot f(x_2)$$

for all a, b, x_1, x_2

prove non-linearity for $f(x) = x^2$

↳ we need only one example

$a = 2$
$b = -2$
$x_1 = 2$
$x_2 = 3$

$$f(2 \cdot 2 + (-2) \cdot 3) = 2 \cdot f(2) + (-2) f(3)$$

$$f(-2) = 2 \cdot 4 - 2 \cdot 9$$

$$4 = -10 \quad \checkmark$$

prove linearity for DFT: $f(x) = \sum_{n=0}^{N-1} x(n) \cdot e^{-j2\pi \frac{nk}{K}}$

$$f(a \cdot x_1 + b \cdot x_2) = \sum_{n=0}^{N-1} (a\, x_1(n) + b \cdot x_2(n))\, e^{-j2\pi \frac{nk}{K}}$$

$$f(a \cdot x_1(n) + b \cdot x_2(n)) = \sum_{n=0}^{N-1} a\, x_1(n) e^{-j2\pi \frac{nk}{K}} + b \cdot x_2(n) e^{-j2\pi \frac{nk}{K}}$$

$$= \sum_{n=0}^{N-1} a\, x_1(n)\, e^{-j2\pi \frac{nk}{K}} + \sum_{n=0}^{N-1} b\, x_2(n)\, e^{-j2\pi \frac{nk}{K}}$$

$$= a \sum_{n=0}^{N-1} x_1(n)\, e^{-j2\pi \frac{nk}{K}} + b \cdot \sum_{n=0}^{N-1} x_2(n)\, e^{-j2\pi \frac{nk}{K}}$$

$$= a\, f(x_1(n)) + b \cdot f(x_2(n))$$