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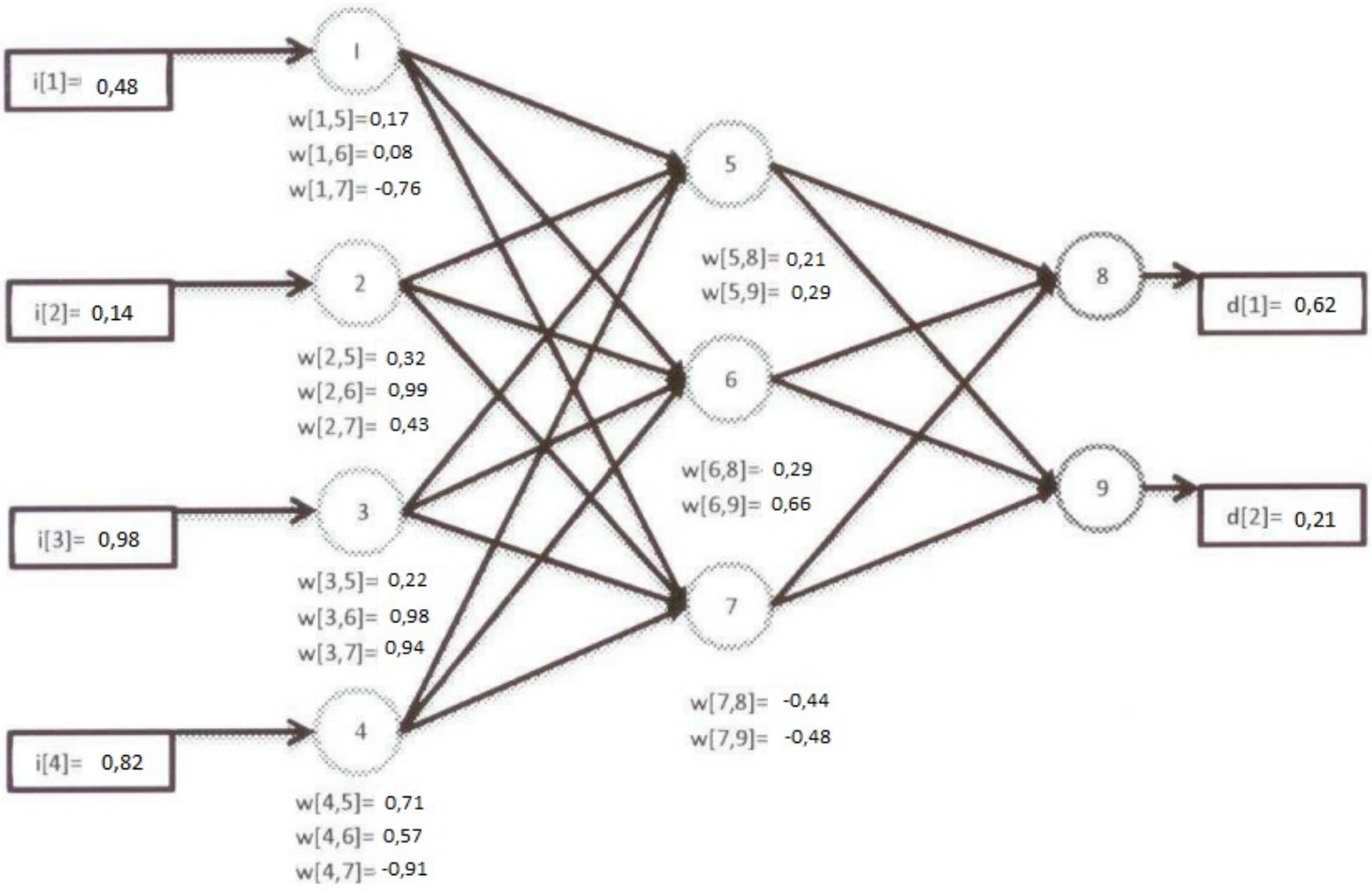
Examen la disciplina

Rețele neuronale. Aplicații.

Fie următoarea rețea neuronală MLP:



cu rata de învățare η=0,71 și eroarea maximă E_{max}=0,01.

Asupra acestei rețele se aplică algoritmul Back-propagation.

Iterația 1

Propagarea înainte

Strat ascuns
$o_5=f(w_{15}*o_1+w_{25}*o_2+w_{35}*o_3+w_{45}*o_4)$
$o_5=f((0,17)(0,48)+(0,32)(0,14)+(0,22)(0,98)+(0,71)(0,82))=f(0,9242)$
$o_5=0,7159$
$o_6=f(w_{16}*o_1+w_{26}*o_2+w_{36}*o_3+w_{46}*o_4)$
$o_6=f((0,08)(0,48)+(0,99)(0,14)+(0,98)(0,98)+(0,57)(0,82))=f(1,6048)$
$o_6=0,83269$
$o_7=f(w_{17}*o_1+w_{27}*o_2+w_{37}*o_3+w_{47}*o_4)$
$o_7=f((-0,76)(0,48)+(0,43)(0,14)+(0,94)(0,98)+(-0,91)(0,82))=f(-0,1296)$
$o_7=0,46765$

Stratul de ieşire
$o_8=f(w_{58}*o_5+w_{68}*o_6+w_{78}*o_7)$
$o_8=f((0,21)(0,716)+(0,29)(0,833)+(-0,44)(0,468))=f(0,18605)$
$o_8=0,54638$
$o_9=f(w_{59}*o_5+w_{69}*o_6+w_{79}*o_7)$
$o_9=f((0,29)(0,716)+(0,66)(0,833)+(-0,48)(0,468))=f(0,53271)$
$o_9=0,63012$

Propagarea înapoi

Stratul de iesire
$\delta_8=(d_8-o_8)*o_8*(1-o_8)$
$\delta_8=((0,62-0,54638)*(0,54638)*(1-0,54638))$
$\delta_8=0,01825$
$\delta_9=(d_9-o_9)*o_9*(1-o_9)$
$\delta_9=((0,21-0,63012)*(0,63012)*(1-0,63012))$
$\delta_9=-0,09792$

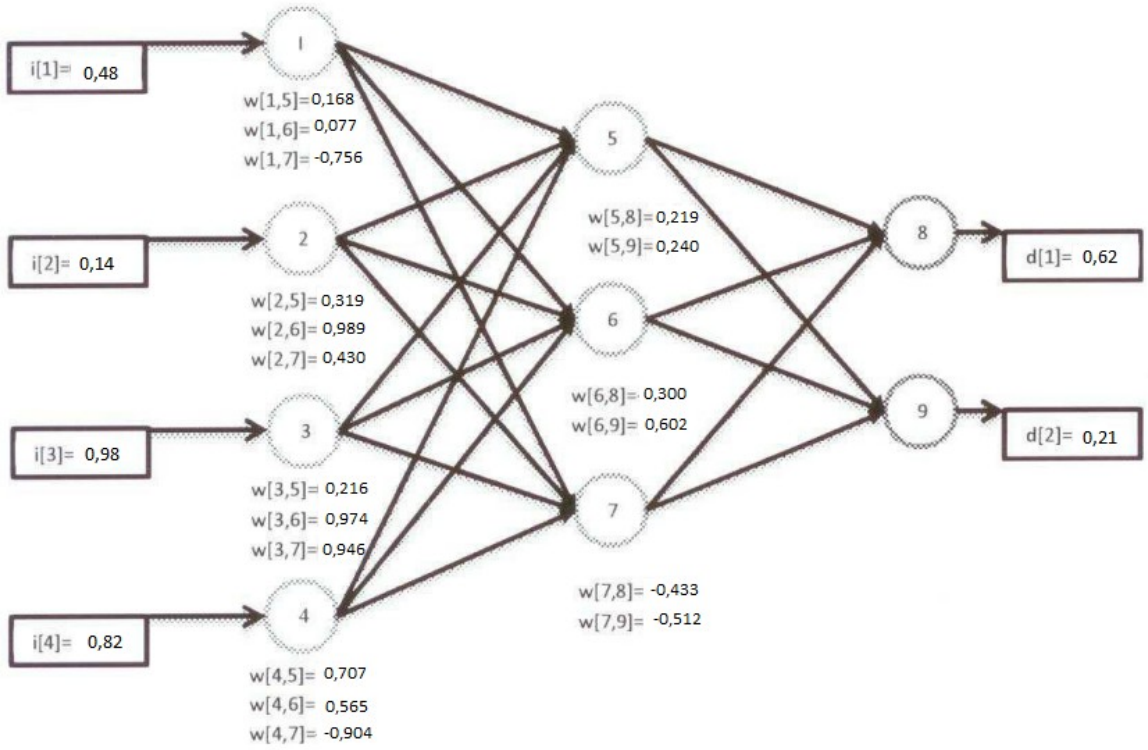
Stratul ascuns
$\delta_5=(\delta_8*w_{58}+\delta_9*w_{59})*o_5*(1-o_5)$
$\delta_5=((0,01825)*(0,21)+(-0,09792)*(0,29))*(0,7159)*(1-(0,7159))$
$\delta_5=-0,005$
$\delta_6=(\delta_8*w_{68}+\delta_9*w_{69})*o_6*(1-o_6)$
$\delta_6=((0,01825)*(0,29)+(-0,09792)*(0,66))*(0,83269)*(1-(0,83269))$
$\delta_6=-0,00827$
$\delta_7=(\delta_8*w_{78}+\delta_9*w_{79})*o_7*(1-o_7)$
$\delta_7=((0,01825)*(-0,44)+(-0,09792)*(-0,48))*(0,46765)*(1-(0,46765))$
$\delta_7=0,0097$

Valorile delta:
$\Delta w_{15}=\eta*\delta_5*o_1=(0,71)(-0,005)(0,48)=-0,0017$

$\Delta w_{16}=\eta*\delta_6*o_1=(0,71)(-0,00827)(0,48)=-0,00282$
$\Delta w_{17}=\eta*\delta_7*o_1=(0,71)(0,0097)(0,48)=0,00331$
$\Delta w_{25}=\eta*\delta_5*o_2=(0,71)(-0,005)(0,14)=-0,0005$
$\Delta w_{26}=\eta*\delta_6*o_2=(0,71)(-0,00827)(0,14)=-0,00082$
$\Delta w_{27}=\eta*\delta_7*o_2=(0,71)(0,0097)(0,14)=0,00096$
$\Delta w_{35}=\eta*\delta_5*o_3=(0,71)(-0,005)(0,98)=-0,00348$
$\Delta w_{36}=\eta*\delta_6*o_3=(0,71)(-0,00827)(0,98)=-0,00575$
$\Delta w_{37}=\eta*\delta_7*o_3=(0,71)(0,0097)(0,98)=0,00675$
$\Delta w_{45}=\eta*\delta_5*o_4=(0,71)(-0,005)(0,82)=-0,00291$
$\Delta w_{46}=\eta*\delta_6*o_4=(0,71)(-0,00827)(0,82)=-0,00481$
$\Delta w_{47}=\eta*\delta_7*o_4=(0,71)(0,0097)(0,82)=0,00565$

$\Delta w_{58}=\eta*\delta_8*o_5=(0,71)(0,01825)(0,7159)=0,00927$
$\Delta w_{59}=\eta*\delta_9*o_5=(0,71)(-0,09792)(0,7159)=-0,04977$
$\Delta w_{68}=\eta*\delta_8*o_6=(0,71)(0,01825)(0,83269)=0,01079$
$\Delta w_{69}=\eta*\delta_9*o_6=(0,71)(-0,09792)(0,83269)=-0,05789$
$\Delta w_{78}=\eta*\delta_8*o_7=(0,71)(0,01825)(0,46765)=0,00606$
$\Delta w_{79}=\eta*\delta_9*o_7=(0,71)(-0,09792)(0,46765)=-0,03251$

În funcție de aceste valori se ajustează ponderile rețelei folosite în următoarea iterație a algoritmului, adăugând valoarea fiecărui delta la ponderea corespunzătoare. Astfel, rețeaua se modifică în:



Iterația 2

Propagarea inainte

Strat ascuns
$o_5=f(w_{15}*o_1+w_{25}*o_2+w_{35}*o_3+w_{45}*o_4)$
$o_5=f((0,168)(0,48)+(0,32)(0,14)+(0,217)(0,98)+(0,707)(0,82))=f(0,91752)$
$o_5=0,71454$
$o_6=f(w_{16}*o_1+w_{26}*o_2+w_{36}*o_3+w_{46}*o_4)$
$o_6=f((0,077)(0,48)+(0,989)(0,14)+(0,974)(0,98)+(0,565)(0,82))=f(1,59375)$
$o_6=0,83114$
$o_7=f(w_{17}*o_1+w_{27}*o_2+w_{37}*o_3+w_{47}*o_4)$
$o_7=f((-0,757)(0,48)+(0,431)(0,14)+(0,947)(0,98)+(-0,904)(0,82))=f(-0,11663)$
$o_7=0,47088$

Stratul de iesire
$o_8=f(w_{58}*o_5+w_{68}*o_6+w_{78}*o_7)$
$o_8=f((0,219)(0,715)+(0,301)(0,831)+(-0,434)(0,471))=f(0,20234)$
$o_8=0,55041$
$o_9=f(w_{59}*o_5+w_{69}*o_6+w_{79}*o_7)$
$o_9=f((0,24)(0,715)+(0,602)(0,831)+(-0,513)(0,471))=f(0,43076)$
$o_9=0,60606$

Propagarea inapoi

Stratul de iesire
$\delta_8=(d_8-o_8)*o_8*(1-o_8)$
$\delta_8=((0,62-0,55041)*(0,55041)*(1-0,55041))$
$\delta_8=0,01722$
$\delta_9=(d_9-o_9)*o_9*(1-o_9)$
$\delta_9=((0,21-0,60606)*(0,60606)*(1-0,60606))$
$\delta_9=-0,09456$

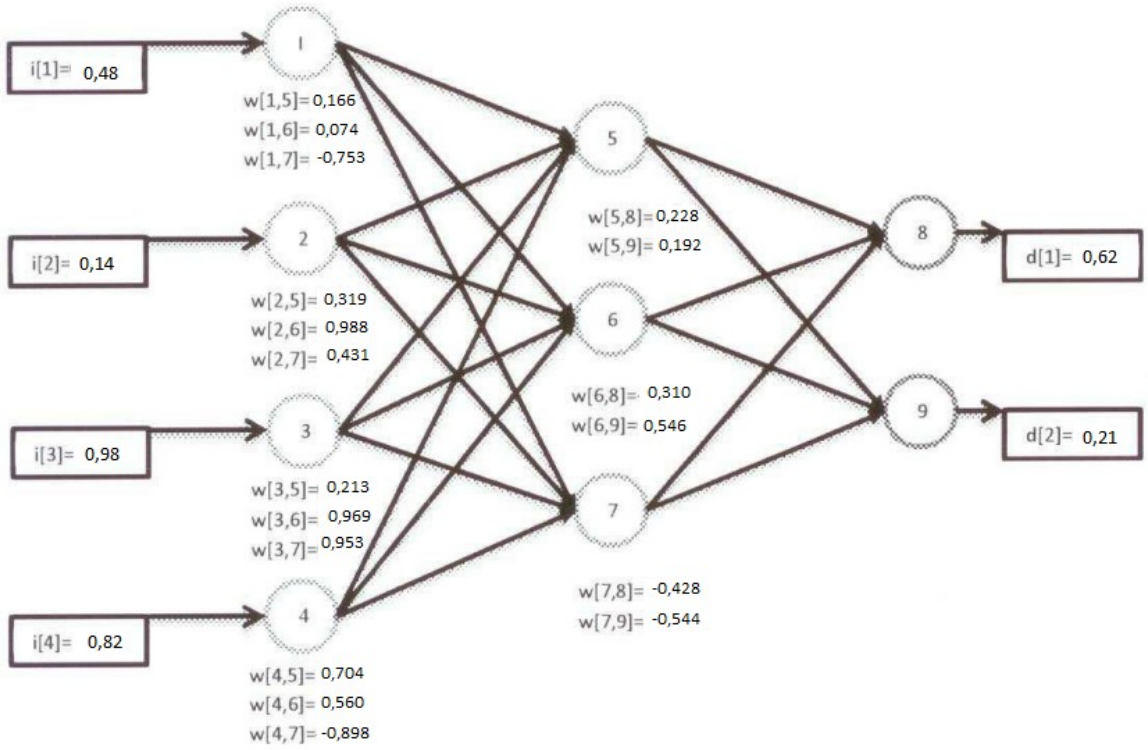
Stratul ascuns
$\delta_5=(\delta_8*w_{58}+\delta_9*w_{59})*o_5*(1-o_5)$
$D5=((0,01722)*(0,21927)+(-0,09456)*(0,24023))*(0,71454)*(1-(0,71454))$
$D5=-0,00386$
$\delta_6=(\delta_8*w_{68}+\delta_9*w_{69})*o_6*(1-o_6)$
$\delta_6=((0,01722)*(0,30079)+(-0,09456)*(0,60211))*(0,83114)*(1-(0,83114))$
$\delta_6=-0,00726$
$\delta_7=(\delta_8*w_{78}+\delta_9*w_{79})*o_7*(1-o_7)$
$\delta_7=((0,01722)*(-0,43394)+(-0,09456)*(-0,51251))*(0,47088)*(1-(0,47088))$
$\delta_7=0,01021$

Valorile delta:
$\Delta w_{15}=\eta*\delta_5*o_1=(0,71)(-0,00386)(0,48)=-0,00132$
$\Delta w_{16}=\eta*\delta_6*o_1=(0,71)(-0,00726)(0,48)=-0,00248$
$\Delta w_{17}=\eta*\delta_7*o_1=(0,71)(0,01021)(0,48)=0,00348$

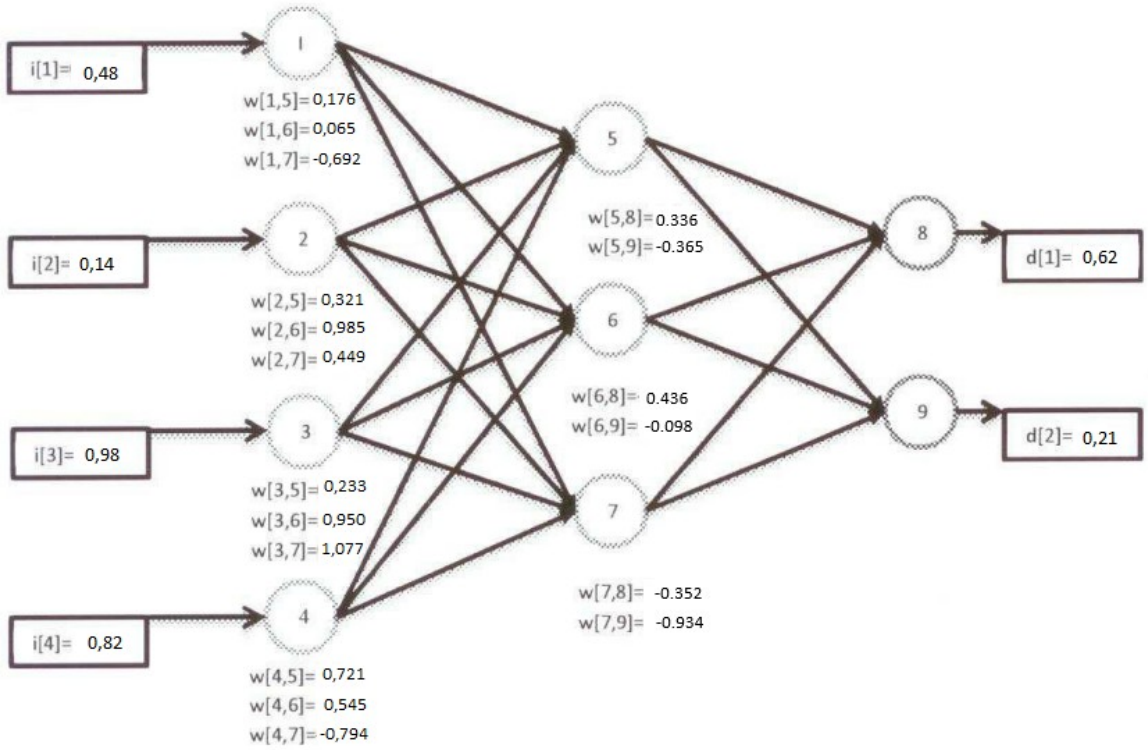
$\Delta w_{25}=\eta*\delta_5*o_2=(0,71)(-0,00386)(0,14)=-0,00038$
$\Delta w_{26}=\eta*\delta_6*o_2=(0,71)(-0,00726)(0,14)=-0,00072$
$\Delta w_{27}=\eta*\delta_7*o_2=(0,71)(0,01021)(0,14)=0,00102$
$\Delta w_{35}=\eta*\delta_5*o_3=(0,71)(-0,00386)(0,98)=-0,00269$
$\Delta w_{36}=\eta*\delta_6*o_3=(0,71)(-0,00726)(0,98)=-0,00505$
$\Delta w_{37}=\eta*\delta_7*o_3=(0,71)(0,01021)(0,98)=0,00711$
$\Delta w_{45}=\eta*\delta_5*o_4=(0,71)(-0,00386)(0,82)=-0,00225$
$\Delta w_{46}=\eta*\delta_6*o_4=(0,71)(-0,00726)(0,82)=-0,00423$
$\Delta w_{47}=\eta*\delta_7*o_4=(0,71)(0,01021)(0,82)=0,00595$

$\Delta w_{58}=\eta*\delta_8*o_5=(0,71)(0,01722)(0,71454)=0,00874$
$\Delta w_{59}=\eta*\delta_9*o_5=(0,71)(-0,09456)(0,71454)=-0,04797$
$\Delta w_{68}=\eta*\delta_8*o_6=(0,71)(0,01722)(0,83114)=0,01016$
$\Delta w_{69}=\eta*\delta_9*o_6=(0,71)(-0,09456)(0,83114)=-0,0558$
$\Delta w_{78}=\eta*\delta_8*o_7=(0,71)(0,01722)(0,47088)=0,00576$
$\Delta w_{79}=\eta*\delta_9*o_7=(0,71)(-0,09456)(0,47088)=-0,03161$

Ca rezultat al acestei iterații, rețeaua se modifică astfel:



Algoritmul se va executa pentru încă 23 de iterații, rețeaua finală fiind:



Pentru această rețea se obține eroarea de 0,00947, iar vectorul real de ieșire este: [0,60213; 0,30066].