Neural Network I: Fundamental Theory and Applications (CSA01)

Team Project III

Image restoration based on associate memory

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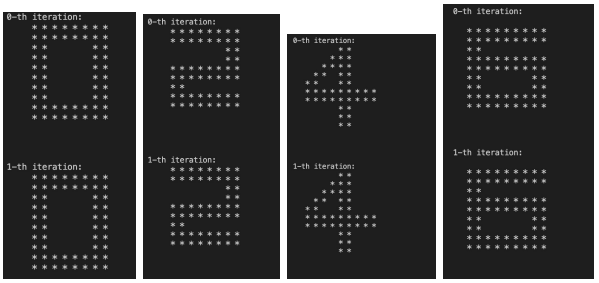
a)
We checked how the results changed when the noise was changed to 0%, 10%, and 15%.

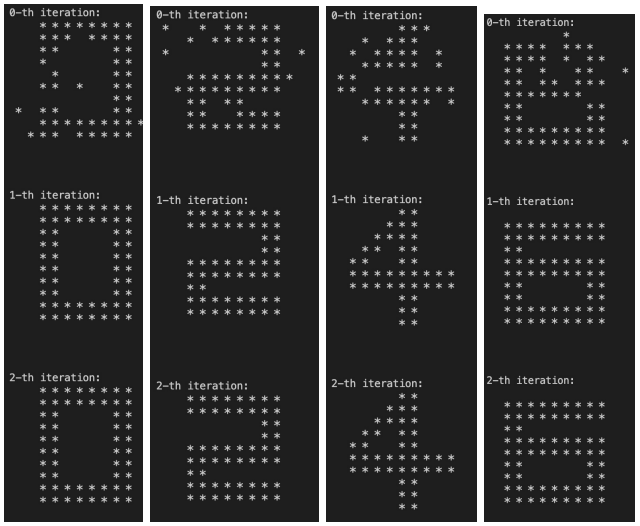
b)
We changed noise rates.

```
#define noise_rate 0.1
```

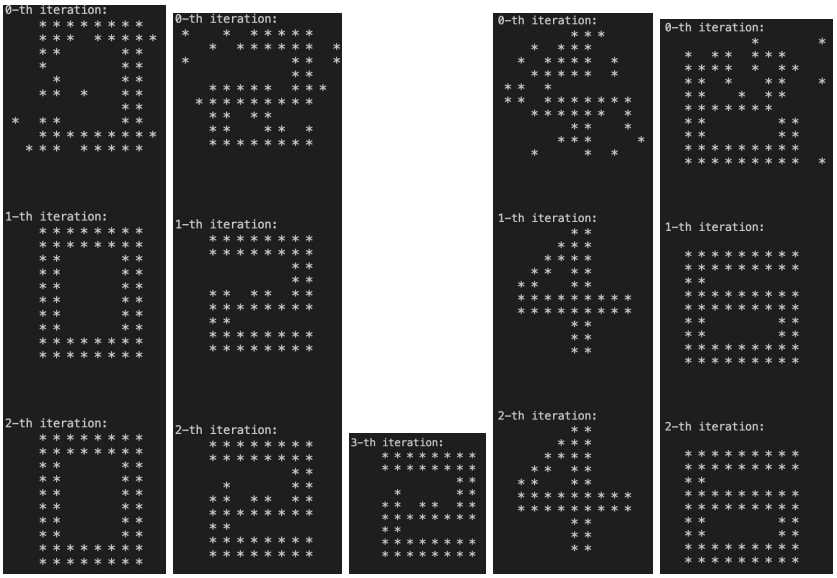
0%



10%

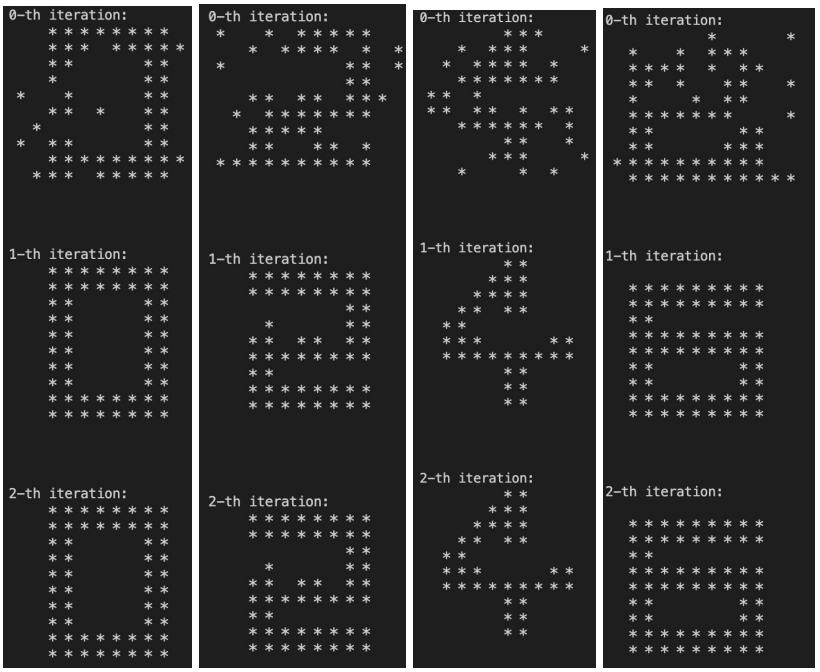


15%

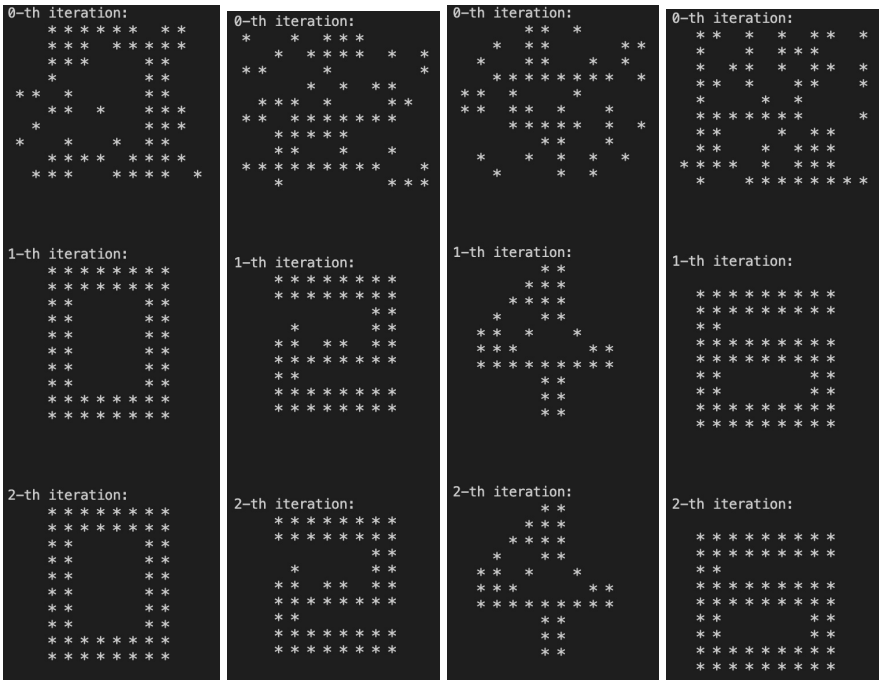


c) It was found that 15% took more time to repair than 10%.
At 15%, it could not be repaired correctly. (2 is not correct)

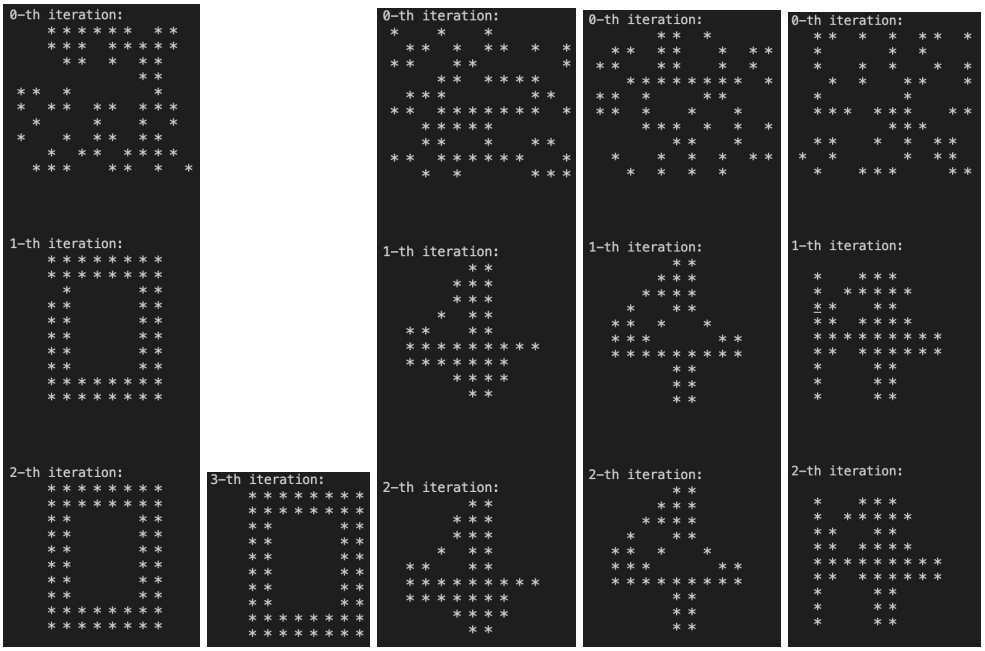
d) At what % will it become irreparable?
e) We increased noise. (noise_rate changed 20, 30, 40)
f) Result outputs
20%



30%



40%



From the results, if we changed 40%, HNN may not change the correct result.

Source code----------

```
/*********************************************************************/
/* c-Program for constructing an autoassociative memory              */
/* The model is the Hopfield neural network with asynchorous update  */
/* If you want to use it for applications other than that described  */
/* in this project, please provide the patterns to be stored         */
/*                                                                   */
/* This program is produced by Qiangfu Zhao.                         */
/* You are free to use it for educational purpose                    */
/*********************************************************************/
#include <stdlib.h>
#include <stdio.h>

#define n_neuron 120
#define n_pattern 4
#define n_row 10
#define n_column 12
#define noise_rate 0.15

int pattern[n_pattern][n_neuron] = {
   {1, 1, -1, -1, -1, -1, -1, -1, -1, -1, 1, 1,
    1, 1, -1, -1, -1, -1, -1, -1, -1, -1, 1, 1,
    1, 1, -1, -1, 1, 1, 1, 1, -1, -1, 1, 1,
    1, 1, -1, -1, 1, 1, 1, 1, -1, -1, 1, 1,
    1, 1, -1, -1, 1, 1, 1, 1, -1, -1, 1, 1,
    1, 1, -1, -1, 1, 1, 1, 1, -1, -1, 1, 1,
    1, 1, -1, -1, 1, 1, 1, 1, -1, -1, 1, 1,
    1, 1, -1, -1, 1, 1, 1, 1, -1, -1, 1, 1,
    1, 1, -1, -1, -1, -1, -1, -1, -1, -1, 1, 1,
    1, 1, -1, -1, -1, -1, -1, -1, -1, -1, 1, 1},
   {1, 1, -1, -1, -1, -1, -1, -1, -1, -1, 1, 1,
    1, 1, -1, -1, -1, -1, -1, -1, -1, -1, 1, 1,
    1, 1, 1, 1, 1, 1, 1, 1, -1, -1, 1, 1,
    1, 1, 1, 1, 1, 1, 1, 1, -1, -1, 1, 1,
    1, 1, -1, -1, -1, -1, -1, -1, -1, -1, 1, 1,
    1, 1, -1, -1, -1, -1, -1, -1, -1, -1, 1, 1,
    1, 1, -1, -1, 1, 1, 1, 1, 1, 1, 1, 1,
    1, 1, -1, -1, -1, -1, -1, -1, -1, -1, 1, 1,
    1, 1, -1, -1, -1, -1, -1, -1, -1, -1, 1, 1,
    1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1},
   {1, 1, 1, 1, 1, -1, -1, 1, 1, 1, 1, 1,
    1, 1, 1, 1, -1, -1, -1, 1, 1, 1, 1, 1,
    1, 1, 1, -1, -1, -1, -1, 1, 1, 1, 1, 1,
```

```
    1, 1, -1, -1, 1, -1, -1, 1, 1, 1, 1, 1,
    1, -1, -1, 1, 1, -1, -1, 1, 1, 1, 1, 1,
    1, -1, -1, -1, -1, -1, -1, -1, -1, -1, 1, 1,
    1, -1, -1, -1, -1, -1, -1, -1, -1, -1, 1, 1,
    1, 1, 1, 1, 1, -1, -1, 1, 1, 1, 1, 1,
    1, 1, 1, 1, 1, -1, -1, 1, 1, 1, 1, 1,
    1, 1, 1, 1, 1, -1, -1, 1, 1, 1, 1, 1},
   {1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1,
    1, -1, -1, -1, -1, -1, -1, -1, -1, -1, 1, 1,
    1, -1, -1, -1, -1, -1, -1, -1, -1, -1, 1, 1,
    1, -1, -1, 1, 1, 1, 1, 1, 1, 1, 1, 1,
    1, -1, -1, -1, -1, -1, -1, -1, -1, -1, 1, 1,
    1, -1, -1, -1, -1, -1, -1, -1, -1, -1, 1, 1,
    1, -1, -1, 1, 1, 1, 1, 1, -1, -1, 1, 1,
    1, -1, -1, 1, 1, 1, 1, 1, -1, -1, 1, 1,
    1, -1, -1, -1, -1, -1, -1, -1, -1, -1, 1, 1,
    1, -1, -1, -1, -1, -1, -1, -1, -1, -1, 1, 1}};

int w[n_neuron][n_neuron];
int v[n_neuron];
/*************************************************************************/
/* Output the patterns, to confirm they are the desired ones             */
/*************************************************************************/
Output_Pattern(int k)
{
 int i, j;

 printf("Pattern[%d]:\n", k);
 for (i = 0; i < n_row; i++)
 {
   for (j = 0; j < n_column; j++)
     printf("%2c", (pattern[k][i * n_column + j] == -1) ? '*' : ' ');
   printf("\n");
 }
 printf("\n\n\n");
 getchar();
}

/*************************************************************************/
/* Output the state of the network in the form of a picture              */
/*************************************************************************/
Output_State(int k)
{
```

```
 int i, j;

 printf("%d-th iteration:\n", k);
 for (i = 0; i < n_row; i++)
 {
   for (j = 0; j < n_column; j++)
     printf("%2c", (v[i * n_column + j] == -1) ? '*' : ' ');
   printf("\n");
 }
 printf("\n\n\n");
 getchar();
}

/*********************************************************************/
/* Store the patterns into the network                               */
/*********************************************************************/
Store_Pattern()
{
 int i, j, k;

 for (i = 0; i < n_neuron; i++)
 {
   for (j = 0; j < n_neuron; j++)
   {
     w[i][j] = 0;
     for (k = 0; k < n_pattern; k++)
       w[i][j] += pattern[k][i] * pattern[k][j];
     w[i][j] /= (double)n_pattern;
   }
   w[i][i] = 0;
 }
}

/*********************************************************************/
/* Recall the m-th pattern from the network                          */
/* The pattern is corrupted by some noises                           */
/*********************************************************************/
Recall_Pattern(int m)
{
 int i, j, k;
 int n_update;
 int net, vnew;
 double r;
```

```
 for (i = 0; i < n_neuron; i++)
 {
   r = (double)(rand() % 10001) / 10000.0;
   if (r < noise_rate)
     v[i] = (pattern[m][i] == 1) ? -1 : 1;
   else
     v[i] = pattern[m][i];
 }
 Output_State(0); /* show the noisy input pattern */

 k = 1;
 do
 {
   n_update = 0;
   for (i = 0; i < n_neuron; i++)
   {
     net = 0;
     for (j = 0; j < n_neuron; j++)
       net += w[i][j] * v[j];
     if (net >= 0)
       vnew = 1;
     if (net < 0)
       vnew = -1;
     if (vnew != v[i])
     {
       n_update++;
       v[i] = vnew;
     }
   }
   Output_State(k); /* show the current result */
   k++;
 } while (n_update != 0);
}

/*************************************************************************/
/* Initialize the weights                                                */
/*************************************************************************/
Initialization()
{
 int i, j;

 for (i = 0; i < n_neuron; i++)
```

```
   for (j = 0; j < n_neuron; j++)
     w[i][j] = 0;
}

/*************************************************************************/
/* The main program                                                      */
/*************************************************************************/
main()
{
 int k;

 for (k = 0; k < n_pattern; k++)
   Output_Pattern(k);

 Initialization();
 Store_Pattern();
 for (k = 0; k < n_pattern; k++)
   Recall_Pattern(k);
}
```