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General Fuzzy mathematical expression for carrier of a genetic disorder

VIJAYKUMAR N. JOSHI[1]

[1]Ph.D. SUNY Stony Brook USA, Retired Prof. of Computer Science from University of Mumbai (India)
Corresponding Author : e-mail: vnjoshig@gmail.com
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Abstract

In this paper a general fuzzy mathematical model for any genetic disorder is proposed.

A genetic disorder is caused in whole or in part by a change in the DNA sequence away from the normal sequence. A gene is associated with the disorder, e.g. FXN gene is associated with Friedreich's Ataxia, PRKN with Parkinson's disease, *APOE* with Alzheimer disease, HOXB with Breast and Prostate carcinoma etc.. We have attempted to present a carrier model of disorder based on fuzziness factor.

Key words : Fuzzy logic, percentage defect in a gene, gene status
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1 Introduction

To have an autosomal recessive disorder, two mutated genes are inherited, one from each parent. These disorders are usually passed on by two carriers. Their health is rarely affected, but they have one mutated gene (**recessive** gene) and one normal gene (dominant gene) for the condition.

It has been computed that Children of carrier parents have a 25% chance of inheriting two altered genes and developing the disease. These calculations are based on a two-point mathematical models[1] by considering that the gene is either normal or diseased. What we want to emphasize is that between normal and a diseased status of a gene there can be various states of its being abnormal. These different states are not accommodated in a two-point models. We want to therefore, propose a Fuzzy mathematical model taking in to consideration the intermediate states using a membership function[2,3] μ .

We shall proceed as follows. First we shall define a fuzzy status of a single gene in terms of a membership function. Since a paired genes exist in a person, we next define a status of a paired genes. Now taking a paired genes from Dad and a paired genes from Mom we present an expression for a carrier of a genetic trait or of a disease.

2 Fuzzy definition for a single gene-status :

Let X be a Random variable : {defective percentage of a Gene} and

Let U_x denote the Univese of discourse of X : $\{0 \le x \le 100\} = \{0 \le y \le 1\}$ where $y = \frac{x}{100}$.

Let $\mu(y)$ be a continuous membership function. Then the set

$$G_y = \{(y, \mu(y)) \mid y \in U_x\}$$

is a Fuzzy set[2] associated with the given Gene.

Now $g(y) = \begin{cases} 0 & if\, y = 0 \\ Gy & 0 < y < 1 \\ 1 & if\, y = 1 \end{cases}$

can be defined as a Fuzzy definition for the gene-status. The g(0) represents the Normal gene, g(1) represents diseased gene whereas G_y represents a spectrum of intermediate states of the gene.

3 Fuzzy Definition for a paired gene-status :

It is known that a paired genes exist in each person for a given trait[4]. We, therefore, consider a paired-gene and develop its status g_{12} by using the status definition of a single gene and the mean as the best common measure.

$g_{12}(y) = g_1(y) : g_2(y)$ where $y \in U_x$

$$g_1(y) = \begin{cases} 0 & if\, y = 0 \\ G_y^1 & 0 < y < 1 \\ 1 & if\, y = 1 \end{cases} \qquad G_y^1 = \{(y, \mu_1(y)) \mid y \in U_x\}$$

$$g_2(y) = \begin{cases} 0 & if\, y = 0 \\ G_y^2 & 0 < y < 1 \\ 1 & if\, y = 1 \end{cases} \qquad G_y^2 = \{(y, \mu_2(y)) \mid y \in U_x\}$$

and

$$g_{12}(y) = \begin{cases} 0 & if\, y = 0 \\ G_y^{12} = G_y^1 : G_y^2 & 0 < y < 1 \\ 1 & if\, y = 1 \end{cases}$$

where

$$G_y^{12} = G_y^1 : G_y^2 = \{(y, [\mu_1(y) + \mu_2(y)]/2) \mid y \in U_x\}.$$

4 Inheritance :

Let $g_{12}(y)$ be a paired gene-status of Dad and similarly $g_{34}(y)$ be a paired gene-status of Mom where, in usual notation,

$$g_{34}(y) = \begin{cases} 0 & if\, y = 0 \\ G_y^{34} = G_y^3 : G_y^4 & 0 < y < 1 \\ 1 & if\, y = 1 \end{cases}$$

where

$$G_y^{34} = G_y^3 : G_y^4 = \{(y, [\mu_3(y) + \mu_4(y)]/2) \mid y \in U_x\}.$$

Then for $0 < y < 1$, we define the Fuzzy-Cartesian Product :X: of G_y^{12} and G_y^{34} as a set

G_y^{12} :X: $G_y^{34} = \{G_y^{12} \times G_y^{34}\} \cup \{G_y^{34} \times G_y^{12}\}$

where X denotes the usual Cartesian Product operation.

G_y^{12} :X: G_y^{34} = {(y, y), (y, $[\mu_3(y)+\mu_4(y)]/2$), ($[\mu_1(y)+\mu_2(y)]/2$,y), ($[\mu_1(y)+\mu_2(y)]/2$, $[\mu_3(y)+\mu_4(y)]/2$), ($[\mu_3(y) + \mu_4(y)]/2$, y), (y, $[\mu_1(y)+\mu_2(y)]/2$), ($[\mu_3(y)+\mu_4(y)]/2$, $[\mu_1(y)+\mu_2(y)]/2$)}

where $0 < y < 1$.

All the children inheriting genes from this set are affected / carriers of the defect.

If we denote G_y^{12} :X: G_y^{34} *by* G_y^{1234}, then G_y^{1234} is the carrier expression. In nutshell,

$$\text{Fuzzy genotype function} = \begin{cases} 0 & if\, y = 0 \quad aNormalGene \\ G_y^{1234} & 0 < y < 1 \quad aCarriergene \\ 1 & if\, y = 1 \quad aDiseasedGene \end{cases}$$

5 Concluding remarks :

It may be noted that the above development does not require the identification of a particular gene and hence covers all the genes. A medical researcher can focus attention on the gene of his interest. With his medical experience and experimentation, he can select an appropriate membership function or functions to begin with. By choosing an appropriate value of y, he may decide the current status of an inherited disease.

It must be said that a genetic disorder does not turn in to disease overnight. It is a gradual process of acquiring higher and higher degree of mutation. In mathematical terms the process needs higher and higher value of y, $0 < y < 1$. This value of y is determinable in medical laboratories by applying modern innovations.

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