CS344: Introduction to Artificial Intelligence (associated lab: CS386)

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Lecture 35: Backpropagation; need for multiple layers and non linearity

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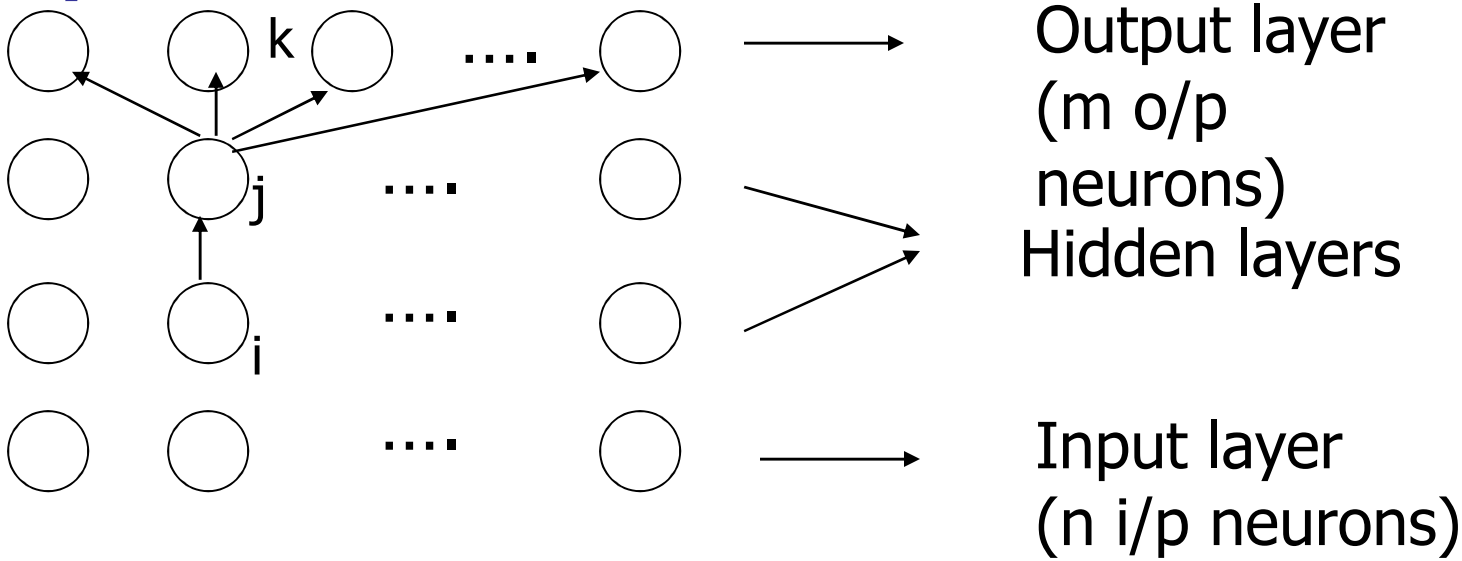
Backpropagation for hidden layers



$$\delta_j = (t_j - o_j) o_j (1 - o_j) \quad \text{for outermost layer}$$

$$= \sum_{k \in \text{next layer}} (w_{kj} \delta_k) o_j (1 - o_j) o_i$$

Observations on weight change rules

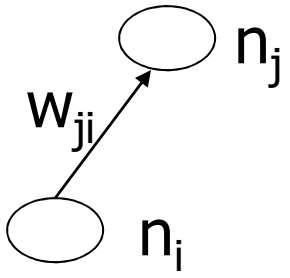
Does the training technique support our intuition?

- The larger the x_i, larger is Δw_i
  - Error burden is borne by the weight values corresponding to large input values

Observations contd.

- Δw_i is proportional to the departure from target
- Saturation behaviour when o is 0 or 1
- If $o < t$, $\Delta w_i > 0$ and if $o > t$, $\Delta w_i < 0$ which is consistent with the Hebb's law

Hebb's law



- If n_j and n_i are both in excitatory state (+1)
  - Then the change in weight must be such that it enhances the excitation
  - The change is proportional to both the levels of excitation

$$\Delta w_{ji} \alpha \; e(n_j)\, e(n_i)$$

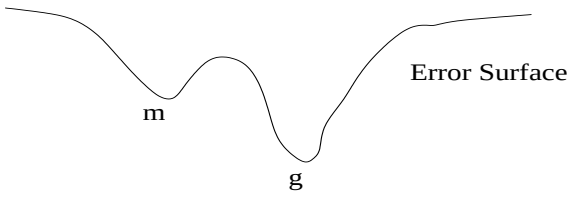
- If n_i and n_j are in a mutual state of inhibition (one is +1 and the other is -1),
  - Then the change in weight is such that the inhibition is enhanced (change in weight is negative)

Saturation behavior

- The algorithm is iterative and incremental
- If the weight values or number of input values is very large, the output will be large, then the output will be in saturation region.
- The weight values hardly change in the saturation region

Local Minima

Due to the Greedy nature of BP, it can get stuck in local minimum *m* and will never be able to reach the global minimum *g* as the error can only decrease by weight change.



m- local minima, g- global minima

Figure- Getting Stuck in local minimum

Momentum factor

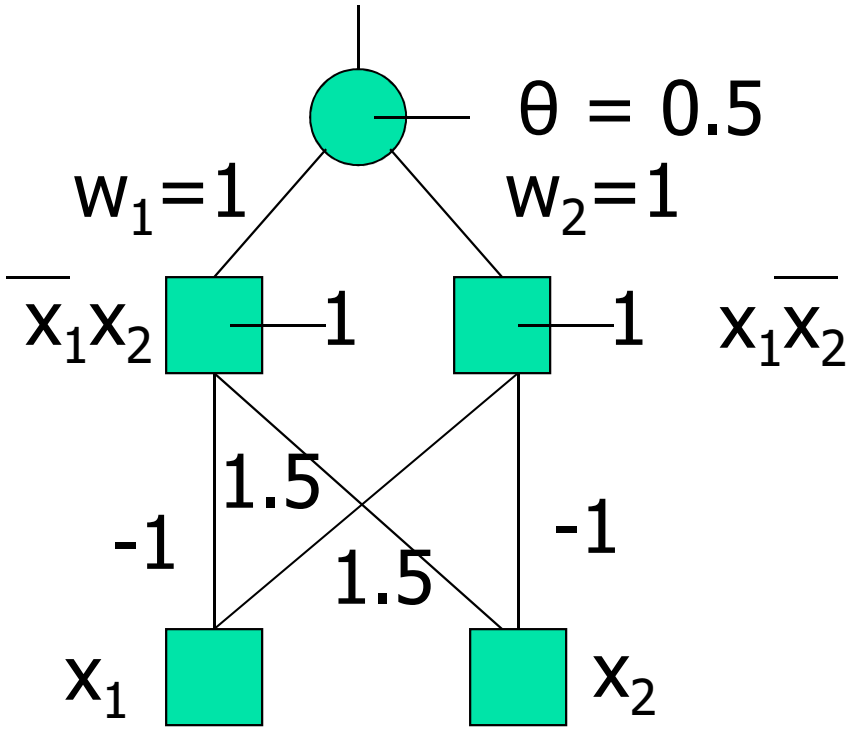
1. Introduce momentum factor.

$$(\Delta w_{ji})_{nth-iteration} = \eta \delta_j O_i + \beta (\Delta w_{ji})_{(n-1)th-iteration}$$

- Accelerates the movement out of the trough.
- Dampens oscillation inside the trough.
- Choosing β : If β is large, we may jump over the minimum.

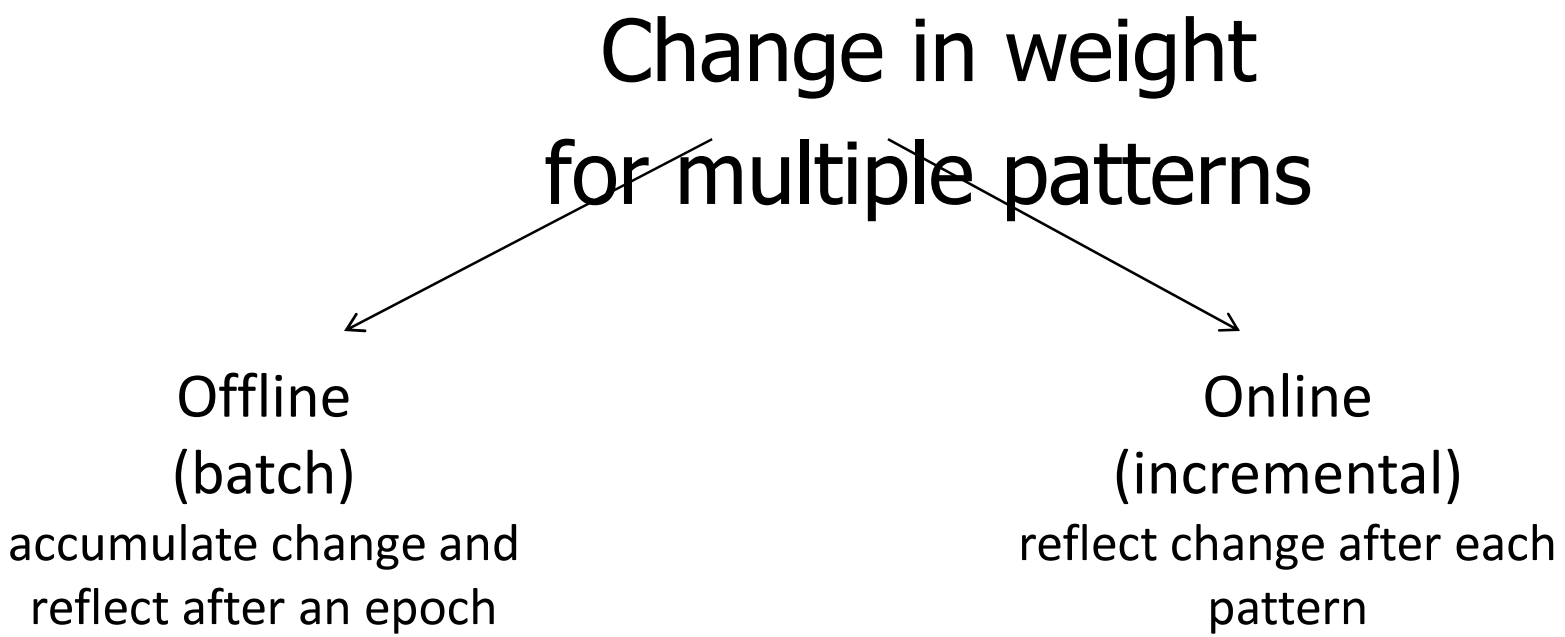
Symmetry breaking

- If mapping demands different weights, but we start with the same weights everywhere, then BP will never converge.

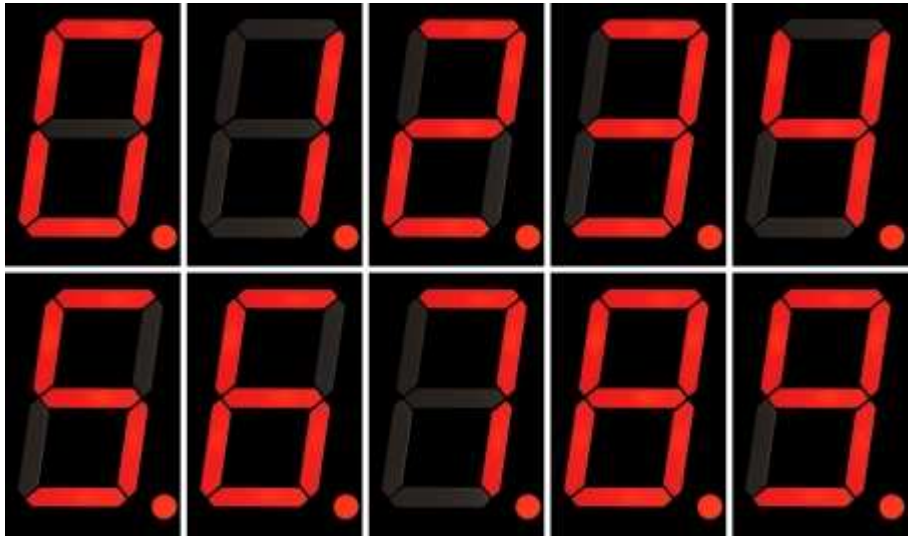


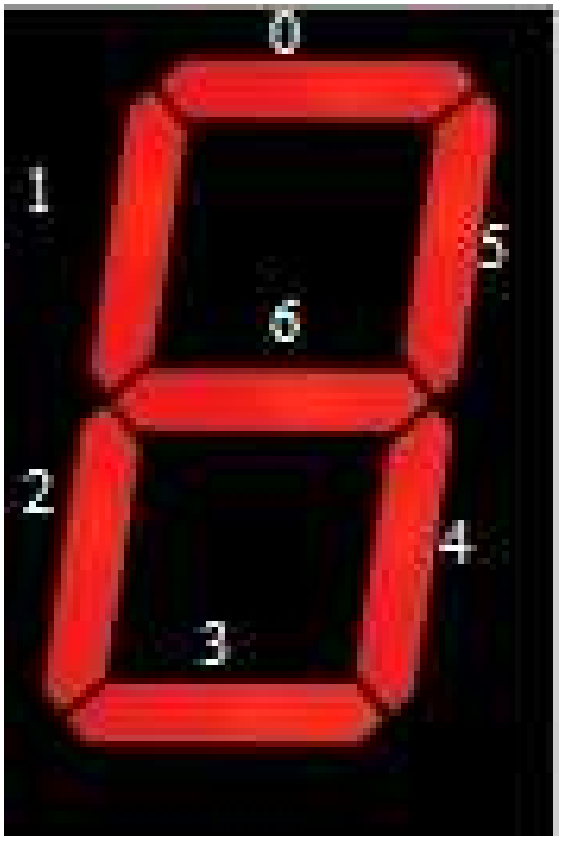
XOR n/w: if we started with identical weight everywhere, BP will not converge

Updating Weights



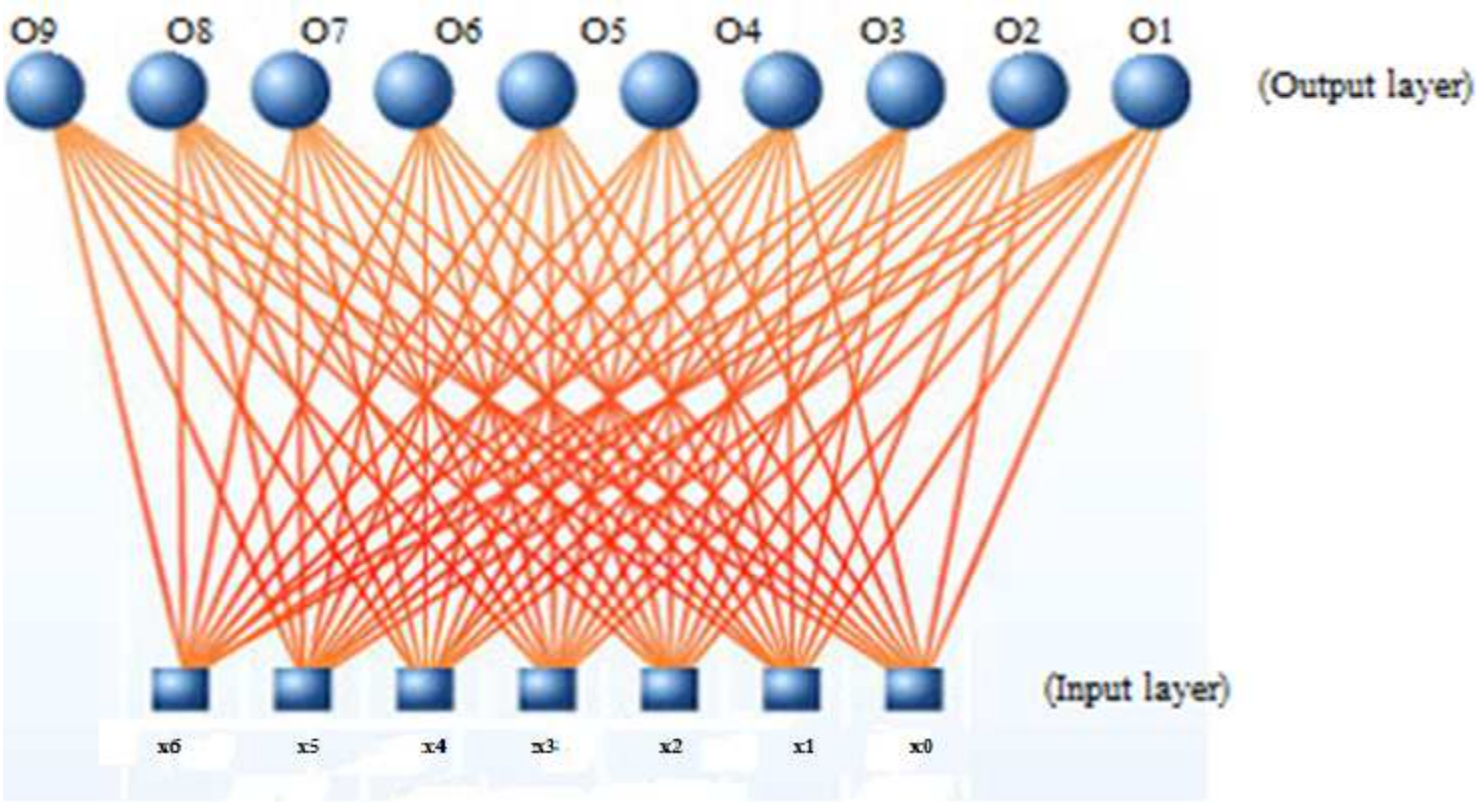
Example-1: Digit Recognition System– 7-segment display





7 segment display - Network Design

(Centralized Representation)



7 segment display – inputs and target outputs

Input								Target Output									
X6	X5	X4	X3	X2	X1	X0		O 9	O 8	O 7	O 6	O 5	O 4	O 3	O 2	O 1	O0
0	1	1	1	1	1	1		0	0	0	0	0	0	0	0	0	1
0	1	1	0	0	0	0		0	0	0	0	0	0	0	0	1	0
1	1	0	1	1	0	1		0	0	0	0	0	0	0	1	0	0
1	1	1	1	0	0	1		0	0	0	0	0	0	1	0	0	0
1	1	1	0	0	1	0		0	0	0	0	0	1	0	0	0	0
1	0	1	1	0	1	1		0	0	0	0	1	0	0	0	0	0
1	0	1	1	1	1	1		0	0	0	1	0	0	0	0	0	0
0	1	1	0	0	0	1		0	0	1	0	0	0	0	0	0	0
1	1	1	1	1	1	1		0	1	0	0	0	0	0	0	0	0
1	1	1	1	0	1	1		1	0	0	0	0	0	0	0	0	0

Example-2 - Character Recognition

- Output layer – 26 neurons (all capital)
- First output neuron has the responsibility of detecting all forms of ‘A’
- Centralized representation of outputs
- In distributed representations, all output neurons participate in output

An application in Medical Domain

Expert System for Skin Diseases Diagnosis

- Bumpiness and scaliness of skin
- Mostly for symptom gathering and for developing diagnosis skills
- Not replacing doctor’s diagnosis

Architecture of the FF NN

- 96-20-10
- 96 input neurons, 20 hidden layer neurons, 10 output neurons
- Inputs: skin disease symptoms and their parameters
  - *Location, distribution, shape, arrangement, pattern, number of lesions, presence of an active norder, amount of scale, elevation of papuls, color, altered pigmentation, itching, pustules, lymphadenopathy, palmer thickening, results of microscopic examination, presence of herald pathc, result of dermatology test called KOH*

Output

- 10 neurons indicative of the diseases:
  - *psoriasis, pityriasis rubra pilaris, lichen planus, pityriasis rosea, tinea versicolor, dermatophytosis, cutaneous T-cell lymphoma, secondery syphilis, chronic contact dermatitis, soberrheic dermatitis*

Training data

- Input specs of 10 model diseases from 250 patients
- 0.5 is some specific symptom value is not knoiwn
- Trained using standard error backpropagation algorithm

Testing

- Previously unused symptom and disease data of 99 patients
- Result:
- Correct diagnosis achieved for 70% of papulosquamous group skin diseases
- Success rate above 80% for the remaining diseases except for psoriasis
- psoriasis diagnosed correctly only in 30% of the cases
- Psoriasis resembles other diseases within the papulosquamous group of diseases, and is somewhat difficult even for specialists to recognise.

Explanation capability

- Rule based systems reveal the explicit path of reasoning through the textual statements
- Connectionist expert systems reach conclusions through complex, non linear and simultaneous interaction of many units
- Analysing the effect of a single input or a single group of inputs would be difficult and would yield incor6rect results

Explanation contd.

- The hidden layer re-represents the data
- Outputs of hidden neurons are neither symtoms nor decisions

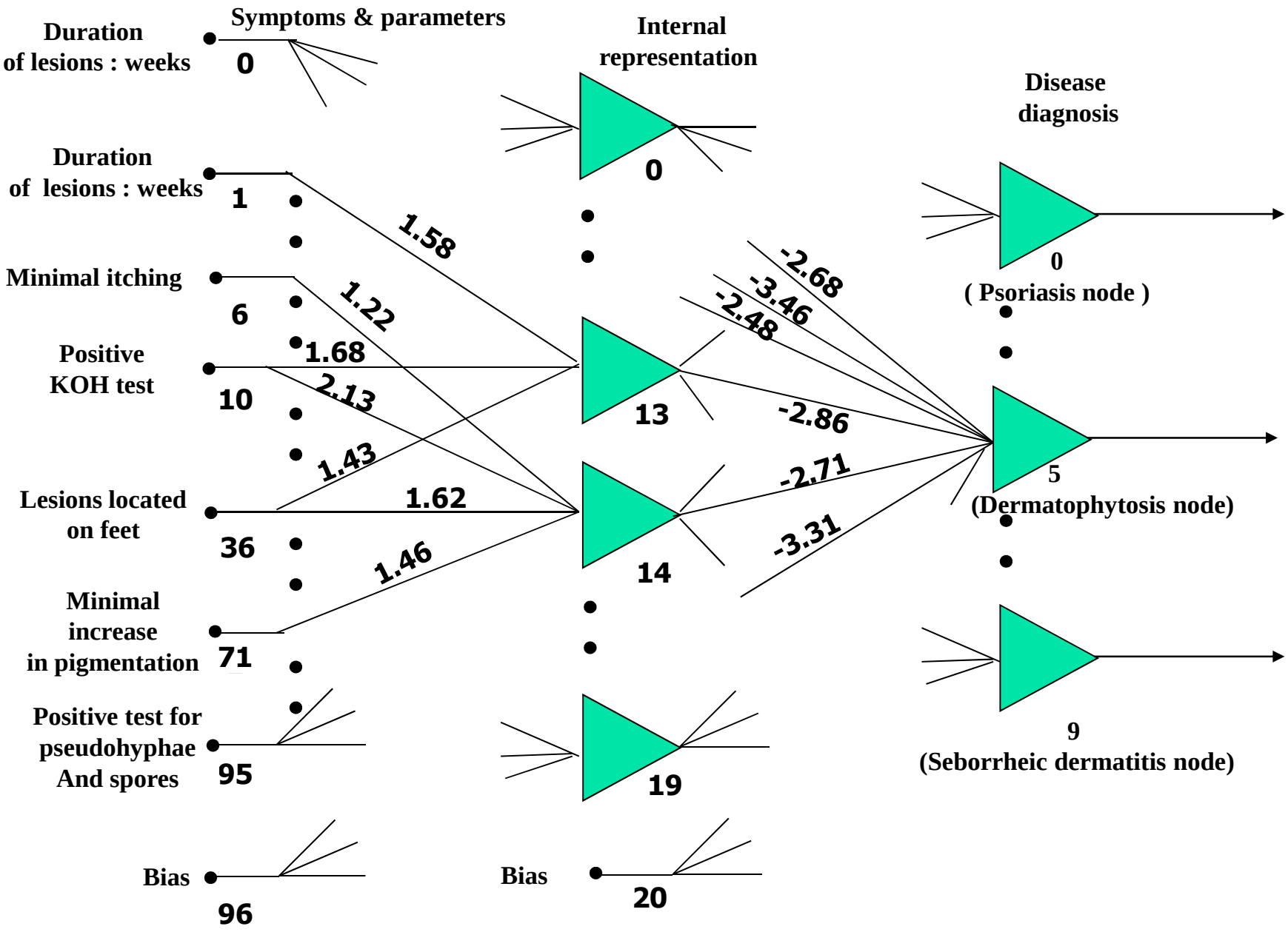


Figure : Explanation of dermatophytosis diagnosis using the DESKNET expert system.

Discussion

- Symptoms and parameters contributing to the diagnosis found from the n/w
- Standard deviation, mean and other tests of significance used to arrive at the importance of contributing parameters
- The n/w acts as apprentice to the expert

Exercise

- Find the weakest condition for symmetry breaking. It is not the case that only when ALL weights are equal, the network faces the symmetry problem.