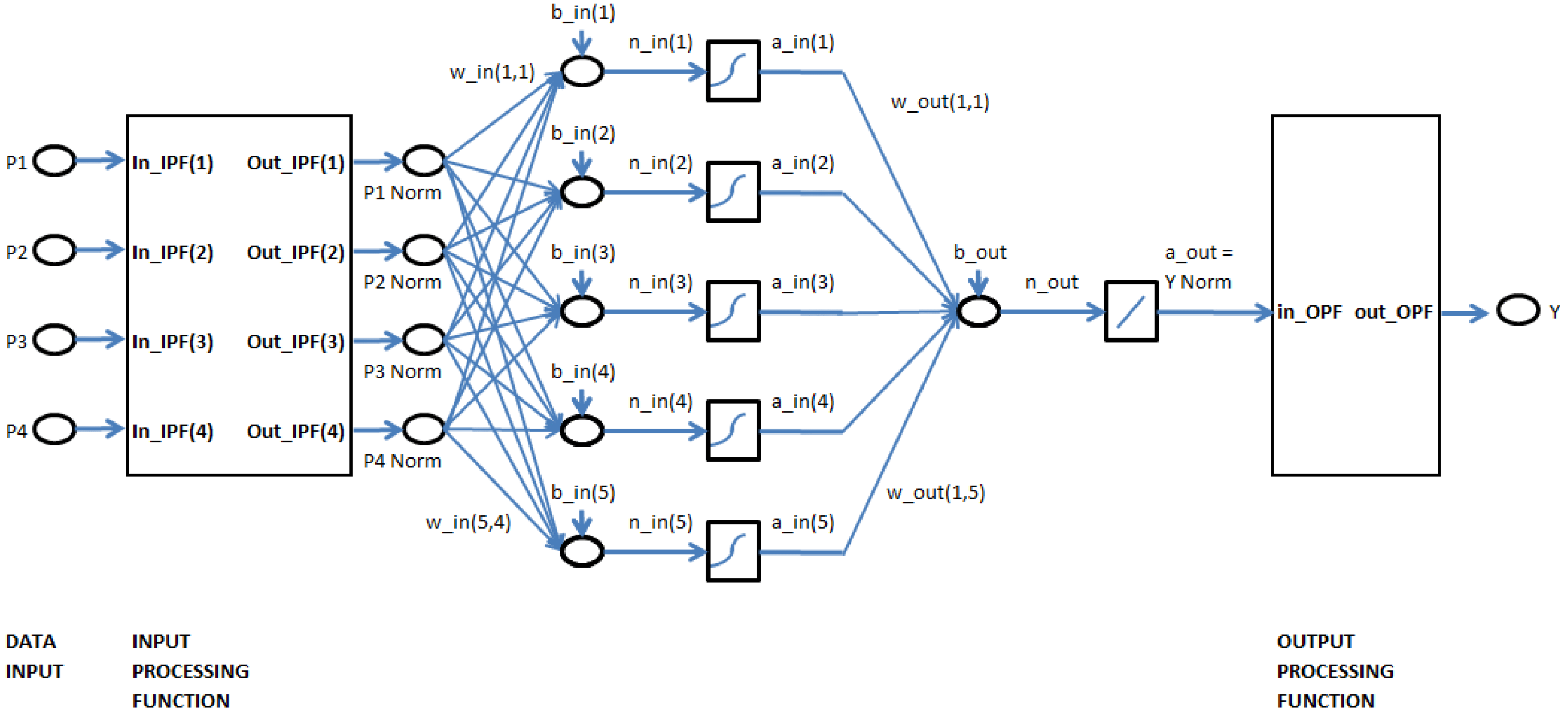
1. NEURAL NETWORK ARCHITECTUR$f(.)$



2. Input and Output Processing Functions.

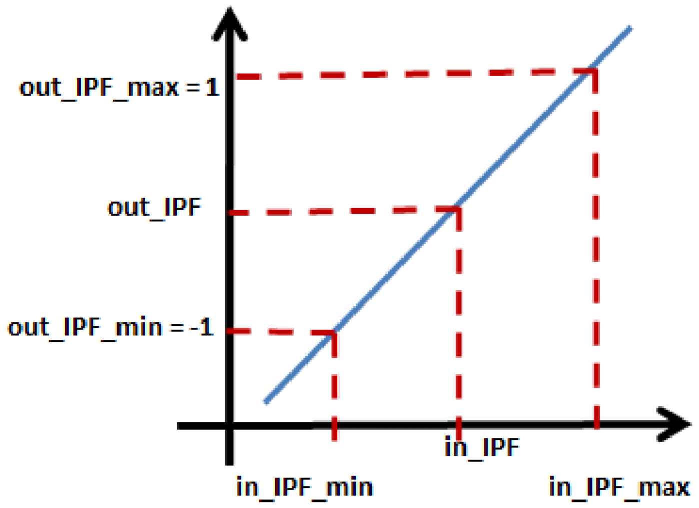
“Input Processing Functions” transforms input data so that all values fall into the interval [-1,1], or normalizes the input values. Training is often faster when values are normalized.

And if “Input Processing Functions” is used to scale the targets, then the output of the network will be trained to produce outputs in the range [-1,1]. To convert these output back into the original units, we use “Output Processing Function”.

Example ilustration of “Input and Output Processing Functions” with the function.

INPUT PROCESSING FUNCTIONS :

“Input Processing Functions” transforms input data so that all values fall into the interval [-1,1], or normalizes the input values.

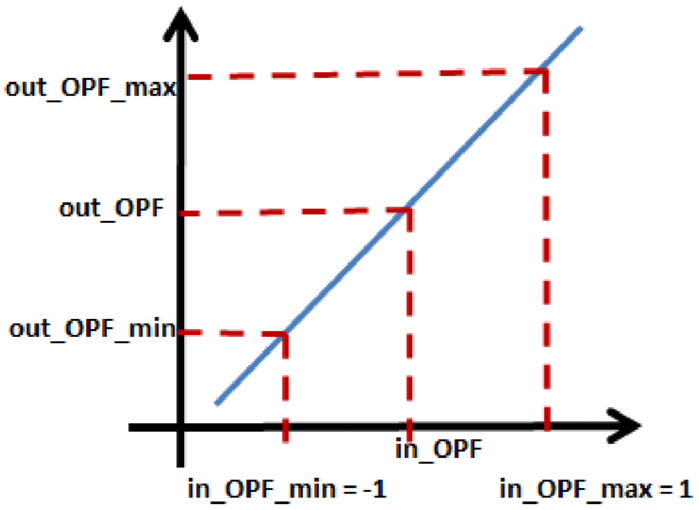


$$\boldsymbol{PNorm = \frac{(P - in\_IPF\_min)\cdot(out\_IPF\_max - out\_IPF\_min)}{(in\_IPF\_max - in\_IPF\_min)} + out\_IPF\_min}$$

$$\boldsymbol{= \frac{(in\_IPF - in\_IPF\_min)\cdot(2)}{(in\_IPF\_max - in\_IPF\_min)} - 1}$$

OUTPUT PROCESSING FUNCTIONS :

If “Input Processing Functions” is used to scale the targets, then the output of the network will be trained to produce outputs in the range [-1,1]. To convert these output back into the original units, we use “Output Processing Function”.



$$\boldsymbol{out\_OPF = \frac{(in\_OPF - in\_OPF\_min)\cdot(out\_OPF\_max - out\_OPF\_min)}{(in\_OPF\_max - in\_OPF\_min)} + out\_OPF\_min}$$

$$\boldsymbol{= \frac{(in_{OPF} + 1)\cdot(out\_OPF\_max - out\_OPF\_min)}{2} + out\_OPF\_min}$$

3. EXAMPLE CALCULATION

From the above architecture :

Input Processing Function Parameter :
 	
In1_max=7.9
In1_min=4.3
In2_max=4.4
In2_min=2
In3_max=6.9
In3_min=1
In4_max=2.5
In4_min=0.1
	w_in(1,1)= -0.743495
	w_in(1,2)= 0.449171
	w_in(1,3)= -0.585676
	w_in(1,4)= -0.309007
	w_in(2,1)= 0.437339
	w_in(2,2)= 0.21939
	w_in(2,3)= -0.869233
	w_in(2,4)= 0.774321
	w_in(3,1)= -0.556053
	w_in(3,2)= 0.387743
	w_in(3,3)= 0.791078
	w_in(3,4)= 0.212789
	w_in(4,1)= 0.546645
	w_in(4,2)= -0.274682
	w_in(4,3)= -0.857102
	w_in(4,4)= 0.181313
	w_in(5,1)= -0.43569
	w_in(5,2)= -0.170569
	w_in(5,3)= 0.301563
	w_in(5,4)= 0.971447
		b_in(1) = 0.537452
		b_in(2) = -0.901691
		b_in(3) = -0.55688
		b_in(4) = -0.860293
		b_in(5) = -0.212749
		
		w_out(1,1) = -0.597222
		w_out(1,2) = -0.67192
		w_out(1,3) = 0.496553
		w_out(1,4) = -0.400212
		w_out(1,5) = 0.801744
		
		b_out = -0.187959
			Output Processing Function Parameter :
			
			Out_max = 3
			Out_min = 1

If we choose
P1=5.9
P2=3
P3=5.1
P4=1.8

$$P\ Norm = \frac{(P1 - in1\_min)\cdot(2)}{(in1\_max - in1\_min)} - 1$$

P1 Norm = -0.111111
P2 Norm = -0.166667
P3 Norm = 0.38983
P4 Norm = 0.416667

$$n\_in(i) = w\_in(i,1)\cdot P1Norm + w\_in(i,2)\cdot P2Norm + w\_in(i,3)\cdot P3Norm + w\_in(i,4)\cdot P4Norm + b\_in(i)$$

n_in(1) = 0.188133
n_in(2) = -1.00307
n_in(3) = -0.162672
n_in(4) = -1.13383
n_in(5) = 0.386417

$$a\_in(j) = f(n\_in(j))$$

$$a_{in(i)} = \frac{2}{1 + \exp\left(-2\cdot n_{in(i)}\right)} - 1$$

a_in(1) = 0.185945
a_in(2) = -0.76288
a_in(3) = -0.161252
a_in(4) = -0.812326
a_in(5) = 0.368267

$$n\_out(k) \ = a\_in(1)\cdot w\_out(k,1) + a\_in(2)\cdot w\_out(k,2) + a\_in(3)\cdot w\_out(k,3) + a\_in(4)\cdot w\_out(k,4) + a\_in(5)\cdot w\_out(k,5) + b\_out(k)$$

$$a\_out(k) = f(n\_out(k))$$

n_out = 0.753875

$Y\ Norm = n\_out$ (activation function : linear)

Y Norm = 0.753875

$$Y = \frac{(Y\_Norm + 1) \cdot (out\_max - out\_min)}{(2)} + out\_min$$

Y = 2.75387

4. Learning Equation

Backpropagation Algorithm

1. Initialization: Randomize the weights to small values.
2. Presentation: Apply a pattern to the input and calculate the network output.
3. Error Computation: Compare the output with the desired output and compute the error (difference).
4. Backward Computation: Backpropagate the error through the network and adjust the weights to minimize the error.
5. Iteration: Repeat steps 2-4 until a desired error goal is reached.

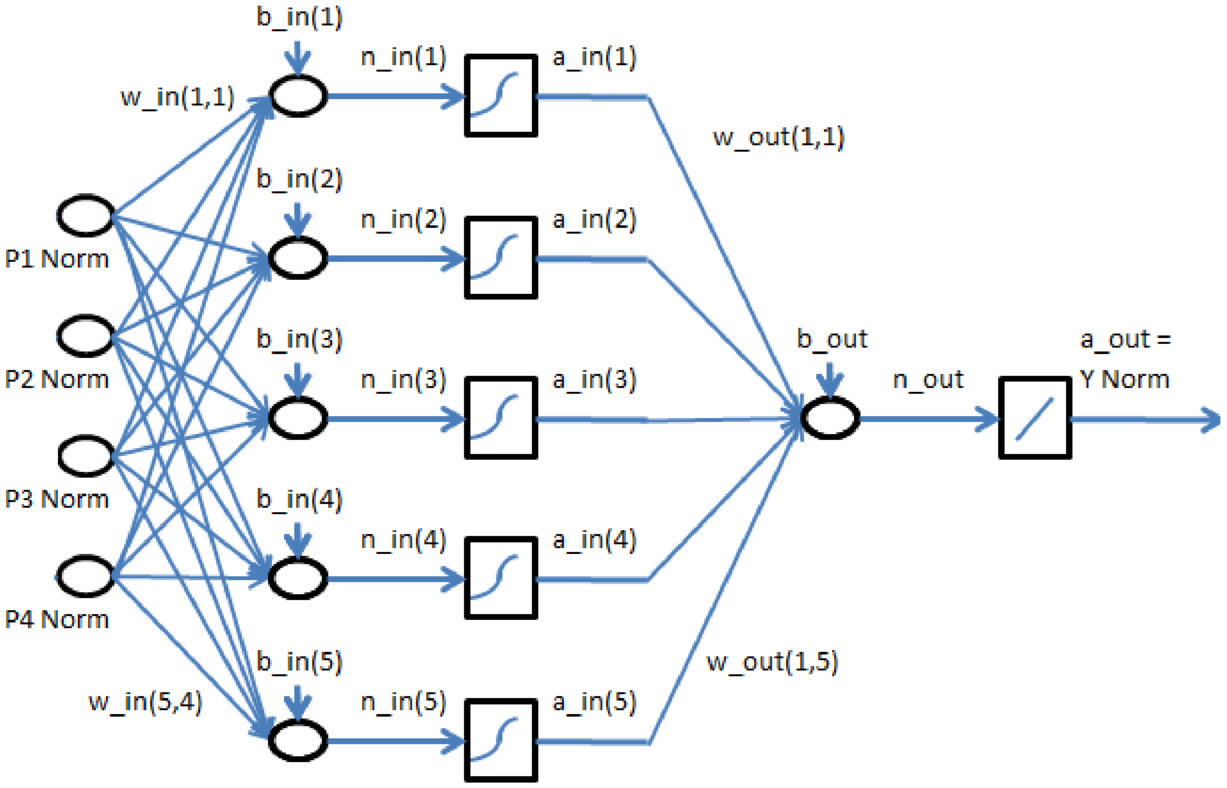
- Total Error Energy : $E = \frac{1}{2}e^2$
- Error Signal at iteration (n) = $e(n) = TNorm(n) - YNorm(n)$
  YNorm : keluaran NN yang masih ternormalisasi (rentang nilai antara -1 s.d. 1)
  Tnorm : target keluaran NN
- Backward Computation :

$$W^{new} = W^{old} + \Delta W$$

$$W^{new} = W^{old} - \eta \frac{dE}{dW}$$

$$W^{new} = W^{old} - \eta \left(\frac{dE}{de}\right) \cdot \left(\frac{de}{dYNorm}\right) \cdot \left(\frac{dYNorm}{dn\_out}\right) \cdot \left(\frac{dn\_out}{dW}\right)$$

$$W^{new} = W^{old} - \eta \cdot e \cdot (-1) \cdot (1) \cdot \left(\frac{dn\_out}{dW}\right)$$



PERSAMAAN NN YANG DIGUNAKAN

$$n\_in(i) = \quad w\_in(i,1) \cdot P1Norm + w\_in(i,2) \cdot P2Norm + w\_in(i,3) \cdot P3Norm + w\_in(i,4) \cdot P4Norm + b\_in(i)$$

$$a_{in(i)} = \quad \frac{2}{1 + \exp(-2 \cdot n_{in(i)})} - 1$$

$$n\_out = \quad a\_in(1) \cdot w\_out(1,1) + a\_in(2) \cdot w\_out(1,2) + a\_in(3) \cdot w\_out(1,3) + a\_in(4) \cdot w\_out(1,4) + a\_in(5) \cdot w\_out(1,5) + b\_out$$

$$Y\ Norm = \quad n\_out$$

MAKA PENURUNAN PERSAMAAN BACKWARD COMPUTATION :

$$
\begin{aligned}
b\_out^{new} &= b\_out^{old} + \eta \cdot e \\
w\_out(1,j)^{new} &= w\_out(1,j)^{old} + \eta \cdot e \cdot a\_in(j) \\
b\_in(j)^{new} &= b\_in(j)^{old} + \eta \cdot e \cdot \left(\frac{dn\_out}{da\_in(j)}\right) \cdot \left(\frac{da\_in(j)}{dn\_in(j)}\right) \cdot \left(\frac{dn\_in(j)}{db\_in(j)}\right) \\
&= b\_in(j)^{old} + \eta \cdot e \cdot (w\_out(1,j)) \cdot \left(\frac{4 \cdot \exp\,(-2 \cdot n\_in(j))}{(1+\exp\,(-2 \cdot n\_in(j)))^2}\right) \cdot (1) \\
w\_in(j,i)^{new} &= w\_in(j,i)^{old} + \eta \cdot e \cdot \left(\frac{dn\_out}{da\_in(j)}\right) \cdot \left(\frac{da\_in(j)}{dn\_in(j)}\right) \cdot \left(\frac{dn\_in(j)}{dw\_in(j,i)}\right) \\
&= w\_in(j,i)^{old} + \eta \cdot e \cdot (w\_out(1,j)) \cdot \left(\frac{4 \cdot \exp\left(-2 \cdot n\_in(j)\right)}{\left(1+\exp\left(-2 \cdot n\_in(j)\right)\right)^2}\right) \cdot PiNorm
\end{aligned}
$$