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BT20ECE075
LAB-08

I. Aim:

Determining error correction capability of given (n,k) code using Hamming bound.

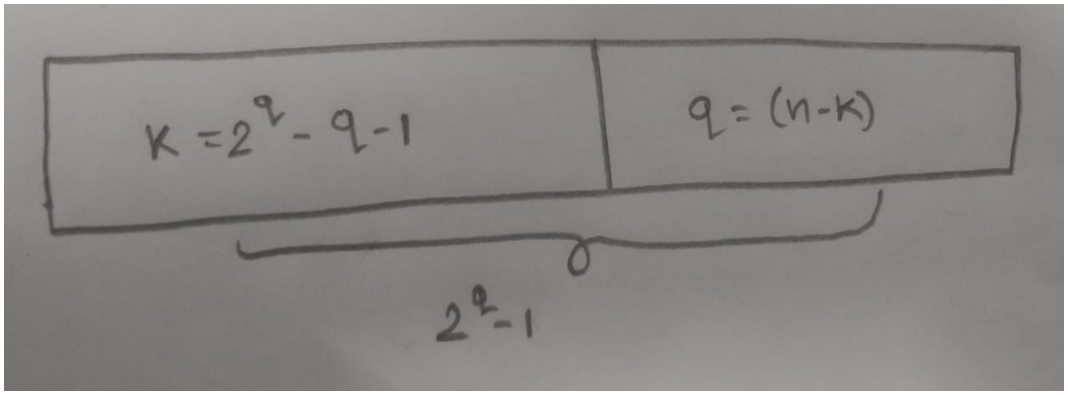
II. Software Required:

Matlab;

III. Theory:

Hamming Code: The Hamming code is a single error correction linear block code with (n, k) $= (2^m - 1, 2^m - 1 - m)$
$2^r m + r + 1 where, r = redundant bit, m = data bit$

where m = n k is the number of check bits in the codeword.
The simplest non-trivial code is for m = 3, which is the (7, 4) Hamming code.
The generator matrix of the Hamming code has dimension k × n and is of the form
G = [Ik×k S] .
For this Hamming code, S has one row for each possible m-bit string with weight at least 2.
There are exactly k = 2m m 1 such strings. Any Hamming code is a 1-error correcting code as the two conditions above are satisfied.



Hamming code is an error correction system that can detect and correct errors when data is stored or trans- mitted. It requires adding additional parity bits with the data. It is commonly used in error correction code (ECC). Hamming code uses a block parity mechanism. The data is divided into blocks, and parity is added to the block. Hamming code can correct single-bit errors and detect the presence of two-bit errors in a data block.

Binary single error correcting perfect codes are called Hamming codes.
Consider (n, k) linear block code that has following parameters

- Block length n = 2q - 1
- Number of message bits k = 2q – q - 1

- Number of parity bits q = (n-k)
- Where q 3.

This code is called Hamming code.

IV. Matlab Code

By Linear Code Method:

```
clc;
%Taking inputs of codeword length,messgebits,generator and Message matrix
n=input('Enter codeword length\n');
k=input('Enter No of msg bits\n');
G=input('Enter Generator matrix\n');
q=n-k;
if k==2^q-q-1 && n==2^q-1
      for i = 1 : 2^k     % Iterate through Vector with Specified Increment
          for j = k : -1 : 1
              if rem(i - 1, 2 ^ (-j + k + 1)) >= 2 ^ (-j + k)
                  M(i, j) = 1;
              else
                  M(i, j) = 0;
              end
          end
      end
      disp('Message matrix');
      disp(M);  %Generating Parity Matrix using generator matrix
      P=G(:,k+1:n);
      disp('Parity matrix');
      disp(P);
      c=mod(M*P, 2);%c=mp
      disp('Code words vector');%displaying Codewords
      disp(c);
      weight = zeros(2^k,1);
      for i=1:2^k
           for j=1:k
              if M(i,j) == 1
                 weight(i) = weight(i) + 1;
              end
           end
      end
      for i=1:2^k
           for j=1:n-k
               if c(i,j) == 1
                 weight(i) = weight(i) + 1;
               end
           end
      end
      sort(weight);%Finding minimum no of ones
      dmin=weight(2);
      disp('Minimum weight(dmin):');
      disp(dmin);%error Detection,correction
      ed=dmin-1;ec=ed/2;
      disp('Error Detection:');disp(ed);
      disp('Error Correction:');disp(ec);
else
    disp('It is not a Hamming code');
end
```

By Normal Method:

```
clc;
n=input('énter the code word length : n :');
k=input('énter the message bits: k :');
m=n-k ;
z=2^m ;
i=0;
for j=0:1:n
    sum=0;
    for i=0:1:j
        c=factorial(n)/(factorial(n-1)*factorial(i));
        sum=sum+c;
    end
    if sum >= zj=j-1;
        sum=sum-c;
        break;

    end
end
op = sprintf('(%d,%d) can correct all combinations of %d errors and it can also correct↙
%d combinations of %d errors', n,k,j,z-sum,j+1);
disp(op);
```

V. Code Explanation:

VI. Matlab Outputs:

By Linear Code Method:
We Use (7,4)Linear Block Code as Hamming Code

```
Enter codeword length
7
Enter No of msg bits
4
Enter Generator matrix
[1 0 0 0 1 1 1;0 1 0 0 1 1 0;0 0 1 0 1 0 1;0 0 0 1 0 1 1];
Message matrix
     0     0     0     0
     0     0     0     1
     0     0     1     0
     0     0     1     1
     0     1     0     0
     0     1     0     1
     0     1     1     0
     0     1     1     1
     1     0     0     0
     1     0     0     1
     1     0     1     0
     1     0     1     1
     1     1     0     0
     1     1     0     1
     1     1     1     0
     1     1     1     1

Parity matrix
     1     1     1
     1     1     0
     1     0     1
     0     1     1

Code words vector
     0     0     0
     0     1     1
     1     0     1
     1     1     0
     1     1     0
     1     0     1
     0     1     1
     0     0     0
     1     1     1
     1     0     0
     0     1     0
     0     0     1
     0     0     1
     0     1     0
     1     0     0
     1     1     1

Minimum weight(dmin):
     3
```

```
MATLAB Command Window


Error Detection:
     2

Error Correction:
     1

>> HammingCode
Enter codeword length
6
Enter No of msg bits
3
Enter Generator matrix
[1 0 0 0 1 1;0 1 0 1 0 1;0 0 1 1 1 0]
It is not a Hamming code
>>
```

By Normal Method:
We Use Different Hamming Codes With Minimum length of 3.

```
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énter the code word length : n :3
énter the message bits: k :8
(3,8) can correct all combinations of -1 errors and it can also correct 3.125000e-02↙
combinations of 0 errors
>> Hammingcodeerrorcorrection
énter the code word length : n :4
énter the message bits: k :77
(4,77) can correct all combinations of -1 errors and it can also correct 1.058791e-22↙
combinations of 0 errors
>> Hammingcodeerrorcorrection
énter the code word length : n :5
énter the message bits: k :4
(5,4) can correct all combinations of -1 errors and it can also correct 2 combinations↙
of 0 errors
>> Hammingcodeerrorcorrection
énter the code word length : n :8
énter the message bits: k :2
(8,2) can correct all combinations of 8 errors and it can also correct 4.225377e+01↙
combinations of 9 errors
>>
```

VII. Conclusion:

We Successfully Determined the error correction capability of given (n,k) code using Hamming bound on Matlab