Implementation of Emotional Intelligence in a machine

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Abstract: This paper is an extended work of our paper “A New Concept on Thinking Machines: Cyber Personality” published in IJCS journal. Our previous work dealt with a new concept on implementing the entire personality in a machine. In this paper we have provided an implementation of introducing emotional intelligence inside a computer by providing a pseudo-code along with a partial implementation of the same. Suitable results have been included to prove our work.

Keywords: Artificial Intelligence, Cyber Personality, Emotional Intelligence, Psychology and Turing Machine.

I. Introduction

This paper involves implementing emotional intelligence inside a computer based on a particular individual. It is an extended work of our previous work Indrajit Sinha, Dr. Kanhaiya Lal, “A New Concept on Thinking Machines: Cyber Personality”, In IJCS, pp: 25-29, Vol 2, issue 1, January, 2015. Our previous work involved implementing the complete personality of an individual in a computer. In this paper we have provided a method to implement emotional intelligence inside a computer. However it is well known that emotions of all humans are unique and different from each other. Hence our implementation also relates to using the emotional approach of a particular human. In other words the computer is to analyze emotions based on the interpretation capabilities of a particular person. To make our work more clear we shall provide a brief introduction of certain topics that are related to our field.

A chatbot is a program designed to simulate a conversation with one or more humans. Its main aim is to fool the human into believing that it is communicating with another human.[1-2] It uses the concept of the Turing machine which is a machine intelligent to fool anyone. Although many chatbots and expert systems have been designed to get close to it none are exact. Cleverbot is a bit more sophisticated than chatbots in the fact that they have a learning system from human inputs.[3]

Some such systems include Elbot created by Fred Roberts[4], Jabberwacky created by Rollo Carpenter[5], ELIZA[6] and A.L.I.C.E. which stands for Artificial Linguistic Internet Computer Entity.[7]

However certain chatbots now involve application of linguistics which is the scientific study of languages.[8] This involves minimalist program which deals with development under generative grammar.[9] Phrase structure is used to define syntax of a language which includes principles and processes used for constructing a sentence for a particular language.[10-11] However all of this is integrated using sentence diagram which is pictorial representation of the structure of a sentence.[12] The theories of linguistics can be implemented mathematically using predicate logic and inference rules.[13-18]

What lacks in these chatbots is the capability to understand the emotions of the human with which the chat is going on. Often a word is stated in different ways depending on the current mood of the person. Using emotional intelligence requires understanding the working of our brain. Our brain contains a neocortex which is a bulb of convoluted tissues forming the top layers. This is the thought region of our brain. The limbic system surrounds the brainstem and looks like a bagel with a bite taken out at the bottom where the brainstem nestles into them. This system generates emotional feelings. The main specialist in emotions is however the amygdala which is an almond-shaped cluster of interconnected structures perched above the brainstem, near the bottom of the limbic ring. There are actually two amygdalas that nestle towards the sides of the brain.[19]

Humans have great creative thinking but cannot deal with huge amounts of data and that’s where statistical and empirical methods come in for aid.[22]

As we know that Artificial Intelligence tries to understand and build intelligent systems,[20-21] it is suitable to say that our work falls under this category. Personality is an individual’s unique traits and the study of emotions has revealed the physiological and psychological aspects of emotions.[23-24] Beliefs help to create attitude and hence enhance the personality of a person.[25] In order to make artificial agents capable of understanding human emotions we have to endow such agents with a suitable model of our emotions.[26] Hence it is of vital importance after so much development that emotions be implemented in a computer that will make it more advanced technologically.
II. Previous Work

In our previous work we provided a model for cyber personality. We will provide the diagram of the model here once more for better understanding of our pseudo-code that we have made in this paper.

![Design Model of the concept](image)

Figure 1. Design Model of the concept

Each of the blocks are separate modules used in our pseudo-code. The functions of each module have been defined in the pseudo-code. The algorithm has already been provided in the previous work.[27]

III. Pseudo-code

1. string s=i/p         [input statement]
2. feedback(s)         [function or module]
3. //In feedback(s)
4. t=0     //initialize
5. t=t+1
6. //In p_event(s),
7. str[]=s;         [store original string]
8. //In knowledge_base(s)
9. k=lang_db(s)                                               [function or module]
10. //In lang_db(s)
11. L=s.length
12. create char array A[L]
13. for i=0 to L
14. if A[i].equals ' '
15. c=c+1                                                          [c is initialized to 0 at the beginning]
16. L2=i                                                         [L2 is different from L]
17. if(c==1)                                                     [nested if loop]
18. for j=0 to L2
20. string s1=B[]                                               [function or module and end of nested if loop]
21. dict(s1)
22. else                                                       [nested else loop]
23. for j=m to L2
25. string s1=B[]                                               [end of nested else loop]
26. dict(s1)
27. m=L2                                                        [end of outer if loop]
28. // In dict(s1)
29. /*send the word to a dictionary software and extract different meanings of it and store them in an array*/
30. D[a]={array of meanings of the word}
31. return D[a]

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//In lang_db(s)
//store word and meanings in a 2-D array
E[i][j]={word with various meanings}

29. for i=0 to c
30. for j=0 to a
31. E[i][j]=D[a]
32. X_Bar(E[][]) and infer(B[],E[][]) [functions or modules]

33. //In X_Bar(*x,*y)
Let us take an input statement:
- Hi, how are you?
First using X-BAR THEORY:

After forming the X-BAR Tree, the meaning of constraints is carried out using E[i][j] to realize that the theme is “how” and it’s a question due to the presence of ‘?’ at the end.

34. Mark F[i][j] [position of each effective meaning as
1 rest 0]
35. We take P as “Hi”, Q as “how are” and R as “you”.
36. Now using Equivalence Laws: -
PV(Q&R) -> (PVQ)&(PVR) (Distributivity Law)
Let (PVQ) = S and (PVR) = D
Therefore,
PV(Q&R)->S&D
Using Inference Rules: -
PV(Q&R)->S (Since, P&Q->P ,Simplification Law)
This resultant is => S
Which means => PVQ?
This means resultant has “Hi” and “how are”.
37. for i=0 to c
38. for j=0 to a
39. if(F[i][j]==1) [F[][] is a 2D array containing
flag value 1 being correct meaning applied here for each word]
40. A1[i][j]=E[i][j] [end of if and both for loops]
41. return A1[][]
42. //In lang_db(s)
knowledge_base(A1[][]) [function call]
43. //In knowledge_base(A1[][])
for i=0 to c
    for j=0 to a
        if(A1[i][j]==H[i][j])                                        //compare with human nature
database
            g=i;
            h=j;
            hit=1;                                                   //hit initialized to 0
            break;                                                   //end of if loop
        if(hit==1) go to step 164
    else
        Boolean x=false
        for i=0 to c
            Y[i]=0                                                   //end of for loop
        infer(Y[],A1[][])
        feedback(x)                                               //function call
        and end of else loop
    if(X[1]=1)
        a1=1
        psych(a1,Z1[][])
    else
        a1=0
        psych(a1,Z1[][])
    if(a1==1)
        Z1[g][h]=H[g][h]                                           //here fixed values of g and h are
used
        return Z1[g][h]
    else
        i=j=0;
        count=0;                                                  //initialization
        while(H[i][j]!=NULL)
            i++;
            j++;
            count++;                                                //end of while loop
        H[i+1][j+1]=Z1[g][h]
        count++;                                                   //end of else loop
    persona(Z1[g][h])                                           //In infer(X[],Z1[][])
    memo(Z1[g][h])                                               //In persona(Z1[g][h])
    think(Z1[g][h])                                              //In memo(Z1[g][h])
    wisdom(Z1[g][h])                                            //another function or module
    a total of three functions or
    modules are called
    i=j=0;
    while(M[i][j]!=NULL)
        if(Z1[g][h]==M[i][j])
            hit=1;
            g=i;
            h=j;                                                   //end of if loop
        i++;
        j++;
        return M[g][h];                                          //end of while
    i=j=0;
    while(T[i][j]!=NULL)
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91. if(Z1[g][h] == T[i][j])
92.   hit = 1;
93.   g = i;
94.   h = j;       [end of if loop]
95.   i++;
96.   j++;
97.   return T[g][h];
98.   //In wisdom(Z1[g][h])

99. i = j = 0;
100. while(W[i][j] != NULL)
101.   if(Z1[g][h] == W[i][j])
102.     hit = 1;
103.     g = i;
104.     h = j;       [end of if loop]
105.     i++;
106.     j++;       [end of while loop]
107.   return W[g][h];
108.   /*In persona(Z2[g][h]) where returned array values from memo(Z1[g][h]), think(Z1[g][h])
109. and wisdom(Z1[g][h]) are received as Z2[g][h] because any one of the three will take a hit.*/
110. for i = 0 to count
111.   for j = 0 to count
112.     if(Z2[g][h] == P[i][j])
113.       hit = 1;
114.     else
115.       if(hit == 1)
116.         i = i;
117.         j = j;
118.         return P[i][j];       [end of if loop]
119.       else
120.         P[i+1][j+1] = Z2[g][h]
121.       return P[i+1][j+1];       [end of else loop]
122.   /*In infer(Y[],A1[][]) Z1[g][h] is received from psych(Z1[g][h]) and P[i1][j1] is received
123. from persona(Z1[g][h]).*/
124. for i = 0 to n
125.   for j = 0 to n
126.     if(Z1[g][h] == F1[i][j])
127.       k1 = i;
128.       k2 = j;
129.       break;       [end of inner if and outer for loops]
130.   for i = 0 to m
131.     for j = 0 to m
132.       if(P[i][j] == F2[i][j])
133.         k3 = i;
134.         k4 = j;
135.       break;       [end of if and outer for loops]
136.     for i = 0 to n1
137.       for j = 0 to n1
138.         if(Big[k1][k2][k3][k4] == Fuz[i][j][i1][j1])
139.           p1 = i;
140.           p2 = j;
141.           p3 = i1;
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141. p4=j1;
142. /*Take corresponding values of column 1 and column 2 of fuzzy table */
    new1=col1  [col1 is variable for column 1]
    new2=col2  [col2 is variable for column 2]
143. F3[new1][new2]  [end of inner if and all for loops]
144. if(capture==1)
145. trigger=1  [trigger is flag variable initialized to 0]
146. p_event(trigger)
147. persona(F3[n1][n2])  [end of if]
148. else
149. trigger=0  [end of else]
150. persona(F3[n1][n2])
151. W1[0][0]=F3[n1][n2]  [W1 has a predefined size of 1X1]
152. persona(A1[][])  [W2 has a predefined size of 1X1]
153. trigger=0;
154. persona(A1[][])  [W2 has a predefined size of 1X1]
155. mood(W1[0][0],W2[0][0])  [function or module]
156. //In mood(W1[0][0],W2[0][0])
157. lang_db(F3[new1][new2])  [function call]
158. //In lang_db(F3[x][y])
159. X_Bar(F3[x][y])  [function call]
160. D[a]={array of meanings of words}
161. return D[a];  [end of both for loops]
162. //In X_Bar(F3[x][y])
163. /*store words and meanings in a 2D array*/
164. F4[x][y]={new words and their various meanings}
165. for i=0 to c
166. for j=0 to a
167. F4[x][y]=D[a];  [end of both for loops]
168. Now the expression PVQ becomes P&Q as both are to be sent compulsorily together.

Thus we have -> P&Q
Figure 3. Output sample using X-BAR Theory

Here the “I am” or R is missing.
Thus using Inference Rules:
\[ P \& Q \]
\[ \neg(P \& R) \& Q \] \hspace{1cm} (P becomes P\&R Simplification rule used in reverse to bring in the missing link R)

Using Equivalence Laws:
\[ \neg P \& (\neg R \& Q) \] \hspace{1cm} (Associativity Law)

Now on replacing variables with constraints we get:
1. Hi, I am fine.
   (Note: ‘,’ is given after observing user’s format and “.” is given in place of “?”)
   Hence the user gets a suitable reply.

```c
for i=0 to c
for j=0 to a
if(G[i][j]==1)
    G1[i][j]=G[i][j]                                   [end of if and both for loops]
infer(C[],G1[][])                                          [function call]
feedback(C[])                                               [function call]
string s2=C[]                                               [convert array to string]
while(t>=t1)                                                  [t1 is a predefined fixed value]
send s2 as o/p
end of while loop
in knowledge_base(A1[][])
//in case of hit in step 45. */
boolean x=true;
feedback(x)                                                 [function call]
p_event(A1[][])                                             [function call]
//In p_event(A1[][]),
HMT[][]=A1[][]                                                 [store information]
infer(str[],A1[][]))                                        [function call]
//In infer(Y[],A1[][])
Z[][]=A1[][]                                                   [send prestored nature]
capture=1;                                                   [capture is initialized to 0]
//In knowledge_base(A1[][])
for i=0 to c
Y[i]=0;                                                     [end of if loop]
infer(Y[],A1[][]))                                          [function call]
```
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Repeat steps 57 to 180. /*except steps where new query or array is created as there will be a hit in each search case. */

IV. Fuzzy Tables

### Fuzzy Table 1

<table>
<thead>
<tr>
<th>Emotion(i/j)</th>
<th>Value Assigned</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excited</td>
<td>0</td>
</tr>
<tr>
<td>Tender</td>
<td>1</td>
</tr>
<tr>
<td>Scared</td>
<td>2</td>
</tr>
<tr>
<td>Angry</td>
<td>3</td>
</tr>
<tr>
<td>Sad</td>
<td>4</td>
</tr>
<tr>
<td>Happy</td>
<td>5</td>
</tr>
</tbody>
</table>

### Fuzzy Table 2

<table>
<thead>
<tr>
<th>Human Nature (i1/j1)</th>
<th>True</th>
<th>False</th>
<th>Reverse (False Case)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extraverted</td>
<td>0</td>
<td>1</td>
<td>Introverted</td>
</tr>
<tr>
<td>Sensing</td>
<td>2</td>
<td>3</td>
<td>Intuitive</td>
</tr>
<tr>
<td>Thinking</td>
<td>4</td>
<td>5</td>
<td>Feeling</td>
</tr>
<tr>
<td>Judging</td>
<td>6</td>
<td>7</td>
<td>Perceiving</td>
</tr>
</tbody>
</table>

### Fuzzy Table 3

<table>
<thead>
<tr>
<th>Serial No.</th>
<th>P1 (i)</th>
<th>P2 (i)</th>
<th>P3 (ii)</th>
<th>P4 (j1)</th>
<th>Col1</th>
<th>Col2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>5</td>
<td>4</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>6</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>7</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>8</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>9</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>10</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>11</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>12</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>13</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>14</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>15</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>16</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

...
The Fuzzy Table 4 has no specific dimensions has number of categories in which different emotions can be categorized is still under research as further developments are being found.

V. Implementation

The partial implementation was done taking the emotional responses of a particular person. We then tested the implemented responses with one of his close friends who knew him well to take results for comparison. The snapshots of our code with input and output are given below:

1. Code Samples:

   ![Figure 4. Sample Of Code](image)

   ![Figure 5. Another Sample Of Code](image)
2. **Test Samples**:

   ![Figure 6. Test 1](image1)

   ![Figure 7. Test 2](image2)

   ![Figure 8. Test 3](image3)

   **VI. Results**

   We have taken the data and compared it with actual results of that particular person.

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1. Test 1:-

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Emotions</td>
<td>Computer Value</td>
<td>Human Value</td>
</tr>
<tr>
<td>2</td>
<td>Anger</td>
<td>19.607843</td>
<td>10</td>
</tr>
<tr>
<td>3</td>
<td>Joy</td>
<td>18.627451</td>
<td>35</td>
</tr>
<tr>
<td>4</td>
<td>Fear</td>
<td>17.647058</td>
<td>10</td>
</tr>
<tr>
<td>5</td>
<td>Depression</td>
<td>19.607843</td>
<td>10</td>
</tr>
<tr>
<td>6</td>
<td>Surprise</td>
<td>24.509804</td>
<td>35</td>
</tr>
</tbody>
</table>

Figure 9. Data Set 1

Figure 10. Column Chart 1

Figure 11. Line Chart 1

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2. Test 2:-

<table>
<thead>
<tr>
<th></th>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td>Emotions</td>
<td>Computer Value</td>
<td>Human Value</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>Anger</td>
<td>21.296297</td>
<td>30</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>Joy</td>
<td>16.66666</td>
<td>10</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>Fear</td>
<td>19.44444</td>
<td>10</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>Depression</td>
<td>18.518518</td>
<td>20</td>
</tr>
<tr>
<td>6</td>
<td></td>
<td>Surprise</td>
<td>24.074074</td>
<td>30</td>
</tr>
</tbody>
</table>

Figure 12. Data Set 2

Figure 13. Column Chart 2

Figure 14. Line Chart 2
3. Test 3:-

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emotions</td>
<td>Computer Value</td>
<td>Human Value</td>
</tr>
<tr>
<td>2</td>
<td>Anger</td>
<td>25</td>
</tr>
<tr>
<td>3</td>
<td>Joy</td>
<td>15.000001</td>
</tr>
<tr>
<td>4</td>
<td>Fear</td>
<td>11</td>
</tr>
<tr>
<td>5</td>
<td>Depression</td>
<td>23</td>
</tr>
<tr>
<td>6</td>
<td>Surprise</td>
<td>26</td>
</tr>
</tbody>
</table>

Figure 15. Data Set 3

Figure 16. Column Chart 3

Figure 17. Line Chart 3
VII. Conclusion

We can observe that the first test could not give much expected results. However the second and third tests have shown improved results and the program results are quite close to the human results. The advantage of this work is that this test proves that emotions can be implemented in computers and that it is also feasible. One limitation of this implementation remains that only one word was considered for analyzing the emotions. Further research is required to use complete sentences for the purpose. This work has huge possibilities in the near future. Computers with emotions can be used to create more efficient robots. This concept can also be used in modern warfare to create super soldiers. Machines with intelligence not only logical but also emotional can be used in security purpose, daily life task performing robots and so on. The most important thing is that simple existing tools are enough to implement this concept and this can also be made platform independent if developed further.

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Journal Papers: