行政院國家科學委員會專題研究計畫成果報告

霍氏類神經網路於震測反射層之檢取

The Study of Hopfield Neural Net for Seismic Horizon Picking

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一、中文摘要

Hopfield 類神經網路被用來解震測反射層檢取之問題。一個輸入的震測資料經過前處理後，波子(wavelet)變成頂點(peak)。在 Hopfield net 每一個先前處理的點均代表一個神經元。偵測震測反射層的條件被用於建立 Lyapunov 能量函數。介於神經元的連接鍵的權重可從 Lyapunov 能量函數抽取得到。由運動方程式，每一個神經元的下一次狀態值可以被計算出來。改變一個神經元的狀態值將可減低能量，當每一個神經元的狀態值不再改變時，系統將趨於穩定。

每一次循環計算，一條反射層將被抽取出來，然後從原先的震測資料去除，而再抽取下一條反射層。整個過程將重複一直到沒有反射層被抽取。在實驗上，在震測亮點的資料中，被抽取的反射層與目視的判斷相吻合。

關鍵詞： Hopfield 類神經網路，Lyapunov 能量函數，震測反射層之檢取。

Abstract

The Hopfield neural net is used to solve the problem of seismic horizon picking. The input seismogram passes through preprocessing steps and becomes the seismic peak data. The preprocessing steps include envelope processing, thresholding, peak detection, and compression in time direction. One peak represents one seismic wavelet. Each preprocessed data item corresponds to one neuron in the Hopfield net. The constraint conditions for detecting seismic horizons are used to construct the Lyapunov energy function. The connection weights between neurons are extracted from this energy function. From the equation of motion, the next state value of each neuron can be calculated. Changing the value of a neuron decreases the energy. The system becomes stable when the value of each neuron is no longer changed. One horizon is extracted by using the algorithm at one survey. The extracted horizon is removed from the original seismic data and the next horizon is extracted. The process is repeated until no more horizons can be extracted. In our experiments on the bright spot peak data, the extracted horizons match those obtained by visual inspection.

Keywords: Hopfield neural net, Lyapunov function, seismic horizon picking.

二、緣由與目的

類神經網路之研究，在國內外均極受重視，其應用之領域更是相當的廣泛。近年來，類神經網路已被廣泛的應用於地球物理的圖型識別.

Hopfield proposed his model of neural networks (Hopfield, 1982, 1984, 1987). Several interesting applications adopted the Hopfield model to associative memory, pattern recognition, and optimization problems (Hopfield and Tank, 1985, 1986; Tank and Hopfield, 1986, 1987). Lippman (1987), Pao (1989), Zurada (1992), and Haykin (1999) analyzed analog and discrete types of the Hopfield model. Huang et al. (1989) applied the Hopfield model to the detection of bright spot pattern in seismic oil exploration. Here the Hopfield model is used to solve the problem of seismic horizon.

三、結果與討論

(1) 結果:

(a) Analysis:

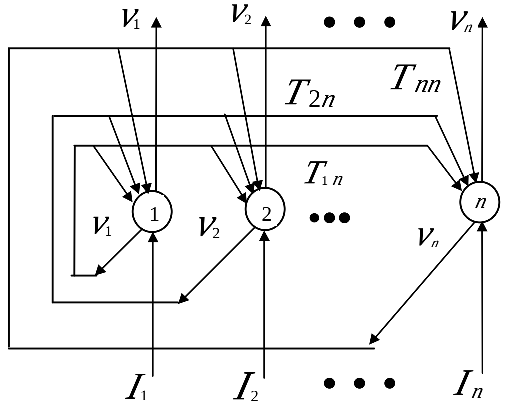
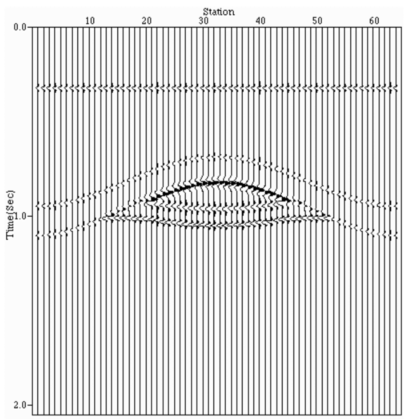
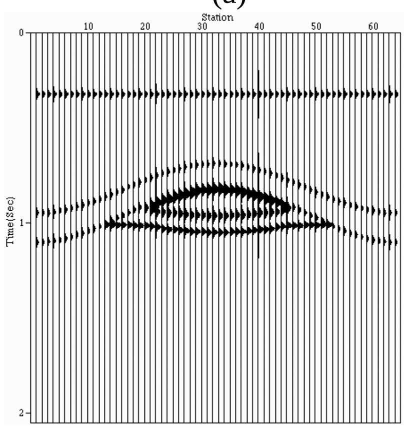


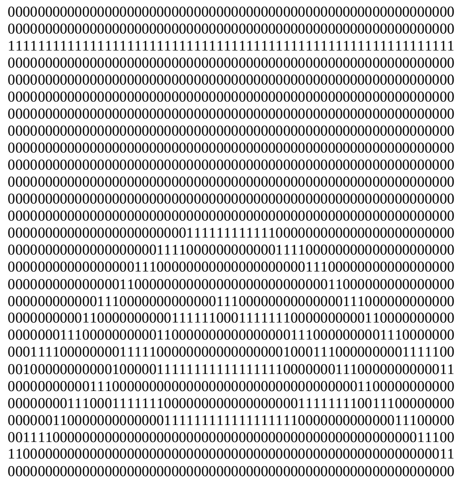
Figure 1. Hopfield neural network.



(a)



(b)



(c)

Figure 2. (a) Bright spot seismogram. (b) Envelope. (c) Thresholding, peaking, and vertical compression.

Figure 1 shows the Hopfield neural model. Figures 2 displays the simulated seismogram of a bright spot, its envelope, and the preprocessed peak seismic data. A preprocessed seismic section is the input to the Hopfield model. Each pixel in the seismic section is the neuron location of the Hopfield model. The position at row x and column i of the seismic data represents the exact location of the neuron. Two indices x and i are used in the representation of the location of the neuron $V_{x,i}$ in two dimensional space. The connection weight between two neurons is represented by $T_{x,i;y,j}$.

The five constraint conditions of a seismic horizon are defined first. The total Lyapunov energy function is constructed for each constraint condition. Next, the connection weights between neurons can be extracted from the total Lyapunov energy function. Then using the motion equation of the Hopfield model, the value of neurons at 1 can be changed to 0 if the neuron (peak) does not satisfy the conditions of the horizon. But if the value of neurons (nonpeak) is 0, then the process is skipped. Finally the peaks satisfying the conditions of the horizon can be linked as one horizon.

The standard form of the system Lyapunov energy function is defined as follows.

$$E = -\frac{1}{2}\sum_x \sum_i \sum_y \sum_j T_{x,i;y,j}\ V_{x,i}(t)\, V_{y,j}(t) - \sum_x \sum_i I_{x,i}\ V_{x,i}(t) + \sum_x \sum_i \overline{\ }_{x,i}\ V_{x,i}(t) \qquad (1)$$

The weighting coefficients $T_{x,i;y,j}$ can be extracted from the energy function.

One example of constraint condition is shown in Figure 3. If $V_{x,i}$ is a peak and two other neighboring peaks are in a straight line, then the energy is decreased.

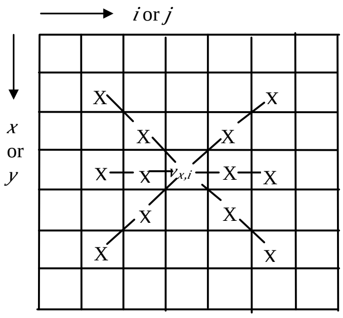


Figure 3. 3rd constraint for detection of local horizon pattern. Energy is decreased.

$$E_3 = -\sum_x \sum_i \Big[\frac{c_1}{2} \big(V_{x,i} V_{x,i+1} V_{x,i+2} + V_{x,i-2} V_{x,i-1} V_{x,i} \big)$$
$$+ \frac{c_2}{2} \big(V_{x,i} V_{x+1,i+1} V_{x+2,i+2} + V_{x,i} V_{x-1,i+1} V_{x-2,i+2} + V_{x-2,i-2} V_{x-1,i-1} V_{x,i} + V_{x+2,i-2} V_{x+1,i-1} V_{x,i} \big) \Big]$$

where c_1 and c_2 are positive constants.

The total energy function is given by:

$$E = E_1 + E_2 + E_3 + E_4 + E_5 \qquad (2)$$

$T_{x,i;y,j}$ can be extracted from E.

An algorithm using a Hopfield net for seismic horizon picking is proposed. The equation of motion is as follows.

Change the value of the neuron $V_{x,i}$.

If $\sum_y \sum_j T_{x,i;y,j} V_{y,j} > 0$, $V_{x,i} = 1$,

if $\sum_y \sum_j T_{x,i;y,j} V_{y,j} < 0$, $V_{x,i} = 0$

(b) Experiments:

In our experiments, a Hopfield neural net is applied to a 10x10 preprocessed peak data of the bright spot pattern given in Figure 4(a). There are 100 neurons and 10,000 connection weights $T_{x,i;y,j}$ in the Hopfield model. The constants a=5.0, $b_1 = b_2 = c_1 = c_2 = d_1 = d_2 = 1.0$, and e =0.0 are chosen. Figure 4(b) is the first extracted horizon after 10 complete surveys. Figure 4(c) is the second extracted horizon after 20 complete surveys. Figure 4(d) is the third extracted horizon after 28 complete surveys. Figure 4(e) is the fourth extracted horizon after 32 complete surveys. The extracted horizons match the results obtained by visual inspection.

Bright spot	Iteration 10	Iteration 20
0000000000	0000000000	0000000000
0000xx0000	0000xx0000	0000000000
000x00x000	000x00x000	0000000000
00x0000x00	00x0000x00	0000000000
0x00xx00x0	0x000000x0	0000xx0000
x00x00x00x	x00000000x	000x00x000
00xxxxxx00	0000000000	00x0000x00
0x000000x0	0000000000	0x000000x0
xxxxxxxxxx	0000000000	x00000000x
0000000000	0000000000	0000000000
	# 1 horizon	# 2 horizon
(a)	(b)	(c)

Iteration 28	Iteration 32
0000000000	0000000000
0000000000	0000000000
0000000000	0000000000
0000000000	0000000000
0000000000	0000000000
0000000000	0000000000
0000000000	000xxxx000
0000000000	0000000000
0xxxxxxxx0	0000000000
0000000000	0000000000
# 3 horizon	# 4 horizon
(d)	(e)

Figure 4. Extracted seismic horizons. "x" represents peak.

(2) 討論:

The constraints on E_2, E_3, and E_4 are the conditions for the detection of horizon. The constraints on E_1 and E_5 achieve one horizon at one survey and exclude the other candidates.

The weighting coefficients $T_{x,i;y,j}$ are not fixed; rather, they are changed whenever the neurons are changed. This is quite different from algorithm of the conventional Hopfield net. The value 1 or 0 of the constants a, b_1, b_2, c_1, c_2, d_1, d_2, and e indicates the inclusion or exclusion of the constraint conditions.

四、成果自評

研究內容與原計畫相符程度: 100%
達成預期目標情況: 100%
研究成果的學術或應用價值: **建立類神經網路於震測** horizon picking **之系統，及幫助探油震測解釋**
是否適合在學術期刊發表: **是**
主要發現或其他有關價值: **可用於** Image segmentation **之抽取**

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