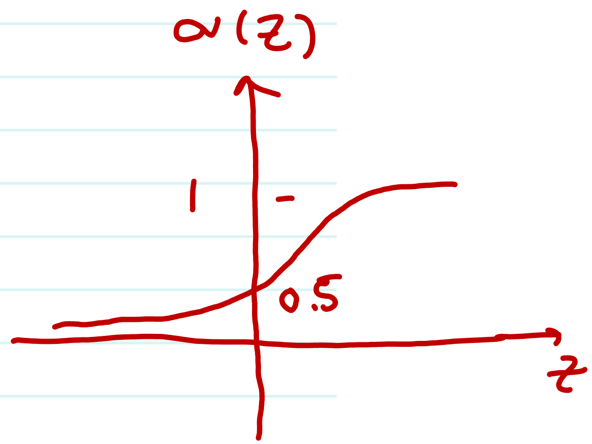
$$\sigma(z) = \frac{1}{1+e^{-z}}, \quad z = w^T x \qquad \{ \, z = w^T x + b$$

regression



$$y_t = \beta_0 + \beta_1 x_1 + \cdots + \beta_d x_d = w^T x$$

$$\begin{bmatrix} \beta_0 & \beta_1 & \cdots & \beta_d \end{bmatrix} \begin{bmatrix} 1 \\ x_1 \\ \vdots \\ x_d \end{bmatrix}$$

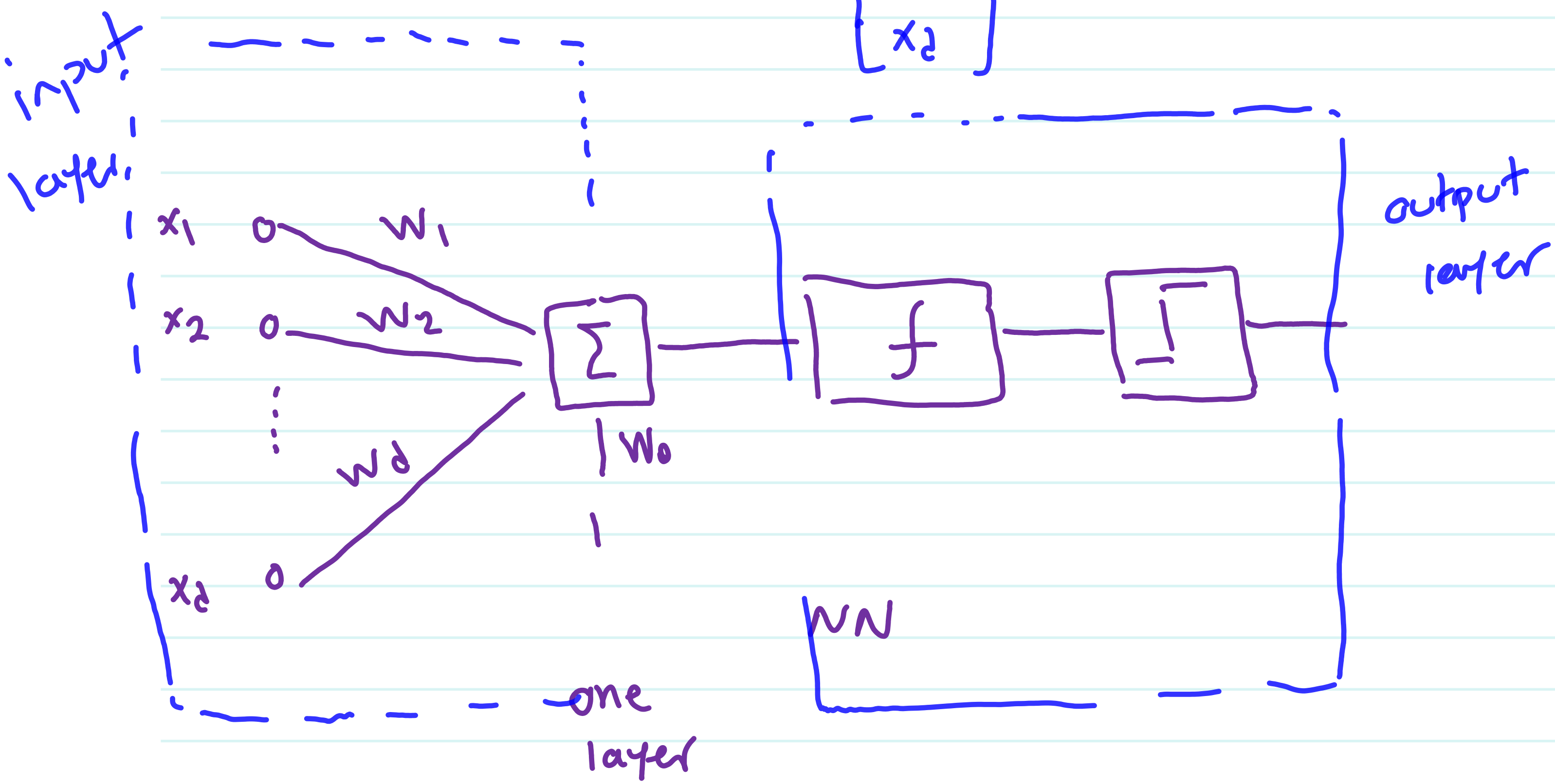
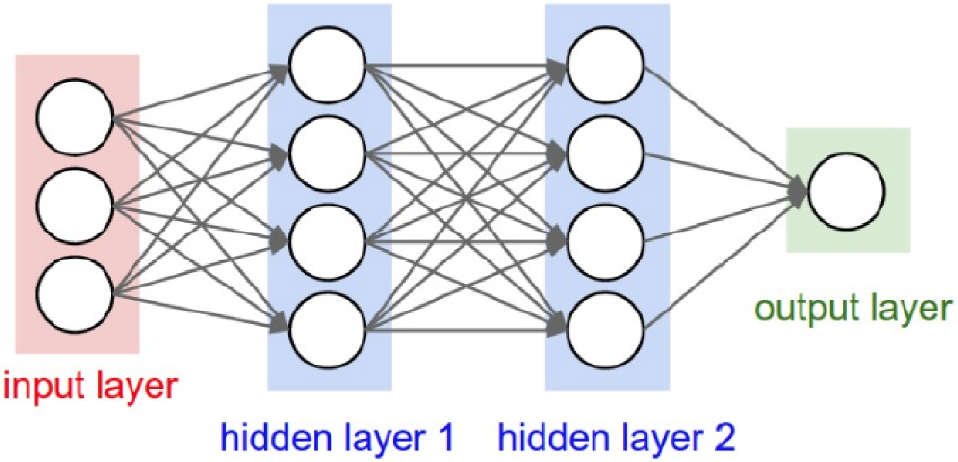


Diagram representation

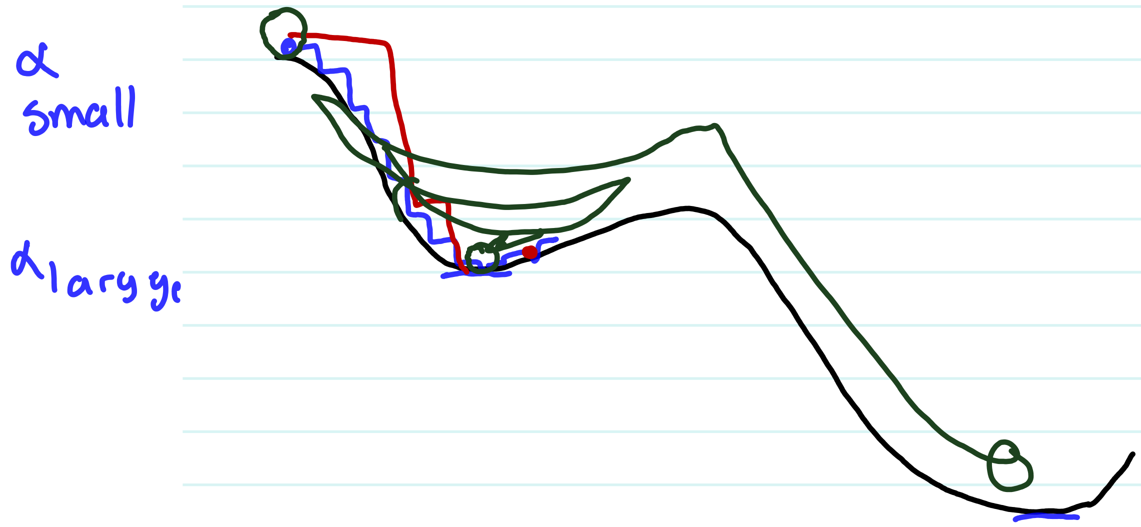
- input layer = 3 units (feature space dimension)
- hidden layer 1 = 4 units
- hidden layer 2 = 4 units
- output layer = 2 units




```
from keras.models import Sequential
from keras.layers import *

model = Sequential()

model.add(Input(shape=(3,))) # Input tensor
model.add(Dense(units=4)) # hidden layer 1
model.add(Dense(units=4)) #hidden layer 2
model.add(Dense(units=1)) #output layer
```



Entropy : $E(S) = \sum_{i=1}^{c} -p_i \cdot \log_2 p_i$

Two classes $\begin{cases} + & 30 & p_1 = 0.3 \\ - & 70 & p_2 = 0.7 \end{cases}$

$$E(S) = -(0.3)\log_2(0.3) - 0.7\log_2(0.7) \approx 0.88$$

* Consider an example loan → { write off / non-write off.

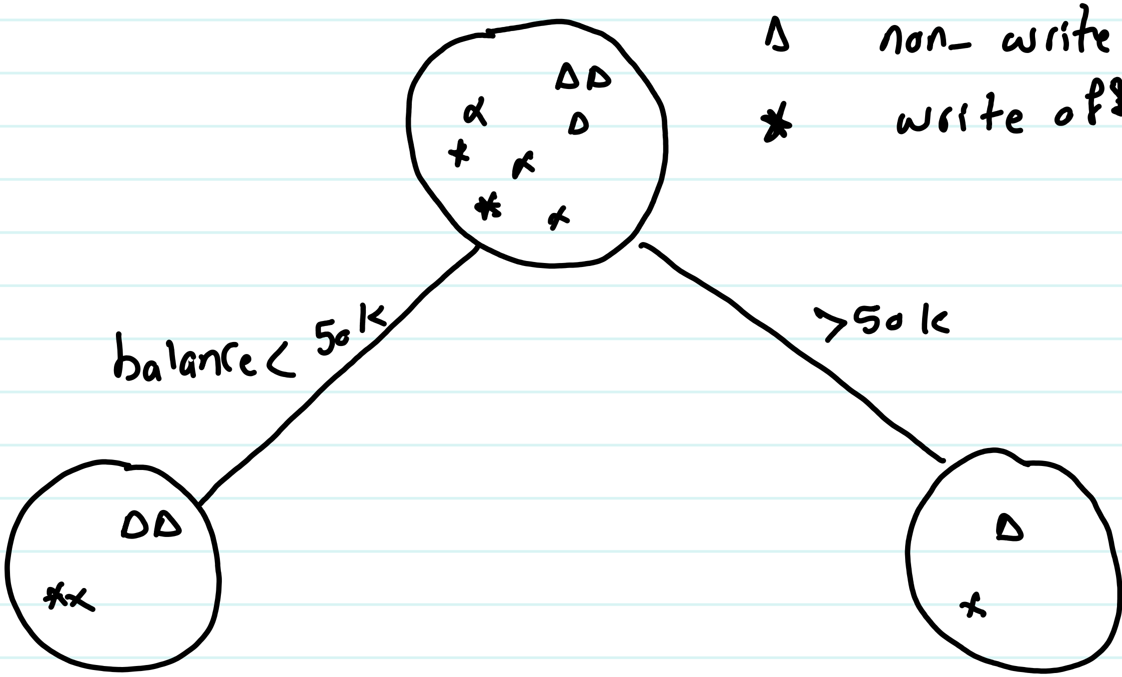
Feature
- 1- balance { $< 50k$ / $> 50k$
- 2- residance { own / rent / other.

using I.G to develop tree.

Δ non-write off 14

* write off 16

Balance



$P(\Delta) = \frac{1}{13}$

$P(*) = \frac{12}{13}$

$P(\Delta) = \frac{4}{17}$

$P(*) = \frac{13}{17}$

lets calculate entropy:

$$E(\text{parent}) = -\frac{14}{30}\log_2\left(\frac{14}{30}\right) - \frac{16}{30}\log_2\left(\frac{16}{30}\right) = 0.99$$

$$E(\text{balance} < 50) = \frac{-1}{13}\log_2\left(\frac{1}{13}\right) - \frac{12}{13}\log_2\left(\frac{12}{13}\right) = 0.39$$

$$E(\text{balance} > 50) = \frac{-4}{17}\log_2\left(\frac{4}{17}\right) - \frac{13}{17}\log_2\left(\frac{13}{13}\right) = 0.79$$

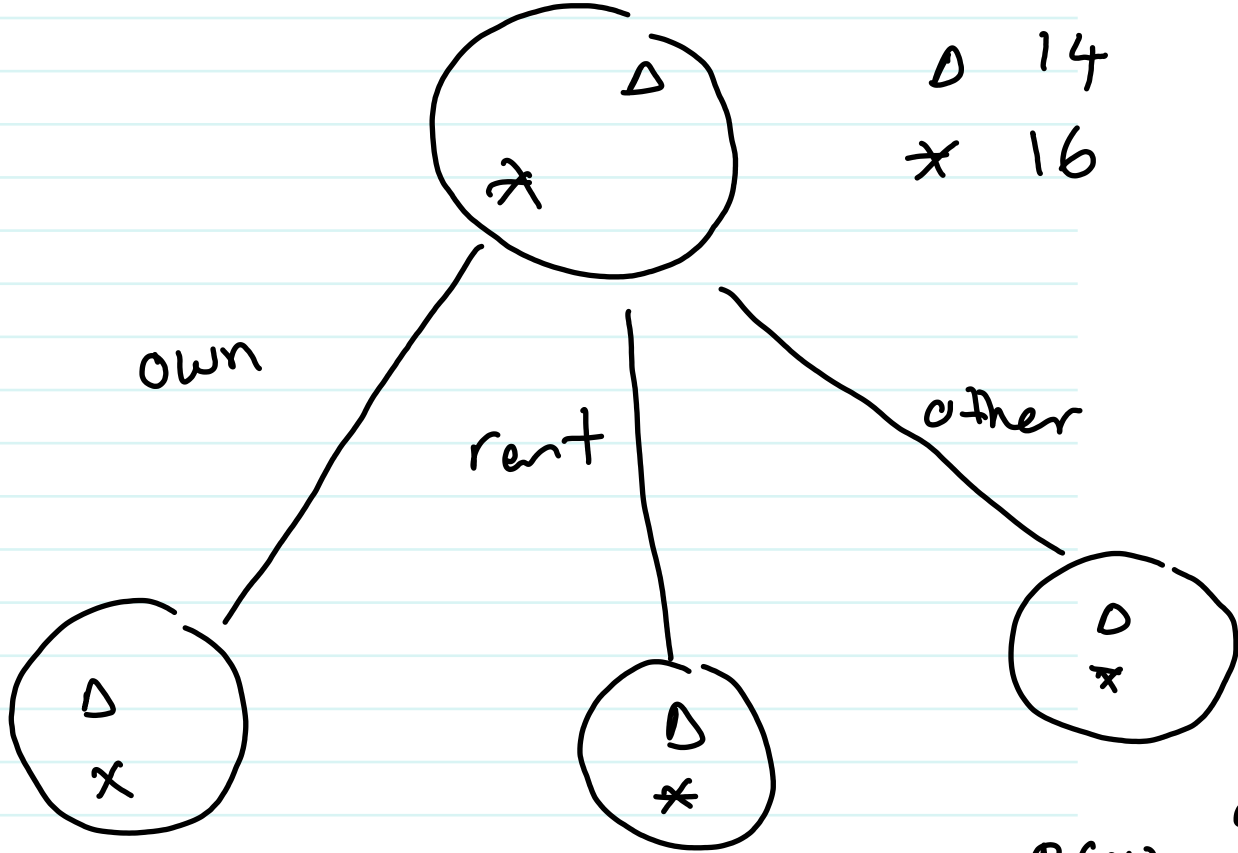
Weighted Average

$$0.39 \times \frac{13}{30} + 0.79 \times \frac{17}{30} = 0.62$$

$$I.G = E(\text{parent}) - E(\text{balance})$$

$$= 0.99 - 0.62 = \boxed{0.37}$$

residance



$P(x) = \frac{7}{8}$

$P(\Delta) = \frac{1}{8}$

$P(x) = \frac{4}{10}$

$P(\Delta) = \frac{6}{10}$

$P(x) = \frac{5}{12}$

$P(\Delta) = \frac{7}{12}$

$E(\text{parent}) = 0.99$

$$E(\text{residence} = \text{own}) = \frac{-7}{8} \cdot \log_2\left(\frac{7}{8}\right) - \frac{1}{8} \log_2\left(\frac{1}{8}\right) = 0.54$$

$$E(\text{residence} = \text{rent}) = -\frac{4}{10} \log_2\left(\frac{4}{10}\right) - \frac{6}{10} \log_2\left(\frac{6}{10}\right) = 0.97$$

$$E(\text{residence} = \text{other}) = \frac{-5}{12} \log_2\left(\frac{5}{12}\right) - \frac{7}{12} \log_2\left(\frac{7}{12}\right) = 0.98$$

Weighted Average :

$$0.54 * \frac{8}{30} + 0.97 * \frac{10}{30} + 0.98 * \frac{12}{30} = 0.86$$

$$I.G = E(\text{Parent}) - E(\text{residence})$$

$$= 0.99 - 0.86 = 0.13$$

	I G
balance	$\boxed{0.37}$
residence	0.13

balace is 3X important than residence

carry more information

$\boxed{\text{out look}}$	Yes	No	total
sunny	2	3	5
overcast	4	0	4
rain	3	2	5
	9	5	14

Day	Outlook	Temperature	Humidity	Wind	PlayTennis
D1	Sunny	Hot	High	Weak	No
D2	Sunny	Hot	High	Strong	No
D3	Overcast	Hot	High	Weak	Yes
D4	Rain	Mild	High	Weak	Yes
D5	Rain	Cool	Normal	Weak	Yes
D6	Rain	Cool	Normal	Strong	No
D7	Overcast	Cool	Normal	Strong	Yes
D8	Sunny	Mild	High	Weak	No
D9	Sunny	Cool	Normal	Weak	Yes
D10	Rain	Mild	Normal	Weak	Yes
D11	Sunny	Mild	Normal	Strong	Yes
D12	Overcast	Mild	High	Strong	Yes
D13	Overcast	Hot	Normal	Weak	Yes
D14	Rain	Mild	High	Strong	No

the value of PlayTennis for

$$\langle Outlook = sunny, Temp = cool, Humidity = high, Wind = strong \rangle$$

$\boxed{\text{Temp}}$	Yes	No	total
Hot	2	2	4
Mild	4	2	6
cool	3	1	4
	9	5	14

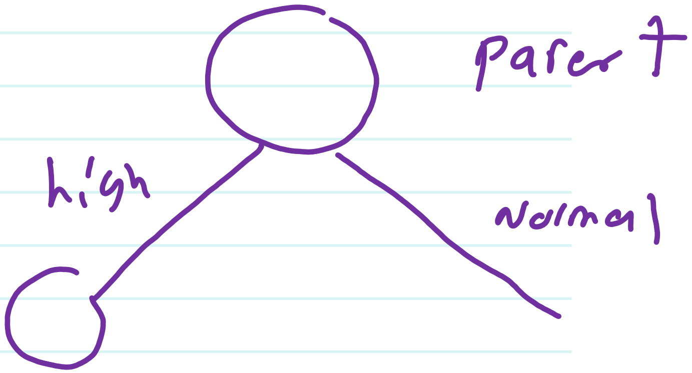
$\boxed{\text{Humidity}}$	Yes	No	
high	3	4	7
Normal	6	1	7
	9	5	14

$\boxed{\text{wind}}$	Yes	No	
weak	6	2	8
Strong	3	3	6
	9	5	14

Yes: 9

No: 5

$$E(\text{parent}) = \frac{-9}{14} * \log_2\left(\frac{9}{14}\right) - \frac{5}{14}\log_2\left(\frac{5}{14}\right) = 0.94$$



E(outlook = sunny) =

E(outlook = overcast) =

E(outlook = rain) =

weighted average

I.G = E (parent) - weighted Average Entropy

$$P\left(\text{tenis} \;\middle|\; \begin{array}{l} \text{wind} = \text{strong} \\ \text{humdity} = \text{Normal} \\ \text{outlook} = \text{rain} \end{array}\right)$$

$$df = [\underbrace{X \quad Y}_{}]$$

Train Test

$$z = \frac{df - df.mean()}{df.std()}$$