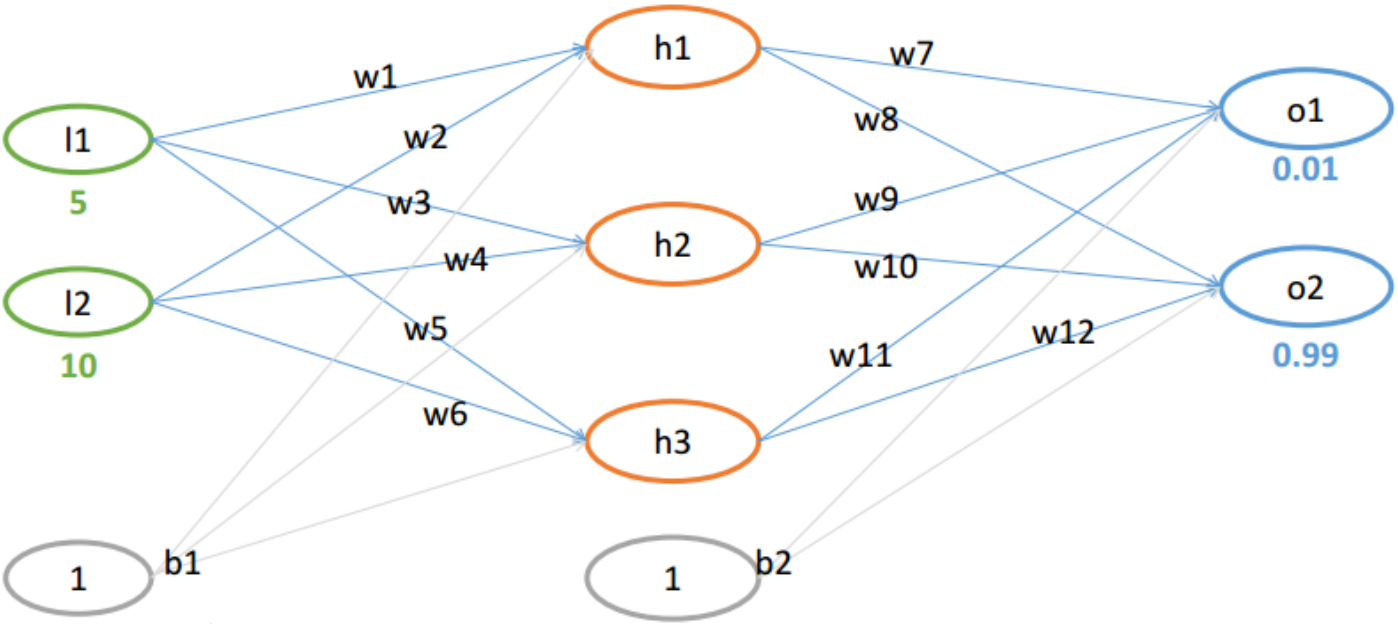
神经网络 backpropagation



w =(0.1,0.15,0.2,0.25,0.3,0.35,0.4,0.45,0.5,0.55,0.6,0.65)
b =(0.35,0.65)

FP 过程

隐藏层的输入与输出公式：

$net_{h1} = w_1 * l_1 + w_2 * l_2 + b_1 * 1$

$out_{h1} = {}^{1}/_{1 + e^{-net_{h1}}}$

计算可得：

$net_{h1} = 2.35$

$out_{h1} = 0.912934$

$out_{h2} = 0.979164$

$out_{h3} = 0.995275$

输出层：

$net_{o1} = w_7 * out_{h1} + w_9 * out_{h2} + w_{11} * out_{h3}$

$out_{o1} = {}^{1}/_{1 + e^{-net_{o1}}}$

计算可得：

$out_{o1} = 0.891090$

$out_{o2} = 0.904330$

输出层误差：

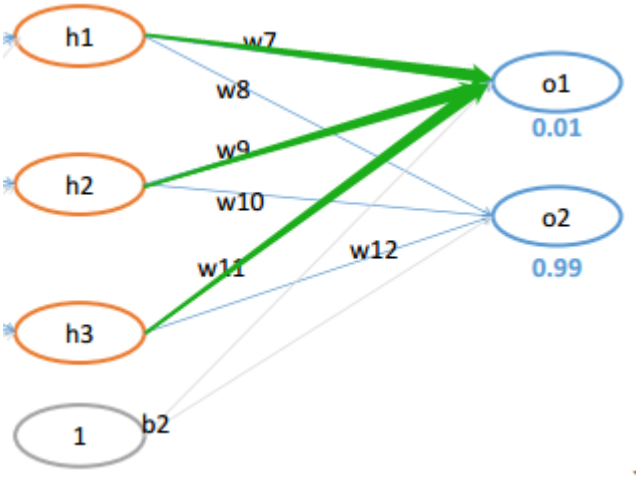
$E_{total} = E_{o1} + E_{o2}$

计算可得：

$E_{total} = 0.391829$

BP 过程

1. 对 o1 做 bp 运算



$$E_{o1} = \frac{1}{2} * (target_{o1} - out_{o1})^2$$

$$\partial E_{total}/\partial w_7 = \partial E_{total}/\partial out_{o1} * \partial out_{o1}/\partial net_{o1} * \partial net_{o1}/\partial w_7$$

$$\partial E_{total}/\partial out_{o1} = 2 * \frac{1}{2} * (target_{o1} - out_{o1})^{2-1} - 1 + 0 = 0.88109$$

$$\partial out_{o1}/\partial net_{o1} = out_{o1} * (1 - out_{o1}) = 0.097049$$

$$\partial net_{o1}/\partial w_7 = 1 * out_{h1} = 0.912934$$

得到：

$$\partial E_{total}/\partial w_7 = 0.88109 * 0.097049 * 0.912934 = 0.078064$$

权重更新：

$$w_7^+ = w_7 + \nabla w_7 = w_7 - \eta * \partial E_{total}/\partial w_7$$

同理可得

$w_8^+ = 0.453383$
$w_9^+ = 0.458137$
$w_{10}^+ = 0.553629$
$w_{11}^+ = 0.557448$
$w_{12}^+ = 0.653688$

2. 对 w1 做 bp 运算

$$\partial E_{total}/\partial w_1 = \partial E_{total}/\partial out_{h1} * \partial out_{h1}/\partial net_{h1} * \partial net_{h1}/\partial w_1$$

$$= \left(\partial E_{o1}/\partial out_{h1} + \partial E_{o2}/\partial out_{h1}\right) * \partial out_{h1}/\partial net_{h1} * \partial net_{h1}/\partial w_1$$

其中：

$$\partial E_{o1}/\partial out_{h1} = \partial E_{o1}/\partial out_{o1} * \partial out_{o1}/\partial net_{o1} * \partial net_{o1}/\partial out_{h1} = -(target_{o1} - out_{o1}) * out_{o1} * (1 - out_{o1}) * w_7$$

得到：

$$\partial E_{total}/_{\partial w_1} = 0.011204$$

$$w_1^+ = w_1 + \nabla w_1 = w_1 - \eta * {}^{\partial E_{total}}/_{\partial w_1} = 0.094534$$

同理反推其他权重。