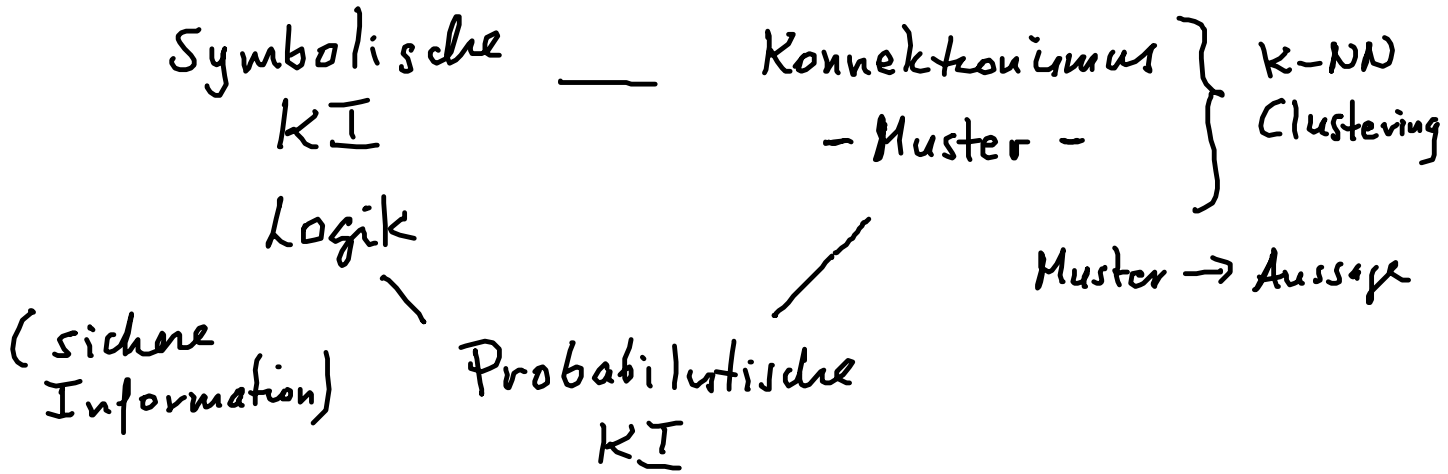
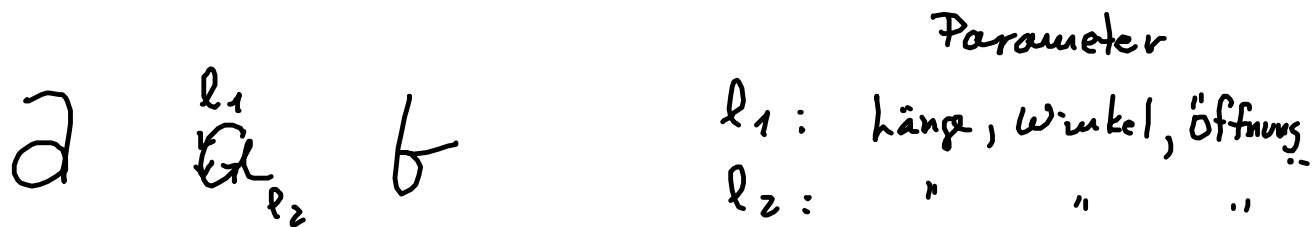
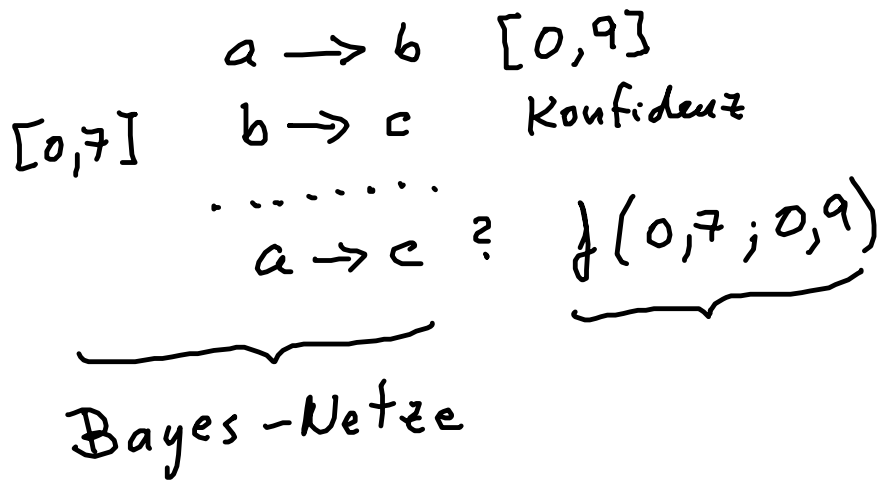


Backprop



unsichere Informationen



Regel:

- 1) If $\text{Öffnung} \leq 0,2$
 then

```
    } teste Null }  
    if  
    if  
    ⋮  
else  
⋮
```

Symbolische KI

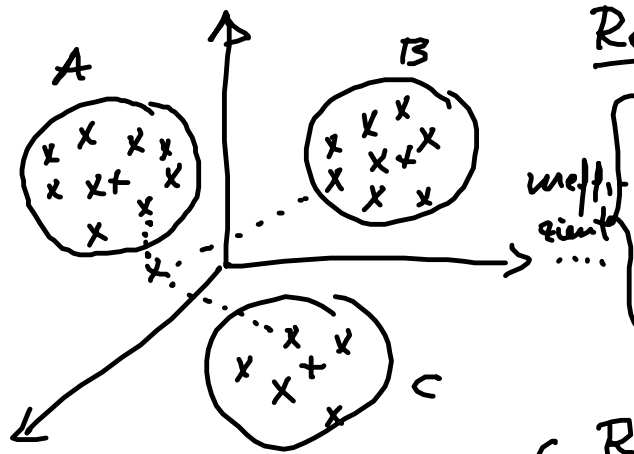
→ Programmierer ⇒ Regelwerk
"Logik"

{ Konnektionische KI

→ Automatische
(Machine Learning)
"lernen"

Backprop

Objekte → Features → Erkennung
 \mathbb{R}^n lernen



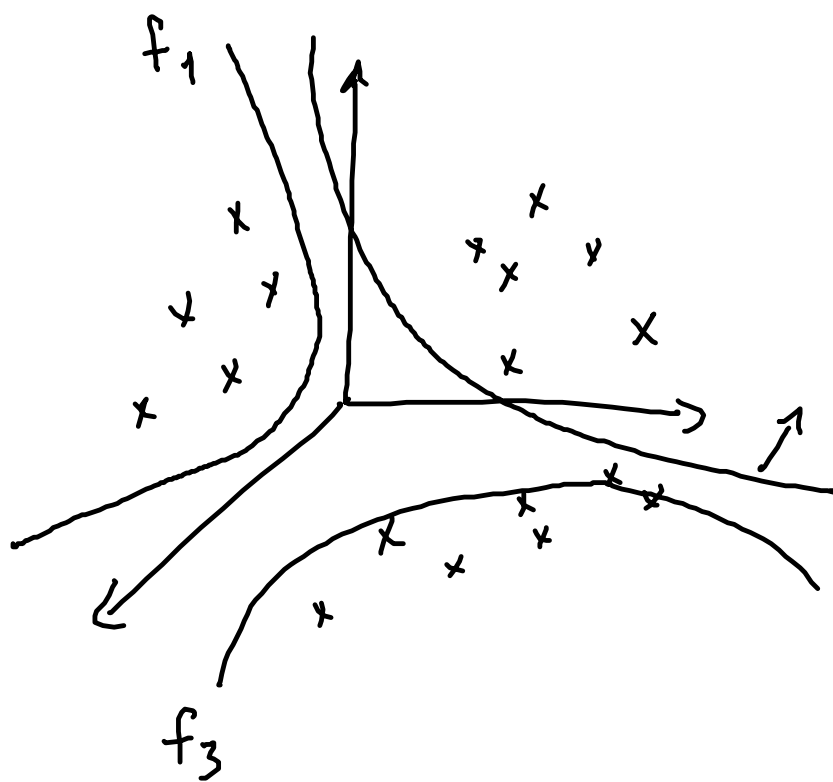
Rep. 1

Alle Daten
 Unbekannter \rightarrow KNN
 betrage
 Nachbarn

Effizient
 Radius
 Zentrum

Rep. 2

[Clusterzentren
 Radius
 Abstand \leq Radius

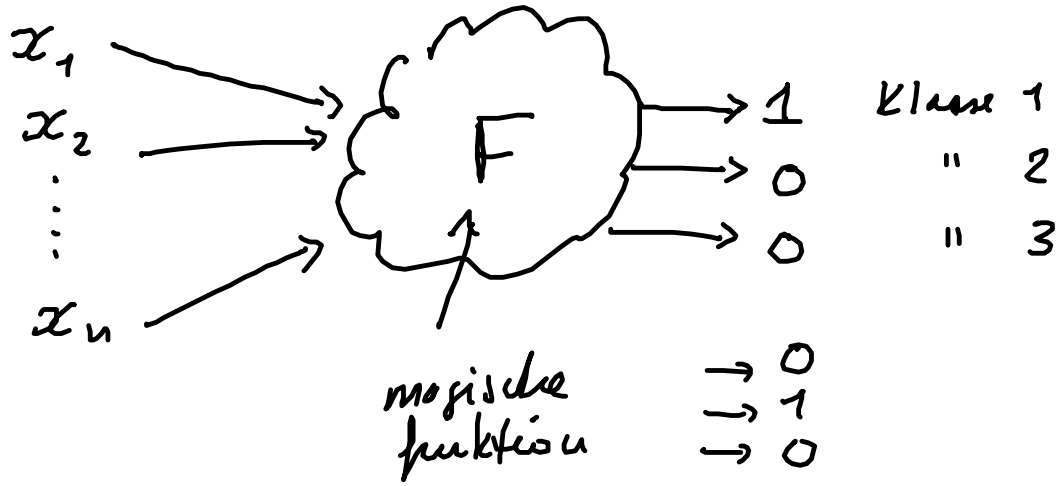


f_2 = Trennung-
 flächen
 = einfache

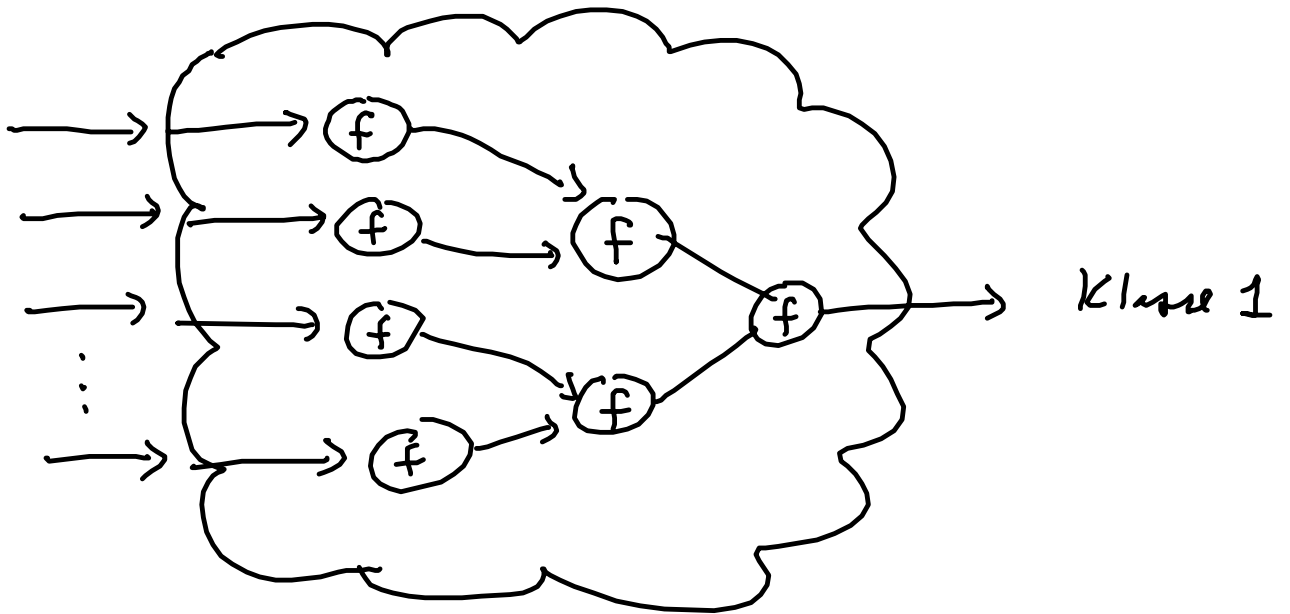
Netz - Neuronal
 Funktional

Merkmale
 ~~~~~

o o



$\rightarrow 0,7$  Klasse 1  
 $\rightarrow 0,3$  " 2  
 $\rightarrow 0,0$  " 3

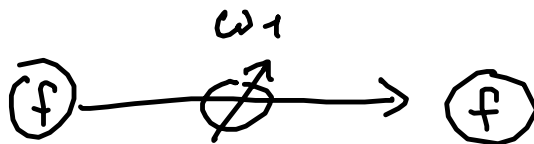
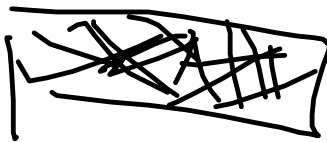
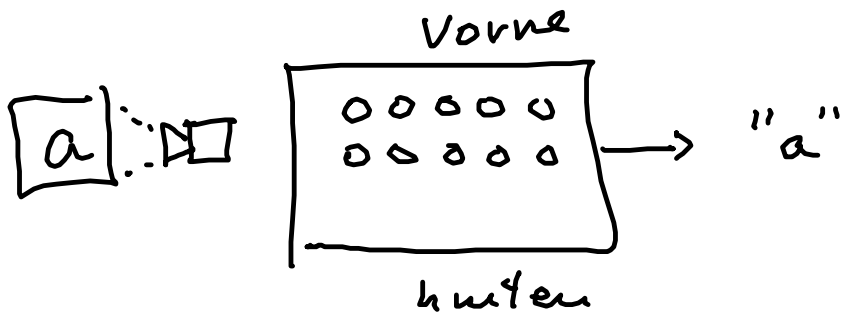
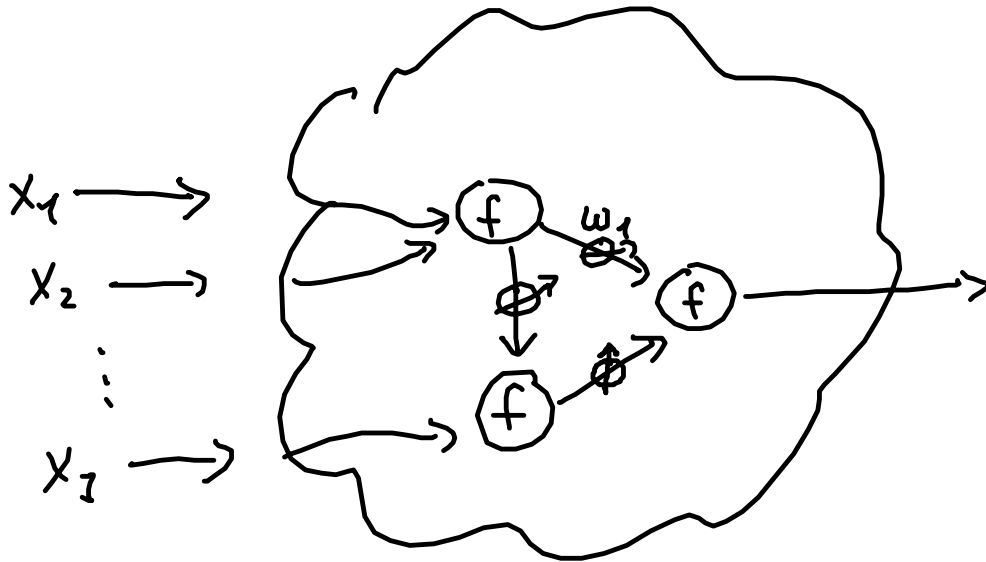


**Einschränkung:**

- Elementarfunktionen sind gleich
- Topologie ist fest
- keine Zyklen
- freie Parameter sind Gewichte der Kanten (modulieren)

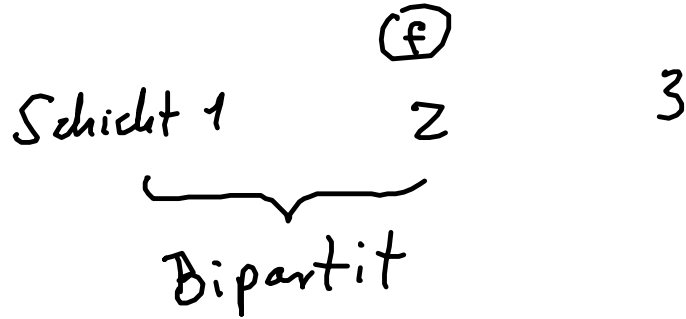
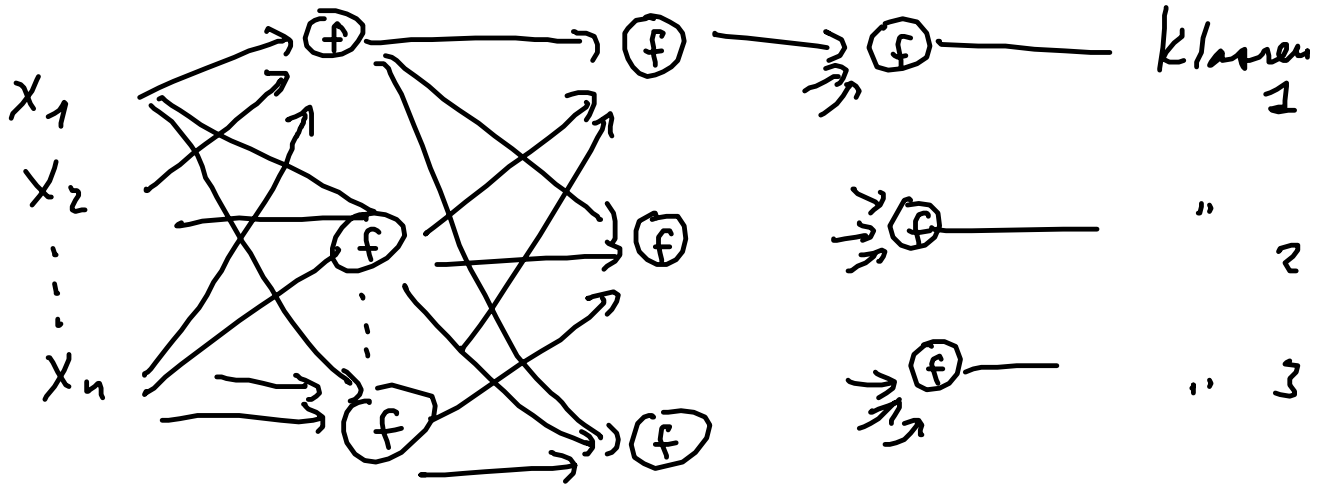


$$0,7 \xrightarrow{0,2} 0,14 = 0,7 \times 0,2$$

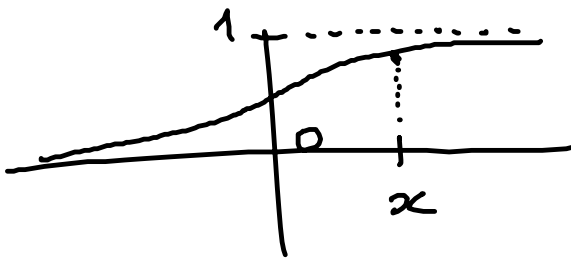


$$w_1 = 0$$

Topologie

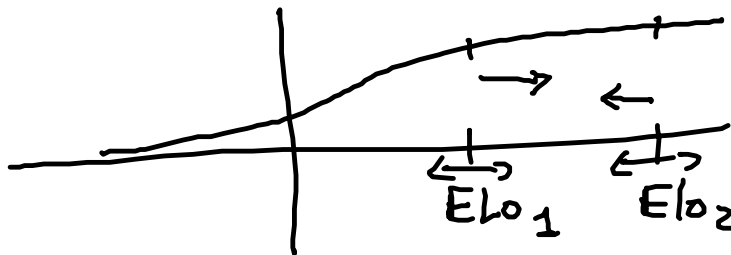


Elementar funktion

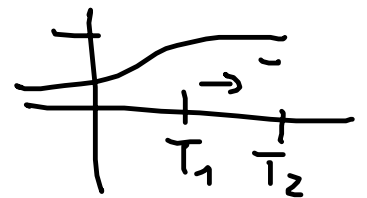


Sigmoide  
logistische Funktion

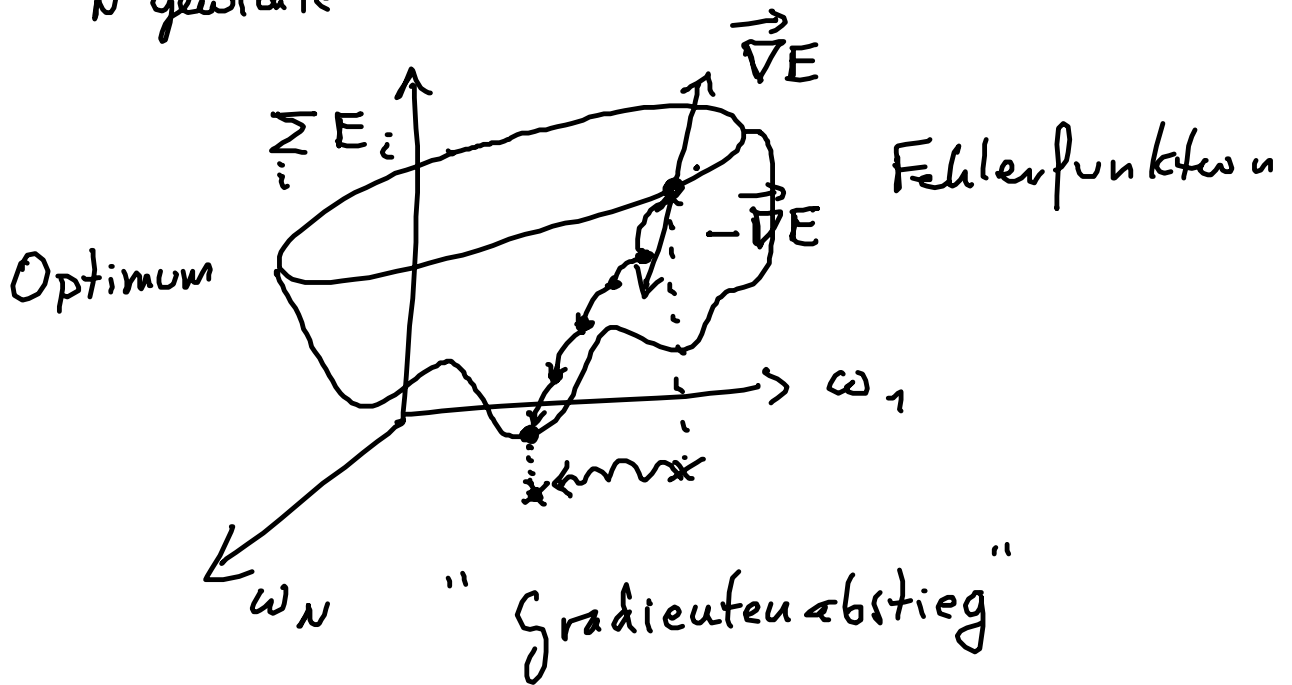
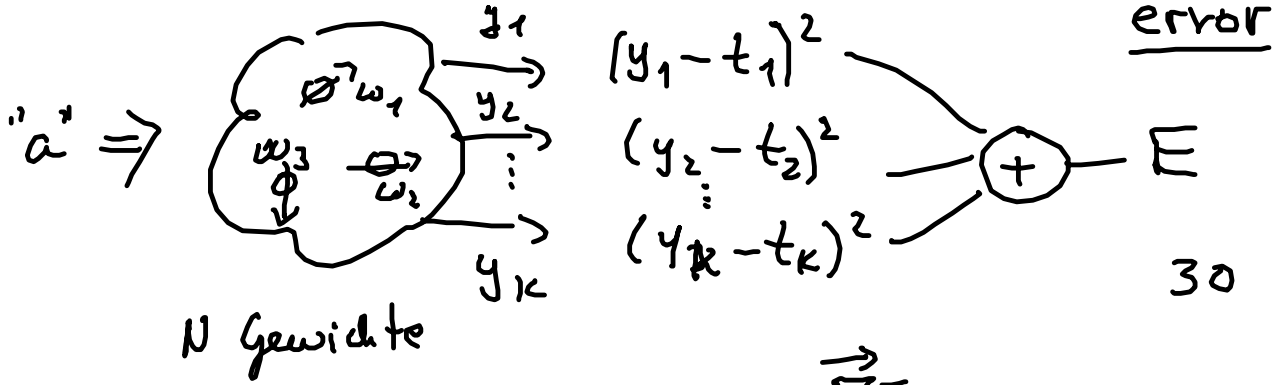
ELO-Rating



Vorschlag  
FIFA







$$\vec{\nabla} E = \left( \frac{\partial E}{\partial w_1}, \frac{\partial E}{\partial w_2}, \dots, \frac{\partial E}{\partial w_N} \right)$$

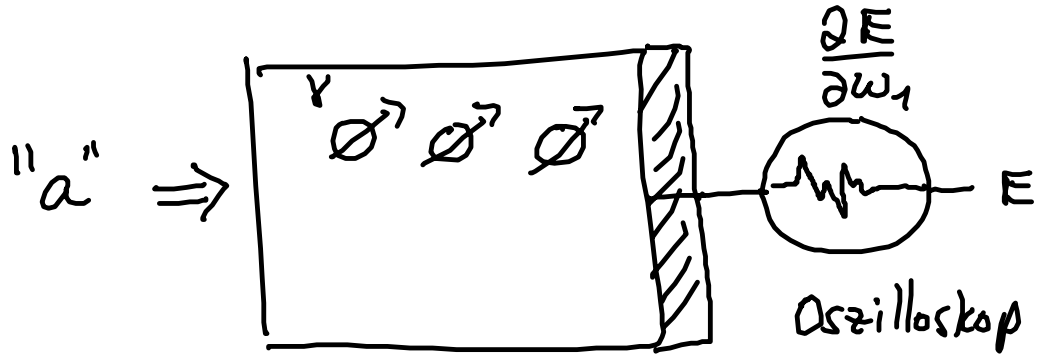
$$w_1 := w_1 - \gamma \frac{\partial E}{\partial w_1}$$

$$w_2 := w_2 - \gamma \frac{\partial E}{\partial w_2}$$

$\vdots$

$$w_N := w_N - \gamma \frac{\partial E}{\partial w_N}$$





Ableitungen

$f'(x)$  ?

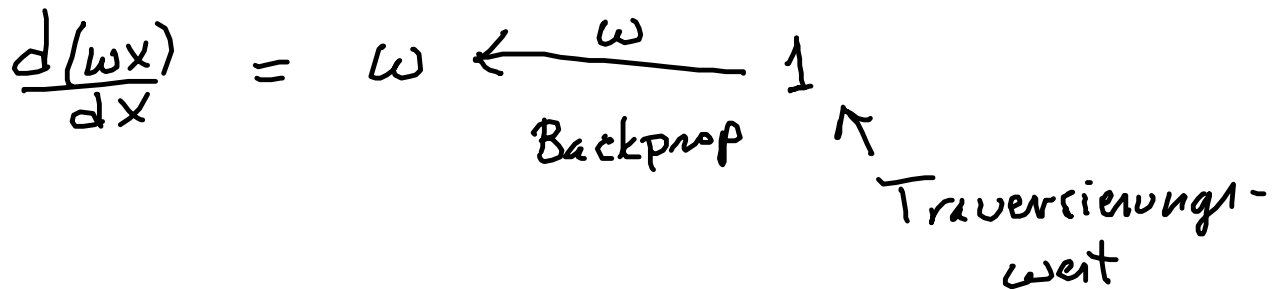
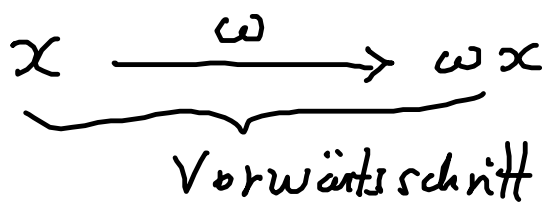
Kleineres Problem



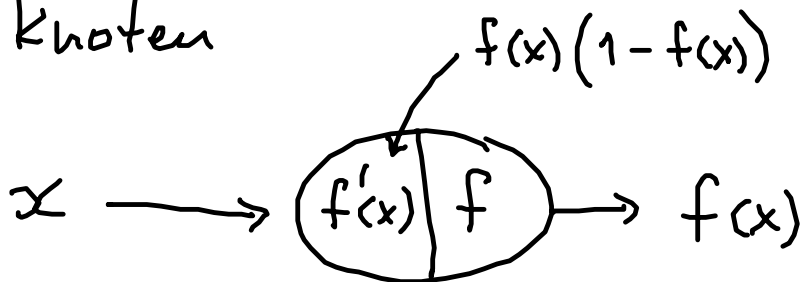
Backprop-Algorithmus

Fälle

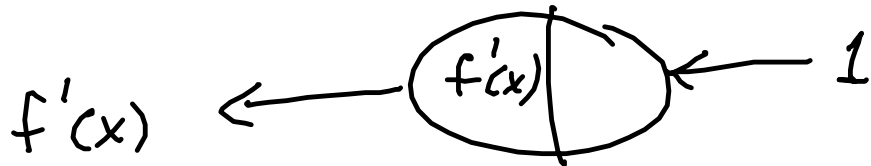
1) Kante



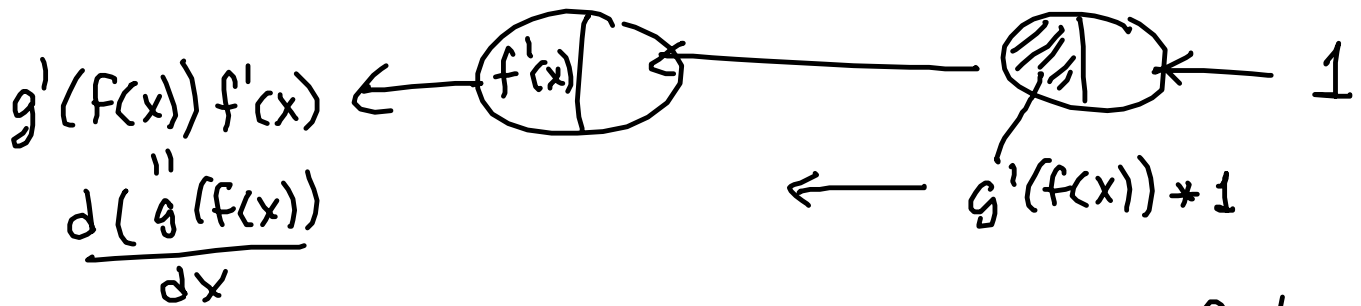
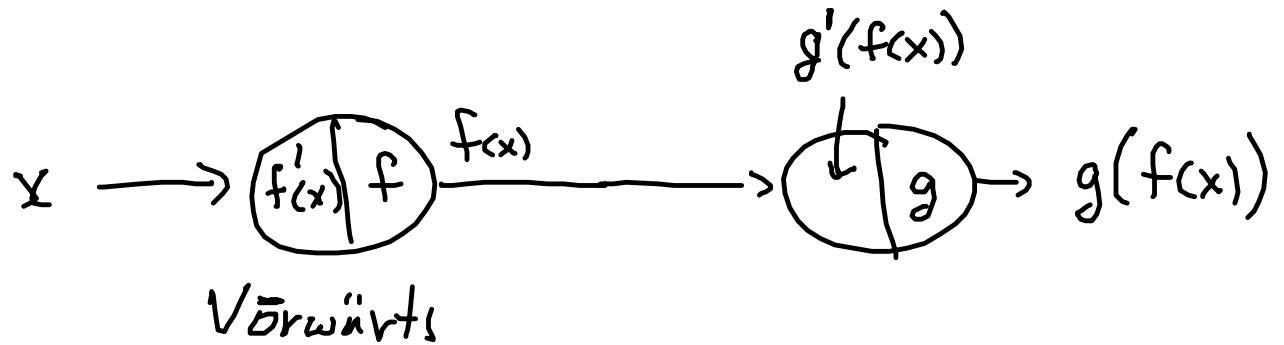
2) Ein Knoten



Vorwärts

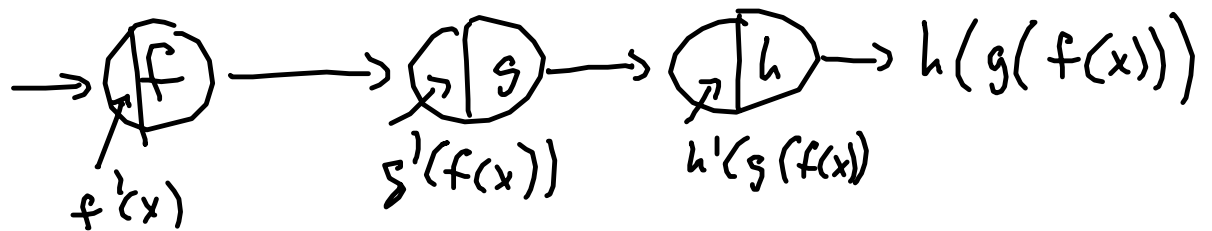


### 3) Funktionskomposition



← Trave.wert \* linke Seite

### 4) Beliebige Funktionskomp.

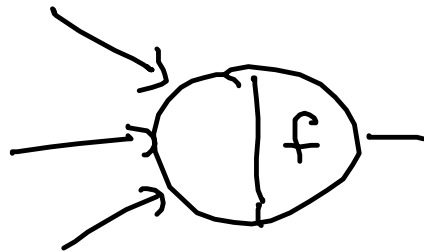


$$h'(g(f(x))) \cdot g'(f(x)) \cdot f'(x)$$

$$\frac{d}{dx} (h(g(f(x)))) \dots$$

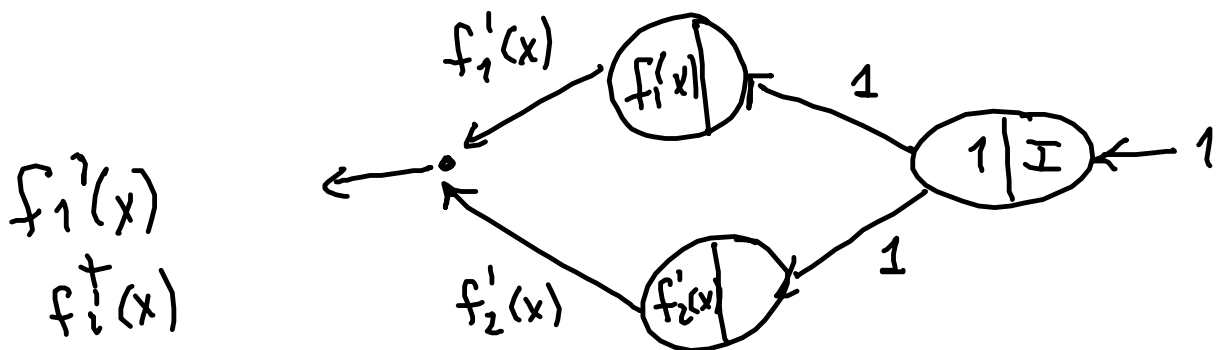
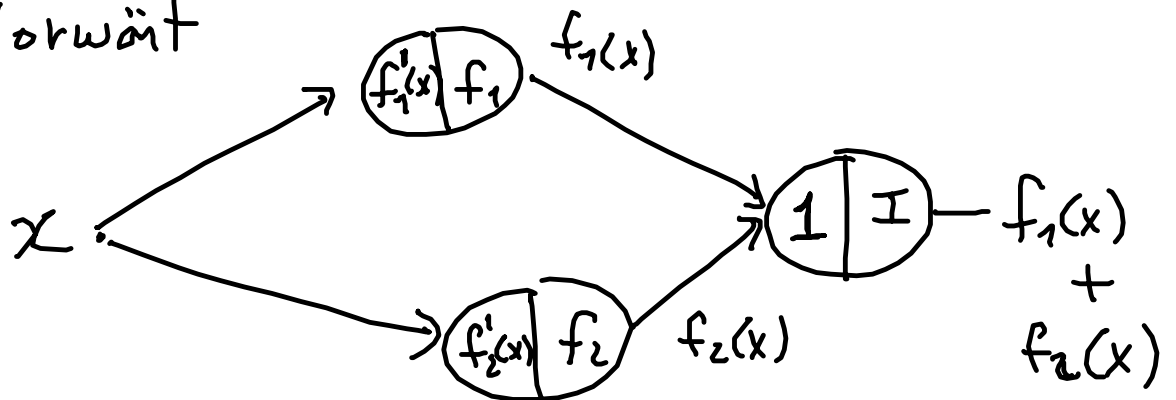
# 5) Addition von Funktionen

Vereinerung



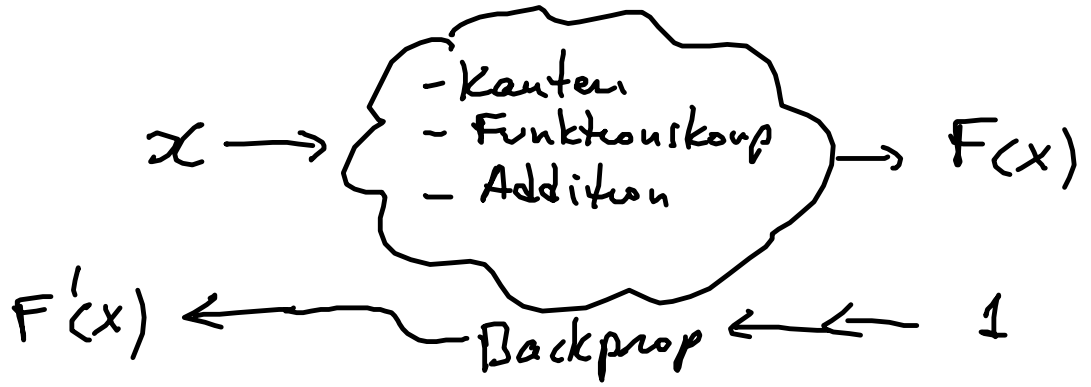
addiert Input

Vorwärts

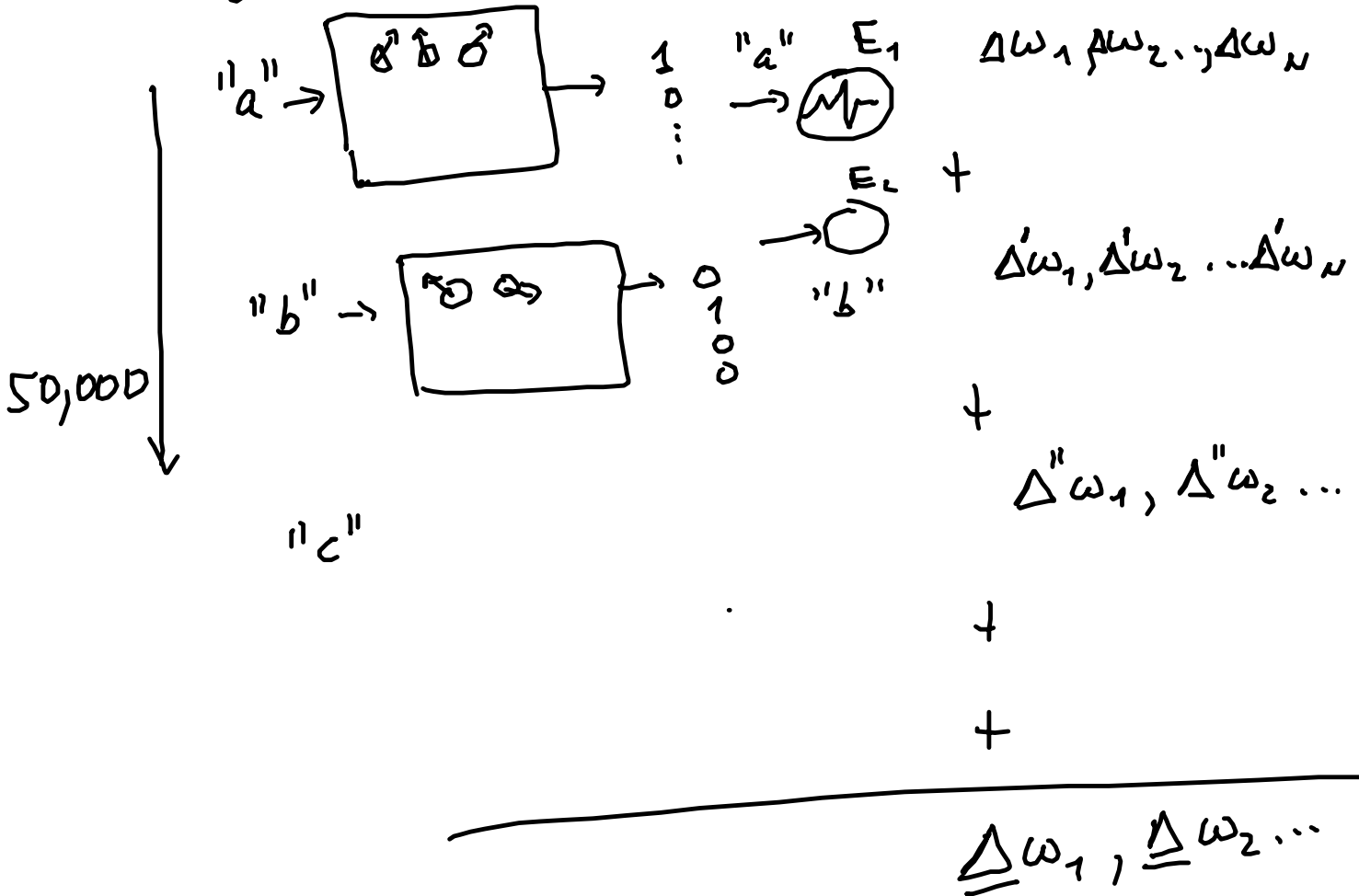


$f_1'(x)$   
 $f_2'(x)$   
 "  $\frac{d}{dx} (f_1(x) + f_2(x))$



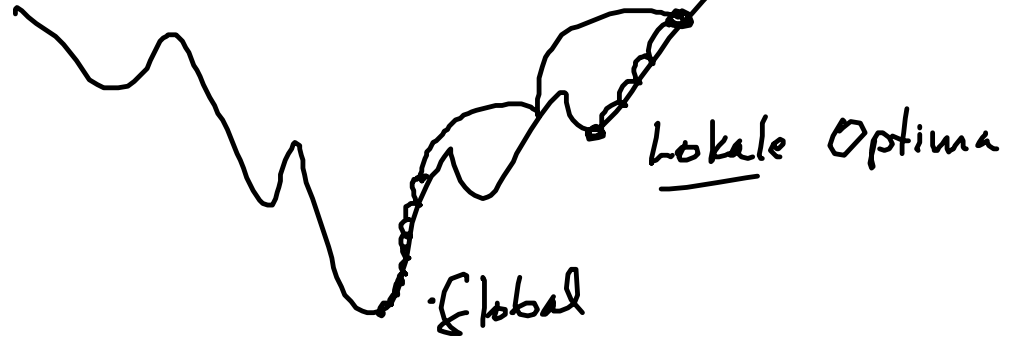


Trainingsmenge

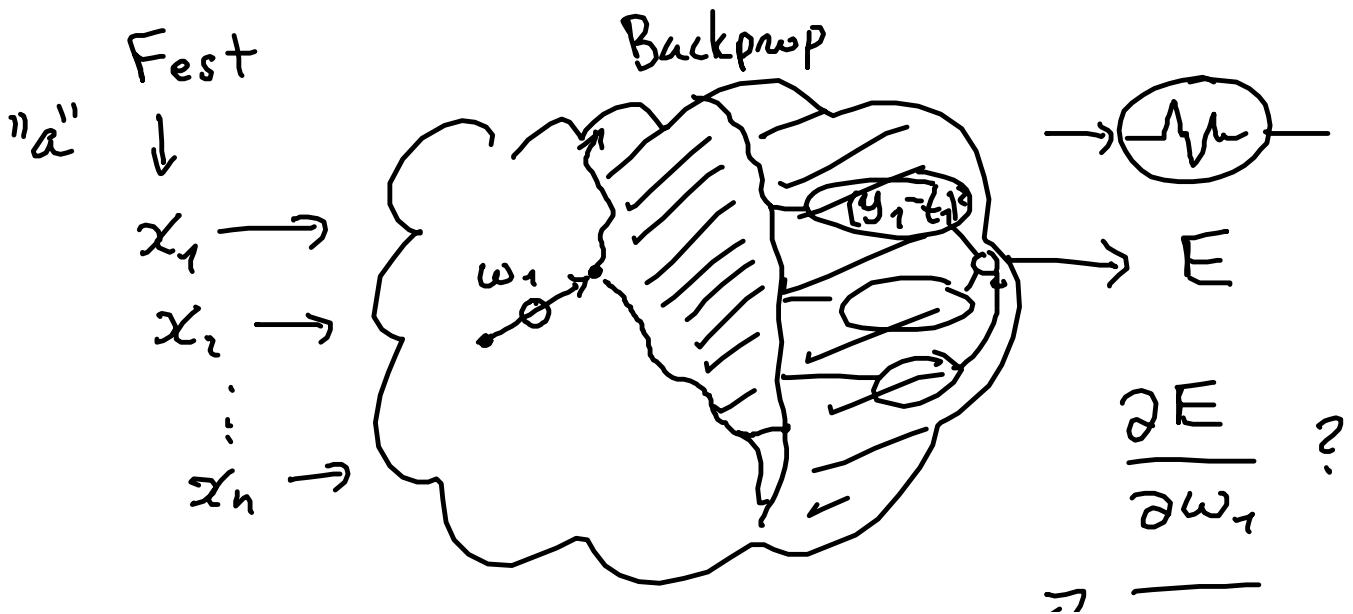


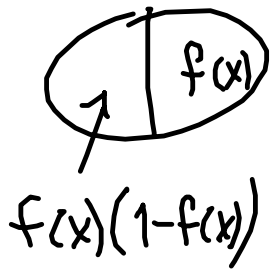
Gradientenabstieg

Simulated Annealing



1000 Gewichte





$$\omega_1 \rightarrow$$

$$\begin{matrix} 1 \\ 1,1 \end{matrix}$$

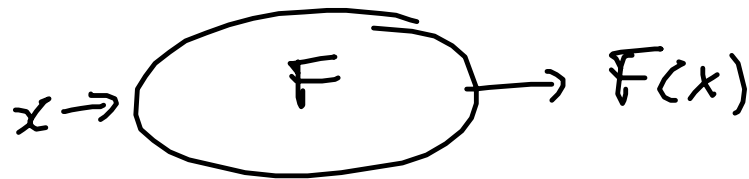
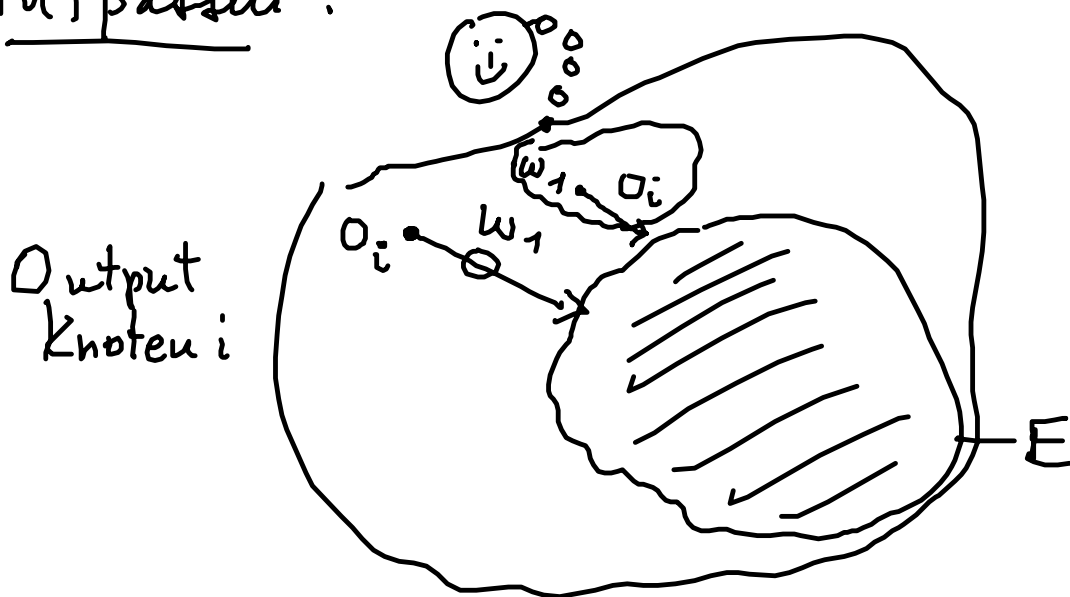
Backprop von  $E$  der Ausgabe bei  $2,2$   $\omega_1$

$$\Delta E = 0,2$$

$$\Delta \omega_1 = 0,1$$

$$\frac{\Delta E}{\Delta \omega_1} = 2$$

Aufpassen!



.....

