VOLUME X
ISBN No.: 978-81-953602-6-0
Physical Science

Estd. 1957

# NALLAMUTHU GOUNDER MAHALINGAM COLLEGE

An Autonomous Institution, Affiliated to Bharathiar University, An ISO 9001:2015 Certified Institution,

Pollachi-642001

## SUPPORTED BY

Computer Society of India ESTD. 1965

Riyasaa Labs

Sakthi as pure as mother's love

ABT Industries Ltd.,
Dairy Division

## PROCEEDING

One day International Conference

EMERGING TRENDS IN SCIENCE AND TECHNOLOGY (ETIST-2021)

27th October 2021

Jointly Organized by

Department of Biological Science, Physical Science and Computational Science

# NALLAMUTHU GOUNDER MAHALINGAM COLLEGE

An Autonomous Institution, Affiliated to Bharathiar University

An ISO 9001:2015 Certified Institution, Pollachi-642001.

Estd. 1957

Proceeding of the

One day International Conference on

EMERGING TRENDS IN SCIENCE AND TECHNOLOGY (ETIST-2021)

27th October 2021

Jointly Organized by

Department of Biological Science, Physical Science and Computational Science

Copyright © 2021 by Nallamuthu Gounder Mahalingam College

All Rights Reserved

ISBN No: 978-81-953602-6-0

978- 81- 953602- 6- 0

Nallamuthu Gounder Mahalingam College

An Autonomous Institution, Affiliated to Bharathiar University

An ISO 9001:2015 Certified Institution, 90 Palghat Road, Pollachi-642001.

www.ngmc.org

## ABOUT THE INSTITUTION

A nations's growth is in proportion to education and intelligence spread among the masses. Having this idealistic vision, two great philanthropists late. S.P. Nallamuthu Gounder and Late. Arutchelver Padmabhushan Dr.N.Mahalingam formed an organization called Pollachi Kalvi Kazhagam, which started NGM College in 1957, to impart holistic education with an objective to cater to the higher educational needs of those who wish to aspire for excellence in knowledge and values. The College has achieved greater academic distinctions with the introduction of autonomous system from the academic year 1987-88. The college has been Re-Accredited by NAAC and it is ISO 9001 : 2015 Certified Institution. The total student strength is around 6000. Having celebrated its Diamond Jubilee in 2017, the college has blossomed into a premier Post-Graduate and Research Institution, offering 26 UG, 12 PG, 13 M.Phil and 10 Ph.D Programmes, apart from Diploma and Certificate Courses. The college has been ranked within Top 100 (72nd Rank) in India by NIRF 2021.

## ABOUT CONFERENCE

The International conference on “Emerging Trends in Science and Technology (ETIST-2021)” is being jointly organized by Departments of Biological Science, Physical Science and Computational Science - Nallamuthu Gounder Mahalingam College, Pollachi along with ISTE, CSI, IETE, IEE & RIYASA LABS on 27th OCT 2021. The Conference will provide common platform for faculties, research scholars, industrialists to exchange and discus the innovative ideas and will promote to work in interdisciplinary mode.

## EDITORIAL BOARD

**Dr. V. Inthumathi**

Associate Professor & Head, Dept. of Mathematics, NGM College

**Dr. J. Jayasudha**

Assistant Professor, Dept. of Mathematics, NGM College

**Dr. R. Santhi**

Assistant Professor, Dept. of Mathematics, NGM College

**Dr. V. Chitra**

Assistant Professor, Dept. of Mathematics, NGM College

**Dr. S. Sivasankar**

Assistant Professor, Dept. of Mathematics, NGM College

**Dr. S. Kaleeswari**

Assistant Professor, Dept. of Mathematics, NGM College

**Dr. N.Selvanayaki**

Assistant Professor, Dept. of Mathematics, NGM College

**Dr. M. Maheswari**

Assistant Professor, Dept. of Mathematics, NGM College

**Mrs. A. Gnanasoundari**

Assistant Professor, Dept. of Mathematics, NGM College

**Dr. A.G. Kannan**

Assistant Professor, Dept. of Physics, NGM College

# Exemplification of a MATLAB program to certain aspects of fuzzy codewords in fuzzy logic

**A. Neeraja [1] – Dr. B. Amudhambigai [2] – Dr. V. Chitra[3]**

**©NGMC 2021**

**ABSTRACT:** It is natural to disguise a message of utmost secrecy such that only the sender and receciver can read the hidden message. The problem arises when there is a disruption that can alter the original message. This alteration is detected and corrected with the aid of computing the Fuzzy Hamming Distance between codewords and Fuzzy Hamming Weight of a codeword, But still manual computation has limitations and it is not possible to compute the above menntioned parameters by hand as it is time consuming. Thus a MATLAB program has been elaborated in this article which determines the Fuzzy Hamming Distance between codewords and Fuzzy Hamming Weight of a codeword instantaneously thereby saving a lot of time.

**Keywords:** Supply few keywords related to your work. All the keywords must be separated by comma.

## 1. INTRODUCTION

Transmission and receival of messages through various channels plays a major role in communication. Communication can be achieved through various mediums. The study of such forms and modes of communication were proposed by Shannon [3] that was later established in several works [8, 9, 11-15] . Whenever the original message is changed due to errors, a new message is received by the receiver. This new message leads to miscommunication as this was not intended to be sent which recovers the original codeword with the aid of Hamming Distance. This concept is now combined with Fuzzy Logic proposed by Zadeh [16], which opens up the additional advantage of having accurate degree of association of each codeword with the others. This accuracy is achieved by using the notion of fuzzy logic as proposed in [1]. MATLAB is a programming language that has its utilisation in almost all branches of Science and Technology. It reduces complex problems to the most simplest form and provides accurate results thereby saving lots of energy and time. This paper is organized as follows. Section -1 consists of Introduction and Section-2 consists of the Preliminaries and the notion of fuzzy hamming ball together with it's properties are also introduced in this section. In Section -3, a simple Matlab program is given which

First Author*[1], Department, University/Institute/Company, City, State, Country. E-mail:xyz@gmail.com
Second Author*[2], Department, University/Institute/Company, City, State, Country. E-mail:xyz@gmail.com

computes the fuzzy hamming weight, fuzzy hamming distance between two codewords and finally conclusions are given.

**2. PRELIMINARIES**

In this section, the basic preliminaries required for the study are given. Throughout this paper $\lfloor C \rfloor$ represents the largest integer less than or equal to $C$.

**Definition 2.1** [1] A q-ary code is a set of sequences of symbols where each symbol is chosen from a set $F_q=\{\lambda_1,\lambda_2,...,\lambda_q\}$ of q distinct elements where $F$ denotes a finite field.

**Definition 2.2** [1] A *Binary Code* is a sequences of $0_s$ and $1_s$ which are called codewords.

**Definition 2.3** [1] For a finite field $F$, let ($F_q^n$) denote the set of all ordered n-tuples a=$a_1, a_2, \dots a_n$ where each $a_i \in F_q$. The elements of $F_q^n$ are called *vectors or words*

**Definition 2.4** [1] For a finite field $F$, the weight w(x) of a vector x in $F_2^n$ is defined to be the number of non-zero entries of x.

**Definition 2.5** [1] If $w_1, w_2, \dots, w_k$ are defined to be the positions of $1_s$ in a codeword $C$, then $w_1 + w_2 + \dots + w_k$ are called relative weight of codeword $C$. If 11...1 is a codeword of length *n*, then its relative weight is

$$1 + 2 + \dots + n = \frac{n(n+1)}{2}$$

This weight is called the $\mathit{maximum\ relative\ weight}$ of code $C$ .

**Definition 2.6** [1] The $\mathit{relativeweight}$ of a codeword $C$ in $(F_2)^n$ is denoted by

$$J(C) = \frac{\mathrm{w}(C)}{\mathit{maximum\ \ relative\ \ weight}}$$

**Definition 2.7** [6] The *Exclusive Or* is a basic computer operation denoted by XOR or $\oplus$, which takes two individual bits $\beta \in \{0,1\}$ and $\beta' \in \{0,1\}$ and yields

$$\beta \oplus \beta' = \begin{cases} 0 & \mathit{if}\ \ \beta\ \ \mathit{and}\ \ \beta'\ \ \mathit{are}\ \ \mathit{same} \\ 1 & \mathit{if}\ \ \beta\ \ \mathit{and}\ \ \beta'\ \ \mathit{are}\ \ \mathit{different} \end{cases}$$

**Definition 2.8** [7] Let $\mathfrak{C}$ be a code and {C $_1$, C $_2$,…, C $_m$} be the collection of codewords having the same or different lengths in $\mathfrak{C}$. The fuzzy hamming weight of any codeword C $_l$ in $\mathfrak{C}$ where 1 ≤ l ≤ m in (denoted by $\mathcal{FHW}$(C $_l$)) is defined as the function from {C $_1$,C $_2$,...,C $_m$} to I = [0, 1] and it is expressed as $\frac{p}{q}$ ($q \neq 0$), where *p* represents the number of non-zero entries of the codeword C $_l$ of $\mathfrak{C}$ and *q* represents the maximum relative weight of the same codeword C $_l$ of $\mathfrak{C}$ (l = 1, 2, ..., m).

**Definition 2.9** [7] Let $\mathfrak{C}$ be a code and {C $_1$, C $_2$ ,…, C $_m$} be the collection of codewords in $\mathfrak{C}$ where each codeword is of the same length . The fuzzy hamming distance between two codewords C $_i$ and C $_j$ in $\mathfrak{C}$ where 1 ≤ i, j ≤ m (denoted by $\mathcal{FHD}$(C $_i$, C $_j$) is defined as the function from {C $_1$,C $_2$,...,C $_m$} to I = [0, 1] and it is expressed as $\frac{p}{q}$ ($q \neq 0$), where *p* represents the number of vectors by which the two codewords C $_i$ and C $_j$ in $\mathfrak{C}$ (1 ≤ i, j ≤ m) differ and *q* represents the maximum relative weight of the codewords C $_i$ and C $_j$ in $\mathfrak{C}$ (1 ≤ i, j ≤ m).

**Proposition 2.10** [7] Let $\mathfrak{C}$ be a code and $\{C_1, C_2, \ldots, C_m\}$ be the collection of codewords in $\mathfrak{C}$ where each codeword is of the same length. Then for any three codewords $C_i, C_j, C_k$ in $\mathfrak{C}$ (where $i \neq j \neq k$, $i, j, k = 1,2,\ldots,m$), the fuzzy hamming distance ($\mathcal{FHD}$) between every pair of codewords in $\mathfrak{C}$ satisfies the triangle inequality

$$\mathcal{FHD}(C_i, C_k) \leq \mathcal{FHD}(C_i, C_j) + \mathcal{FHD}(C_j, C_k).$$

**Remark 2.11** [7] Let $\mathfrak{C}$ be a code and $\{C_1, C_2, \ldots, C_m\}$ be the collection of codewords in $\mathfrak{C}$ where each codeword is of the same length. Then, for any two codewords $C_i$ and $C_j$ in $\mathfrak{C}$ $(1 \leq i, j \leq n)$, $\mathcal{FHD}(C_i, C_j) = \mathcal{FHW}(C_i \oplus C_j)$.

## *2.1 Fuzzy hamming ball and it's properties*

**Definition 2.12** Let $\mathfrak{C}$ be a code and $\{C_1, C_2, \ldots, C_m\}$ be the collection of codewords in $\mathfrak{C}$ where each codeword is of the same length. The fuzzy hamming ball with radius $\frac{p}{q}$ $\left(\text{denoted by } \mathcal{FHB}\left(C_i, \frac{p}{q}\right)\right)$ centered around $C_i \in \{0, 1\}$ ia function from $\{C_1, C_2, \ldots, C_m\}$ to $I = [0, 1]$ and it is defined as the collection of codewords $\{C_j\}_{j=1}^{m}$ for which $\mathcal{FHD}(C_i, C_j) \leq \frac{p}{q}$.

**Notation 2.1** A code $\mathfrak{C}$ of legth *n* having M number of codewords and with minimum fuzzy hamming distance say $\frac{p}{q}$ is denoted by $\left(n, M, \frac{p}{q}\right)$.

**Proposition 2.13** Let $\mathfrak{C}$ be a $\left(n, M, \frac{p}{q}\right)$ code such that the minimum fuzzy hamming distance $\frac{p}{q} = \frac{2e+1}{q}$. Then $\mathfrak{C}$ can correct $\frac{e}{q}$ errors and $\mathfrak{C}$ can detect $\frac{2e}{q}$ errors.

**Remark 2.14** From Proposition 2.6, it is clear that $\mathfrak{C}$ can correct $\left\lfloor\frac{p-1}{2q}\right\rfloor$ errors and can detect $\frac{p-1}{q}$ errors.

**Proposition 2.15** Let $\mathfrak{C}$ be a $(n, M, \frac{p}{q})$ code such that the minimum fuzzy hamming distance $\frac{p}{q} = \frac{2e}{q}$. Then $\mathfrak{C}$ can correct $\frac{e-1}{q}$ errors and simultaneously detect $\frac{e}{q}$ errors.

## *2.2 MATLAB Program*

In this section a simple MATLAB program is framed, which computes the fuzzy hamming weight and fuzzy hamming distance between two codewords along with an example. The manual method of computing the fuzzy hamming weight and fuzzy hamming distance can be used whenever the length of the codewords are small. But if the length increases it is not possible to compute these quantities as they are cumbersome. Having this in mind this MATLAB program has been developed which simplifies the effort and time required in manual computation. The program is framed with the aid of a function file in MATLAB. This function file retains the formula for finding $\mathcal{FHW}$ of a codeword and $\mathcal{FHD}$ between two codewords and whenever necessary this file can be used by just giving the bits in the two codewords whose Fuzzy Hamming Weight and Fuzzy Hamming Distance must be find out. The program in the Function File of MATLAB is as follows:

```
function [ h , g , a ] = hammingweight (n , x , y )  % The syntax of the function file
n = (n*(n+1) ) / 2 ;       % Formula for finding the Maximum Relative Weight
h = (nnz (x==1)) /n;       % Computes FHW of the First Codeword
g = (nnz (y==1)) /n;       % Computes FHW of the Second Codeword
b = [x ; y ] ;             % Combines the two vectors as a single matrix
a = nnz (b (1 , : ) ~=b ( 2 , : ) ) /n ; % Computes FHD between the Codewords
end
```

Again in the command window, the two codewords are given as follows:

>> x = [$a_1$ $a_2$ ... $a_n$];

>> y = [$b_1$ $b_2$ ... $b_n$]; [The codewords are given as separate vectors]

>> n = The length of codewords;

>> format rat [**formatrat** displays fractional output]

>> [Output variables] = functionfile name(n,x,y)

The function file is called after specifying the inputs.

*Example*

For example, if the collection of two codewords whose Fuzzy Hamming Weight and Fuzzy Hamming Distance are to be computed are 1001 and 1101, then they are given in the command window as follows:

>> x = [1 0 0 1 1 1 0 0 1 1 1 0 0 0 0 1 0 1 1 1 0 1 0 1 0 1 0 1 0 1 1 0 1 0 1 0 1 1 0 1 0 0 1 1 0 1 1 0 1 1];

>> y = [1 1 1 1 0 1 1 0 0 1 1 0 1 0 1 1 1 0 1 0 1 1 0 0 0 1 1 0 1 1 1 0 1 1 0 1 0 1 0 1 0 1 1 0 1 0 1 1 0 0];

>> n = 50;

>> format rat

>> [h,g, a] = FHD(n,x,y)

The following output is now obtained

h =

28/1275

g =

2/85

a =

26/1275

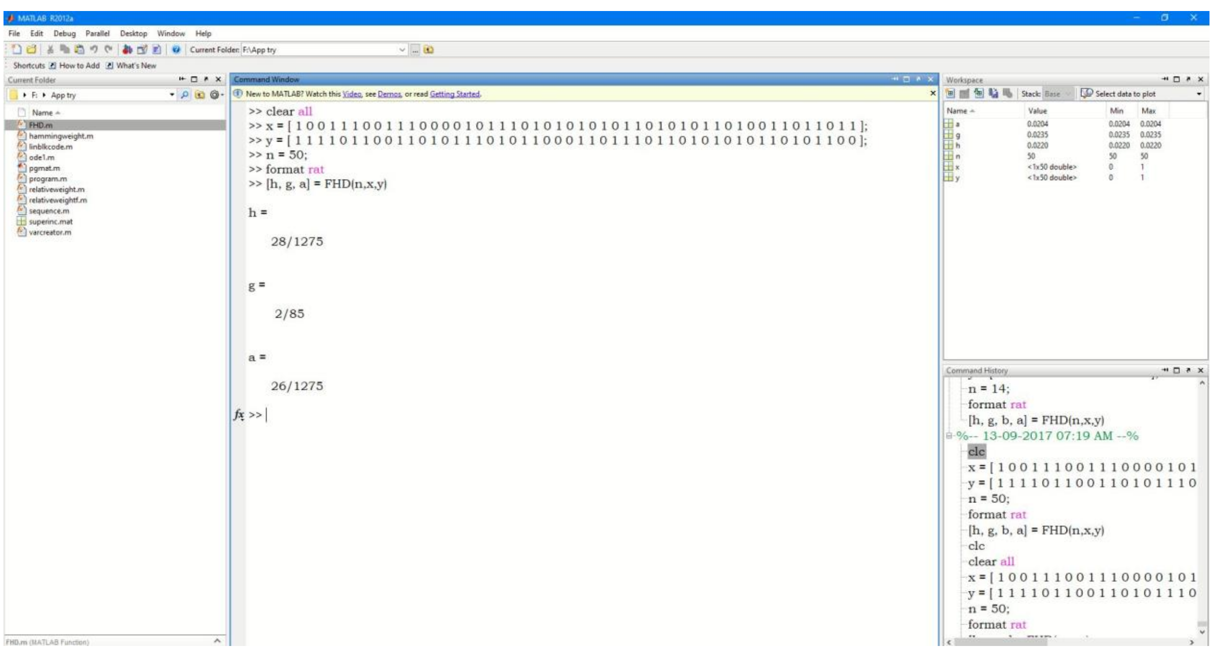


**Fig 1: Computation of Fuzzy Hamming Weight and Fuzzy Hamming Distance Using MATLAB**

## 3. RESULTS & DISCUSSION

From Figure 1, we can see that even for the codewords of length 50 the MATLAB program that has been developed has computed the fuzzy hamming weight and fuzzy hamming distance immediately. The same computation can take a longer time while computed manually and as the length of the codewords increases it is possible that manual computation can go wrong at few places unintentionally. Another advantage of this program is that it can be extended to even for codewords of still higher length say 100, 1000 and so on. Thus, this program can be used to compute the fuzzy hamming weight of codewords and fuzzy hamming distance between two codewords in a matter of few seconds thereby saving us a lots and lots of time.

## 4. CONCLUSION

It is always a truth that whenever people are presented with varied options to choose, they end up choosing the best and when they are given several methods they search for the most easiest method to get their work done faster. Finding a method that is both best and the easiest will save us from lots of time for which an attempt has been done in this paper.

## REFERENCES

[1] Ayten Ozkan and E. Mehmet Ozkan. *A Different Approach to Coding theory*. Pakistan Journal of Applied Sciences, 2002 2(11):1032-1033,.

[2] Brian R. Hunt, Ronald L. Lipsman and Jonathan M. Rosenberg. *A Guide to MATLAB: For Beginners and Experienced Users*. Cambridge University Press, 3rd edition, 2014..

[3] Claude E. Shannon. *A Mathematical Theory of Commuincation*. Bell System Technical Journal , 1948, 27:379-423, 623-656.

[4] David Houcque. *Introduction to MATLAB for Engineering Students*. Northwestern University, August 2005.

[5] George J. Klir and Bo Yuan. *Fuzzy Sets and Fuzzy Logic: Theory and Applications*. Prentice-Hall, INc. New Jersey, 1995.

[6] Jeffrey Hoffstein, Jill Pipher and Joseph H. Silverman. *An Introduction to Mathematical Cryptography*. Springer, 2008.

[7] Neeraja A., Amudhambigai B., A Novel Way of Detecting and Correcting Transmitted Errors using Fuzzy Logic, - *Journal of Physics: IOP Conference Series*, 2021.

[8] Ranjan Bose, *Information Thoery, Coding Theory and Cryptography*, McGraw Hill Education (India) Pvt. Ltd., 2008.

[9] Richard W. Hamming. *Error Detecting and Error Correcting Codes*. Bell System Technical Journal, 29:147, April 1950.

[10] Rudra Pratap. *Getting Started with MATLAB*. New York. Oxford University Press. 2010.

[11] Sarah Spence Adams, *Introduction to Algebraic Coding Theory*, Jan 11, 2008.

[12] Venkatesan Guruswami, Alexander Vardy. *Maximum-Likelihood Decoding of Reed-Solomon Codes is NP-hard*. November 30, 2004.

[13] Venkatesan Guruswami, Atri Rudra, Madhu Sudan. *Essential Coding Theory*. March 15, 2019.

[14] Wade Trappe, Lawrence C. Washington *Introduction to Cryptography with Coding Theory*, Second edition, Pearson Education, Inc. 2006.

[15] Yehuda Lindell, *Introduction to Algebraic Coding Theory Lecture Notes*, Jan 25, 2010.

[16] Zadeh, L.A. *Fuzzy Sets*. Inform. Control, 1965, 8 ,338-353.

[17] *Introduction to Finite Fields*. Graduate Institute of Communication Engineering, 2015.

BIOGRAPHY

**A. Neeraja,** M.Sc., M.Phil., is a research scholar in Mathematics in Sri Sarada College for Women(Autonomous), Salem, Tamilnadu, India. She is currently pursuing her research in the field of fuzzy coding theory. She has published a few articles in the areas of fuzzy coding theory and mathematical modeling using fuzzy logic.

**Dr. B. Amudhambigai**, M.Sc., MPhil, Ph.D is working as an Assistant Professor in Mathematics at Sri Sarada College for Women(Autonomous), Salem, Tamilnadu, India. She has published several articles in many reputed journals and guiding M.Phil and Ph.D students. Her research area includes fuzzy coding theory and Mathematical Modeling.

**Dr. V. Chitra**, M.Sc., M.Phil., Ph.D., B.Ed., is working as an Assistant Professor in Mathematics at NGM College, Pollachi. She has guided several M.Phil scholars and her research areas include Topology, Fluid dynamics and Complex analysis. She has completed one UGC minor project in the year 2012.