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跟隨

用於模式識別的神經網絡Hopfield模型

Bashir Magomedov， 2006年11月7日

★★★★★   4.72（31票）   率：

文章描述了神經網絡的**Hopfield**模型。

下載源文件 **- 9.97 Kb**

下載演示項目 **- 44.7Kb**
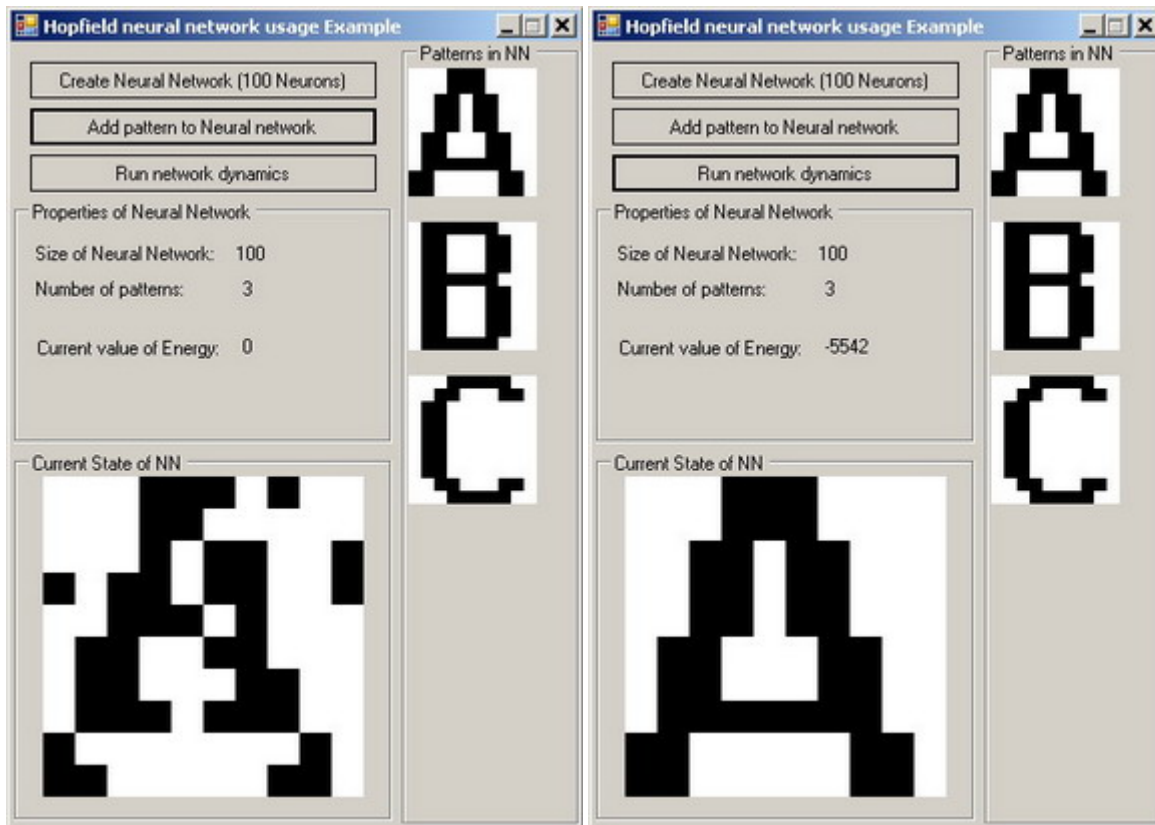
詞彙表

- （**A**）**NN** -（人工）神經網絡
- **HNN** - **Hopfield**神經網絡背景（可選）

介紹

文章描述了神經網絡的**Hopfield**模型。提供了理論基礎，算法和程序代碼。示出了將**Hopfield**神經網絡應用於模式識別問題的能力。

開盤

在這裡我不會談論神經網絡的整體。本文的主要目標是描述**Hopfield**神經網絡的結構和動力學。神經網絡的基本概念，如人造神經元，突觸，權重，連接矩陣等等，都在無數書中解釋。如果你想了解更多關於這些東西的信息，我建議你從Simon Haykin的"神經網絡"一書開始。Google 搜索也很有用。最後，你可以嘗試的Anoop Madhusudanan的很好的文章，這裡在CodeProject上。

Hopfield神經網絡（一點理論）

在**ANN**理論中，在最簡單的情況下（當閾值函數等於1時），**Hopfield**模型被描述為 N 個神經元的一維繫統- 自旋（$s_i = \pm 1$，$i =$
1,2，…，N）可以沿著或反對當地的領域。哈密頓量（也稱為**HNN**能量）描述了這種自旋系統的行為：

$$ E = -\frac{1}{2} \sum_{i \neq j}^{N} T_{i,j} s_i s_j $$

當 小號$_我$ 是的狀態 $我$ 個自旋和

$$T_{i,j} = \sum_{m=1}^{M} s_{mi} s_{mj}$$

是根據關於 $M/個$ 隨機化模式的Hebb規則組織的互連矩陣，即 N 維二進制向量 $S_m = (s_{m1}, s_{m2}, ... s_{mN})$（$m$ = 1,2，... M）。互連矩陣的對角元素被假定為零（$T_{i,i}$ = 0）。對這種系統的傳統方法是假定所有自旋都是自由的，並且它們的動力學僅由當地領域的行為來定義，並且它們是以它們為導向的。HNN的功能算法描述如下。初始自旋方向（神經元狀態）根據輸入向量的分量而定向。在時間t $h_i = \dfrac{\partial E}{\partial s_i}$ 作用於第i個自旋的本地場（該場由所有其餘的NN自旋產生）被計算為：

$$h_i = \sum_{j \neq i}^{N-1} T_{i,j} s_j$$

這個領域的自旋能量是 $E_i = -s_i h_i$。如果自旋方向與局部場（$E_i < 0$）的方向一致，則其位置在能量上是穩定的，並且自旋狀態在下一個時間步驟保持不變。否則（$E_i > 0$），自旋位置不穩定，局部場翻轉，將自旋通過能量（）傳遞到狀態 s_i（t +1）= - s_i（t $E_i(t+1) < 0$）。每次任何自旋翻轉時，NN的能量都會減少; 即NN以有限數量的步驟達到穩定狀態。在某些精確條件下，每個穩定狀態對應於添加到互連矩陣中的一種模式。

換句話說也是一樣

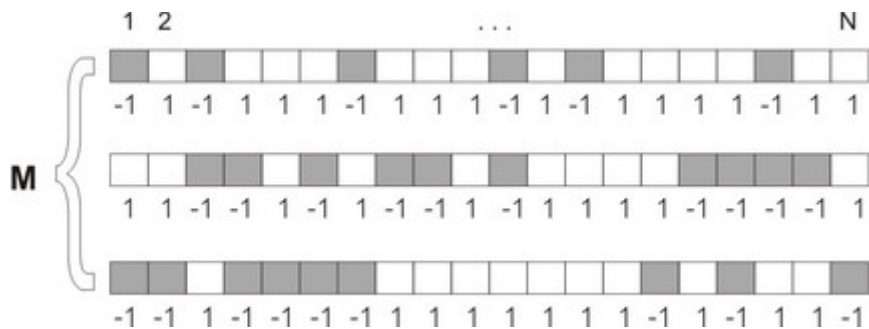所以，從數學上離題，讓我們從實際的角度考慮HNN。假設你有 M，N 維二進制向量（圖3），並且你想將它們存儲在神經網絡中。
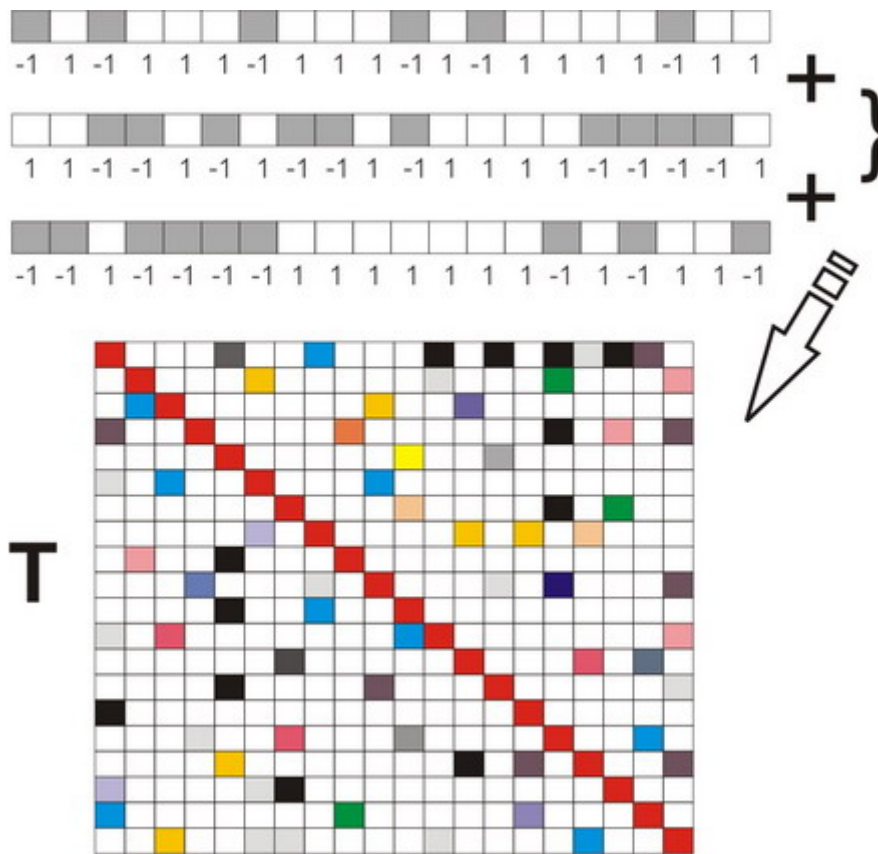

圖3.一組二進制模式

在這種情況下，您必須使用簡單求和將它們添加到互連矩陣中（圖4）。

圖4.互連矩陣的形成

現在網絡已經可以工作了。您必須設置一些NN的初始狀態並運行動態過程。HNN的特性是這樣的，在動態過程中，它進入與圖案之一相對應的某種穩定狀態。神經網絡將以這種模式通過，這與HNN的初始狀態非常相似。

玩演示

要了解它在實際中的工作原理，請運行演示項目（**Hopfield** *Recognizer.exe*）。

1. 在主窗口中按"創建神經網絡（100神經元）"按鈕。神經網絡將被創建。
2. 然後按"添加模式到神經網絡"按鈕並選擇任何10x10圖像（您可以在ABC文件夾中找到一些圖像）。例如添加3個與A，B和C圖像相對應的圖案。
3. 點擊添加的模式中的一個（例如A），並以百分比定義初始失真水平的值（您可以將其等於10%）。
4. 按"運行網絡動態"按鈕。這裡是:)

潛入代碼

我們來考慮一下神經網絡的對像模型。它由兩個主要類組成：**Neuron**和。是一個基類，它包含屬性和方法。是一個數字，但實際上它只有兩個值：+1或-1（這些值也可以從靜態類訪問，其中等於1且等於-1）。接收作用於神經元的場的值並做出決定，或者改變自己的狀態。如果更改，則返回。

NeuralNetwork**NeuronStateChangeState()StateInt32NeuronStatesNeorunStates.AlongFieldNeorunStates.AgainstFieldChangeState()ChangeState()trueState**

隱藏 縮小 ▲   複製代碼

```
public class Neuron
{
    private int state;
    public int State
    {
        get { return state; }
        set { state = value;}
    }

    public Neuron()
    {
```

```
        int r = new Random().Next(2);
        switch (r)
        {
            case 0: state = NeuronStates.AlongField; break;
            case 1: state = NeuronStates.AgainstField; break;
        }
    }

    public bool ChangeState(Double field)
    {
        bool res = false;
        if (field * this.State < 0)
        {
            this.state = -this.state;
            res = true;
        }
        return res;
    }
}
```

Neural**Network** 類包含神經元的類型列表，添加模式和運行動態的方法：

```
public List<Neuron> Neurons;
public void AddPattern(List<Neuron> Pattern)
public void Run(List<Neuron> initialState)
```

類構造函數初始化所有字段，創建列表和數組，並用零填充互連矩陣：

```
public NeuralNetwork(int n)
{
    this.n = n;
    neurons = new List<Neuron>(n);
    for (int i = 0; i< n; i++)
    {
        Neuron neuron = new Neuron();
        neuron.State = 0;
        neurons.Add(neuron);
    }

    T = new int[n, n];
    m = 0;

    for (int i = 0; i < n; i++)
        for (int j = 0; j < n; j++)
        {
            T[i, j] = 0;
        }
}
```

的**AddPattern()**和**AddRandomPattern()**添加了指定的（或隨機生成的）圖案到互連矩陣：

```
public void AddPattern(List<Neuron> Pattern)
    {
        for (int i = 0; i < n; i++)
            for (int j = 0; j < n; j++)
            {
                if (i == j) T[i, j] = 0;
                else T[i, j] += (Pattern[i].State * Pattern[j].State);
            }
        m++;
    }
```

該**Run()**方法運行HNN的動態：

```
public void Run(List<Neuron> initialState)
{
```

```
        this.neurons = initialState;
        int k = 1;
        int h = 0;
            while(k != 0)
            {
                k = 0;
                for (int i = 0; i < n; i++)
                {
                    h = 0;
                    for (int j = 0; j < n; j++)
                      h += T[i, j] * (neurons[j].State);

                    if (neurons[i].ChangeState(h))
                    {
                        k++;
                        CalculateEnergy();
                        OnEnergyChanged(new EnergyEventArgs(e,i));
                    }
                }
            }
            CalculateEnergy();
}
```

每當任何自旋改變其狀態時，系統的能量都會EnergyChanged發生變化，NN會引發事件。這個事件允許用戶及時跟踪NN狀態。

使用代碼

要在您的項目中使用此代碼，您必須添加對*Hopfield神經網絡.dll*的引用。然後你需要創建一個類的實例，並訂閱事件（可選）：
NeuralNetworkEnergyChanged

隱藏　複製代碼

```
NeuralNetwork NN = new NeuralNetwork(100);
NN.EnergyChanged += new EnergyChangedHandler(NN_EnergyChanged);
private void NN_EnergyChanged(object sender, EnergyEventArgs e)
{
  //...
}
```

之後，您需要在互連矩陣中添加一些模式。

隱藏　複製代碼

```
List<Neuron> pattern = new List<Neuron>(100);
//... some pattern forming code goes
NN.AddPattern(pattern);
```

最後，您可以運行網絡的動態：

隱藏　複製代碼

```
List<Neuron> initialState = new List<Neuron>(100);
//... some initialState forming code goes
NN.Run(initialState);
```

遺言

HNN於1982年提出，它不是模式識別問題的最佳解決方案。模式之間的相關性非常明智。如果你嘗試在矩陣中添加一些非常相似的模式（例如（ABC文件夾）中的B和C），它們就會一起流動並形成新的模式，稱為嵌合體。對於存儲在互連矩陣中的模式數量也是明智的。從神經元的數量來看，它不能超過10-14%。儘管存在這樣的缺點，HNN及其現代修改是簡單和流行的算法。

執照

本文以及任何關聯的源代碼和文件均根據GNU通用公共許可證（GPLv3）

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關於作者

Bashir Magomedov

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question
th_cue   4-Jun-13 23:43

🔼
🔽   I meet error in line : imNNState.pixels = new int[imageDim, imageDim];
      You can hepl me solve problems !!!

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My vote of 5
Kanasz Robert   6-Nov-12 18:01

very good article and well explained. good job bashir

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How do I change to recognize binary pattern?
shamlen   7-Jun-11 7:56

Hi,

Thanks for the posting. I am a newbie to AI world. I would like to understand, how could I change your algorithm to recognize binary pattern. For example,

I may have set of data as below

Day	Data
1	101010
2	110011
3	101110
4	011010
5	001100

I would like to predict the data for day 6. I have 1000 set of historical data. Please advice if this is achievable using your algorithm. I would appreciate if you could direct me to the right path.

Thanks

-Balan Sinniah-

Balan

Reply · Email · View Thread   5.00/5 (1 vote)

My vote of 5
Filip D'haene   26-May-11 22:39

Excellent article!

Thanks for sharing. 😊

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Hopfield NN for pattern recognition in visual prolog
ngelina   16-Nov-10 17:02

hi..
i wan to disscusss about hopfield NN for pattern recog in vis-pro.
can u give me advice about the algorithm?
thx 😊

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You asked me about the procedure NN_EnergyChanged()
phamvanloi_nd   31-Mar-10 17:05

Hi!
You asked me about the procedure NN_EnergyChanged(object sender, EnergyEventArgs e)

Why in the procedure CreateNNBut_Click(object sender, EventArgs e)you call procedure NN_EnergyChanged.

NN.EnergyChanged += new EnergyChangedHandler(NN_EnergyChanged);

I do not really understand this function.

Hope you can explain techniques are not for me!

thank you very much.

wish you a happy day! 😳

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You asked me about the procedure NN_EnergyChanged(object sender, EnergyEventArgs e)
phamvanloi_nd   31-Mar-10 17:03

Hi!
You asked me about the procedure NN_EnergyChanged(object sender, EnergyEventArgs e)

Why in the procedure CreateNNBut_Click(object sender, EventArgs e)you call procedure NN_EnergyChanged.

NN.EnergyChanged += new EnergyChangedHandler(NN_EnergyChanged);

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wish you a happy day! 😳

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Neural network
SajanakiSasiri   8-Dec-09 13:06

How can i design a neural network for image recognition with mathLab?
What is the neural network technology?

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Association Between Input and Reference Patterns
JackEMoore   9-Nov-09 5:40

In the example with patterns A, B, C, what is a good algorithm way to associate the result after the NN has acheived a stable state with the particular reference pattern?

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Question

sandreli   20-Jun-09 18:23

Can you please show the method CalculateEnergy

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Re: Question

Bashir Magomedov   20-Jun-09 18:38

What do you mean by show? You can see it in the code. Just download it. Please do not hesitate to ask if you need some details ot explanation about this method.

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Question

dennykidz7   18-Jun-09 15:18

What the Neuron Index..For what?

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Re: Question

Bashir Magomedov   18-Jun-09 15:27

Have you meant something certain by index? If not I can answer in general. To iterate trough all the neurons of system and either change the state of particular neuron or remain it unchanged.

Everything is possible!

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About Hopfield Neural network Source code

monisha101   30-Jul-08 17:58

I find out the code for Hopfield neural network from ur site....its demo working fine...but i need this code in C language instead of C++ language [D'Oh!]

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Ask

amal_kh   3-Jul-08 15:00

Can i ask you how did you use neural network in your project, i mean what was the input layer,hiddden layer, the function that you used and the output layer?

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Re: Ask

Bashir Magomedov   3-Jul-08 15:14

The deal is that this is not a multi-layer perceptron (as you might thought), but Hopfiled neural network (HNN). This

is a special kind of neural network for pattern recognition and it doesn't have any layers. In general case each neuron of HNN has activation function but here (for the simplicity) it was reduced to bipolar function when each neuron can be either + or - 1.

Please read the article carefully, all these points were stated in it, and do not hesitate to contact me in future if you need help.

Everything is possible!

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HopfieldNeuralNetwork_demo is not working
mohammadnassif　　17-May-08 2:00

pleas help me i download the project and try to run
from this icon : HopfieldRecognizer.exe
but the project dont run and return this message:
The application failed to initialize properly(0xc0000135).Click on ok to terminate the application.

pleas help me and tell me whats i can do.

thanks

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Re: HopfieldNeuralNetwork_demo is not working
Bashir Magomedov　　17-May-08 13:12

It seems that you do not have .NET Framework installed on your machine. Please install .NET 2.0 (or later) Framework and try again.😎

Everything is possible!

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pleas help me
yasamin　　5-Apr-08 14:43

hi
I'm yasamina
Ihave aproject in nural network Iwant to make astndared or model back propagation network but Idont have any idea how i can do this if any one have a code or idea pleas giv it to me
thank you

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hi
lulukuku　　27-Nov-07 23:16

thank you very much,i saw it.😊

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Question!!

lulukuku   26-Nov-07 16:44

in the program of you,i don't see method you create neural's images(about 100 neuron)! you can explain for me!!! 🤚
thanks you very much.

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Re: Question!!
Bashir Magomedov   26-Nov-07 16:51

Here is requested code. This method is an event handler of "Create neural network (100 Neurons)" button. You can find it in the frmMain class (MainForm.cs file).

Hide   Copy Code

```
<br />
        private void CreateNNBut_Click(object sender, EventArgs e)<br />
        {<br />
            NN = new NeuralNetwork(imageDim*imageDim);<br />
            panelStoredImages.Controls.Clear();<br />
            NN.EnergyChanged += new EnergyChangedHandler(NN_EnergyChanged);<br />
            Random rnd = new Random();<br />
            int r = 0;<br />
            imNNState.pixels = new int[imageDim, imageDim];<br />
            for (int i = 0; i < imageDim; i++)<br />
                for (int j = 0; j < imageDim; j++)<br />
                {<br />
                    r = rnd.Next(2);<br />
                    if (r == 0) imNNState.pixels[i, j] = Color.Black.ToArgb();<br />
                    else if (r == 1) imNNState.pixels[i, j] = Color.White.ToArgb();
<br />
                }<br />
            patternSelected = false;<br />
            butAddPattern.Enabled = true;<br />
            butRunDynamics.Enabled = false;<br />
            imNNState.Visible = true;<br />
            imNNState.Invalidate();<br />
            UpdatePropertiesPB();<br />
        }<br />
```

Thank you for your attention

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ERROR!!!
lulukuku   25-Nov-07 14:52

i meet ERROR "Warning 1 Could not find type 'ImageMagnifier.ImageMagnifier'. Please make sure that the assembly that contains this type is referenced. If this type is a part of your development project, make sure that the project has been successfully built. 0 0
" and "Warning 2 The variable 'imNNState' is either undeclared or was never assigned. C:\Documents and Settings\Administrator\Desktop\HopfieldRecognizer\MainForm.Designer.cs 175 0
"
You can hepl me solve problems !!! 🤚
where do i find "'ImageMagnifier.ImageMagnifier'" ?
Thanks you very much!! 😊

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Re: ERROR!!!
Bashir Magomedov　　25-Nov-07 17:18

Dear lulukuku!
This class (ImageMagnifier) is needed only for demo-project and located in the root folder of the project. It is possible that references are out of date, so you should remove reference from project and add it again by yourself.
If you are looking for the source-codes of this control, you can try out following link:
http://www.codeproject.com/cs/miscctrl/ImageMagnifier.asp[^]

Sincerely yours, Bashir

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help me!
lulukuku　　23-Nov-07 23:46

please,help me!i need informaiton for hopfield model of neural network for pattern recognition. you can send me all code "Hopfield model of neural network for pattern recognition ".thanks you very much!!

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