



Dietary Strategies for People with Celiac Disease by Neutrosophic Entropy Approach

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Abstract

Celiac disease is an autoimmune illness that causes damage to the small intestine and, in some cases, the bones as well. Histological analysis of duodenal biopsies obtained during upper digestive endoscopy is required for a diagnosis. The production of antibodies may be detected by immunological testing by taking a blood sample. Histology takes a long time, and endoscopy is intrusive. This paper used the MCDM method to compute the objective the celiac disease. In statistical distribution theory, entropy is often employed as a proxy for the uncertainty, unpredictability, or chaos of experimental results. The literature's entropy approaches provide a numeric measure of a random variable's information but struggle to handle data with interval values. The results of an experiment with an unknown outcome are often presented in interval form. The entropy method is used to compute the weights of the criteria. The neutrosophic sets were used to overcome the uncertain information in this study. This paper used six criteria and nine alternatives. The results are shown in this study.

Keywords: Neutrosophic Set; MCDM; Celica Disease; Entropy Method

1. Introduction

The lengthiest section of the human digestive process is the small intestine. Villi and crypts make up the mucosal lining, and together they provide a lot of surface area for absorbing food. Celiac disease (CD) is an inherited autoimmune illness characterized by damage to the small intestine because of eating gluten. Gluten causes inflammation and atrophy of the villi in the small intestine, which prevents nutrients from being absorbed properly. Neurological problems and other autoimmune illnesses, such as thyroid disease that is autoimmune and type I diabetes,

have been linked to celiac disease. Anyone of any age may be diagnosed with celiac disease, however, the incidence is highest between the ages of 6 and 10 and between 40 and 50[1]–[3].

If celiac disease isn't caught early on, it may lead to serious health issues such as osteoporosis, impaired fertility in women, gastrointestinal cancers, intestinal B- and T-cell lymphomas, and heart problems. Thus, for effective therapy, an early diagnosis of celiac disease is essential[4]–[6].

About 1% to 2% of people worldwide, mostly women, suffer from celiac disease, an autoimmune illness triggered by eating gluten. Celiac disease is characterized by both intestinal and extraintestinal manifestations, such as diarrhea, malabsorption, and weight loss. To cure this condition, patients must adhere to a strict gluten-free diet for the rest of their lives, which may alleviate their symptoms in many cases. As a result, celiac disease treatment necessitates a specialized diet tailored to each individual's needs and circumstances. To help those with celiac disease make the best dietary choices they can within their financial means, this study develops a decision-support tool[7]–[10].

This research makes use of one of MCDM Techniques (MCDM) to rank the goals and assign relative importance. The neutrosophic Entropy technique is used in our model to calculate the relative importance of various goals. At this point, the research includes both celiac patients and the appropriate dietician perspectives[11], [12]. With the right advice, you can get the health outcomes you want. The model is developed in light of the selection procedure[13]–[15].

From a philosophical stance, Smarandache developed the neutrosophic set (NS) in 1999, which includes the truth-membership value (T), an indeterminacy-membership value (I), and a falsity-membership value (F). It extends concepts like crisp sets, fuzzy sets, and infinite fuzzy sets. Recently, numerous academics have suggested other neutrosophic sets to further investigate this innovative notion[16]–[18].

The goal of this study, building a decision-making model for celiac disease. There is no study in neutrosophic sets dealing with celiac disease. So, this study used the neutrosophic sets to overcome the uncertain information. This study hybrid the neutrosophic sets with the entropy method. The entropy method is used to compute the weights of criteria.

2. MCDM Methodology

A neutrosophic set extends the concept of a fuzzy set beyond its traditional bounds. Fuzziness (truth, falsehood, and indeterminacy) and incomplete knowledge characterize this collection[19]–[22]. Zadeh used the entropy concept to evaluate how obscure a collection of data was. Specifics on how to calculate entropy for fuzzy sets are presented. Here, we establish the neutrosophic entropy of a Weibull distribution with two parameters[23]–[25].

$$F(x) = 1 - e^{-\alpha x^\beta} \quad (1)$$

We can compute the density function as:

$$f(x, \alpha, \beta) = \alpha \beta x^{\beta-1} e^{-\alpha x^\beta}, x > 0 \quad (2)$$

We can put the neutrosophic form as:

$$f(x, \alpha_{(L,U)}, \beta_{(L,U)}) = \alpha_{(L,U)} \beta_{(L,U)} x^{\beta_{(L,U)}-1} e^{-\alpha_{(L,U)} x^{\beta_{(L,U)}}} \quad (3)$$

The Shannon Entropy can be computed as:

$$H(x) = -\log(\alpha\beta) + \frac{(\beta-1)}{\beta} [\gamma + \log \alpha] + 1 \quad (4)$$

The neutrosophic Shannon Entropy can be computed as

$$H_N(x) = \left(-\log(\alpha_L\beta_L) + \frac{(\beta_L-1)}{\beta_L} [\gamma + \log(\alpha_L)] + 1, -\log(\alpha_U\beta_U) + \frac{(\beta_U-1)}{\beta_U} [\gamma + \log(\alpha_U)] + 1 \right) \tag{5}$$

The steps of the entropy method are shown in Figure 1.

Step 1: Build the decision matrix as:

$$X = \begin{bmatrix} x_{11} & \cdots & x_{1n} \\ \vdots & \ddots & \vdots \\ x_{m1} & \cdots & x_{mn} \end{bmatrix} \tag{6}$$

Step 2: Obtain the values of normalization as:

$$N_{ij} = \frac{x_{ij}}{\sum_{i=1}^m x_{ij}} \tag{7}$$

Step 3: Obtain the entropy value

$$v_j = -K \sum_{i=1}^m N_{ij} \ln N_{ij} \tag{8}$$

$$K = \frac{1}{\ln n} \tag{9}$$

Step 4: Compute the weights of variables

$$w_j = \frac{1-e_j}{\sum_{i=1}^n (1-e_j)} \tag{10}$$

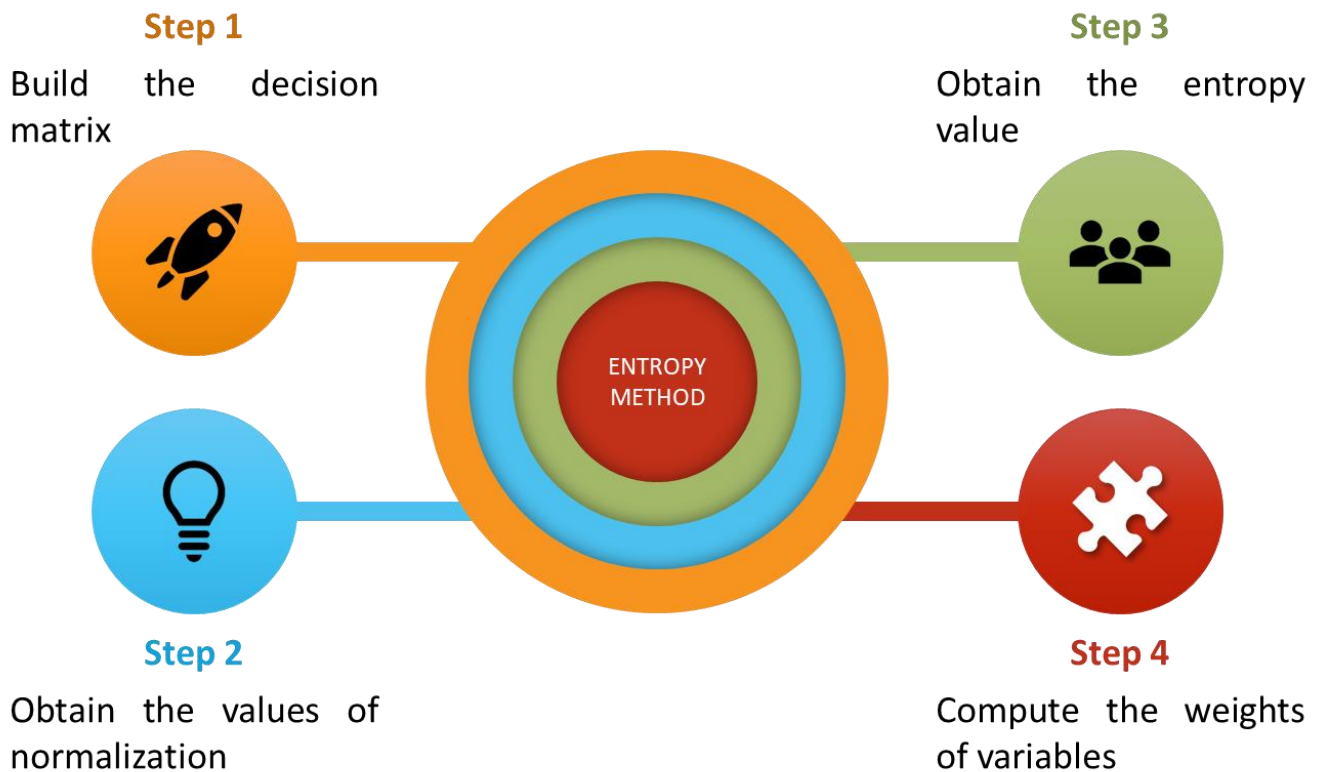


Figure 1: The steps of the entropy method.

3. Application

This section presented the results of applying the neutrosophic entropy method. There are six criteria and nine alternatives. The list of criteria are Wages, sex, body weight, body tallness, age, and level of mobility [26], [27], [28].

First, build the decision matrix between criteria and alternatives by using Eq. (6). The decision matrix between criteria and alternatives is shown in Table 1.

Table 1: The decision matrix between criteria and alternatives.

	CDC ₁	CDC ₂	CDC ₃	CDC ₄	CDC ₅	CDC ₆
CDA ₁	0.332	0.369	0.236	0.569	0.236	0.283
CDA ₂	0.333	0.369	0.213	0.39	0.232	0.962
CDA ₃	0.233	0.312	0.362	0.23	0.723	0.845
CDA ₄	0.1589	0.369	0.263	0.369	0.456	0.8562
CDA ₅	0.396	0.1236	0.362	0.236	0.4632	0.8633
CDA ₆	0.236	0.369	0.126	0.236	0.236	0.8562
CDA ₇	0.892	0.456	0.369	0.456	0.362	0.4236
CDA ₈	0.253	0.236	0.136	0.236	0.236	0.963
CDA ₉	0.369	0.256	0.36	0.9562	0.932	0.986

Then normalize the decision matrix to obtain the normalization decision matrix by using Eq. (7). The normalization decision matrix is shown in Table 2. Then compute the value of entropy using Eq. (8) as shown in Table 3. Then use Eq. (10) to compute the weights of criteria as shown in Figure 2.

Table 2: Normalization decision matrix

	CDC ₁	CDC ₂	CDC ₃	CDC ₄	CDC ₅	CDC ₆
CDA ₁	0.103656	0.129039	0.097239	0.154695	0.060884	0.040209
CDA ₂	0.103968	0.129039	0.087763	0.10603	0.059852	0.136681
CDA ₃	0.072747	0.109106	0.149155	0.062531	0.186523	0.120057
CDA ₄	0.049611	0.129039	0.108364	0.100321	0.117641	0.121649
CDA ₅	0.123638	0.043223	0.149155	0.064162	0.119498	0.122657
CDA ₆	0.073683	0.129039	0.051916	0.064162	0.060884	0.121649
CDA ₇	0.278498	0.159463	0.15204	0.123974	0.09339	0.060185
CDA ₈	0.078991	0.082529	0.056036	0.064162	0.060884	0.136823
CDA ₉	0.115208	0.089523	0.148331	0.259964	0.240442	0.140091

Table 3: The values of entropy.

	CDC ₁	CDC ₂	CDC ₃	CDC ₄	CDC ₅	CDC ₆
CDA ₁	-0.10204	-0.11475	-0.09842	-0.12538	-0.074	-0.05612
CDA ₂	-0.10221	-0.11475	-0.09274	-0.10333	-0.07319	-0.11813
CDA ₃	-0.0828	-0.10498	-0.12326	-0.07528	-0.13603	-0.11053
CDA ₄	-0.06471	-0.11475	-0.10458	-0.10018	-0.10934	-0.1113
CDA ₅	-0.11224	-0.05897	-0.12326	-0.07653	-0.11025	-0.11178
CDA ₆	-0.08346	-0.11475	-0.0667	-0.07653	-0.074	-0.1113

CDA ₇	-0.15462	-0.12715	-0.12437	-0.1124	-0.09616	-0.07346
CDA ₈	-0.08708	-0.08941	-0.07013	-0.07653	-0.074	-0.11819
CDA ₉	-0.10812	-0.09383	-0.12293	-0.1521	-0.14883	-0.11958

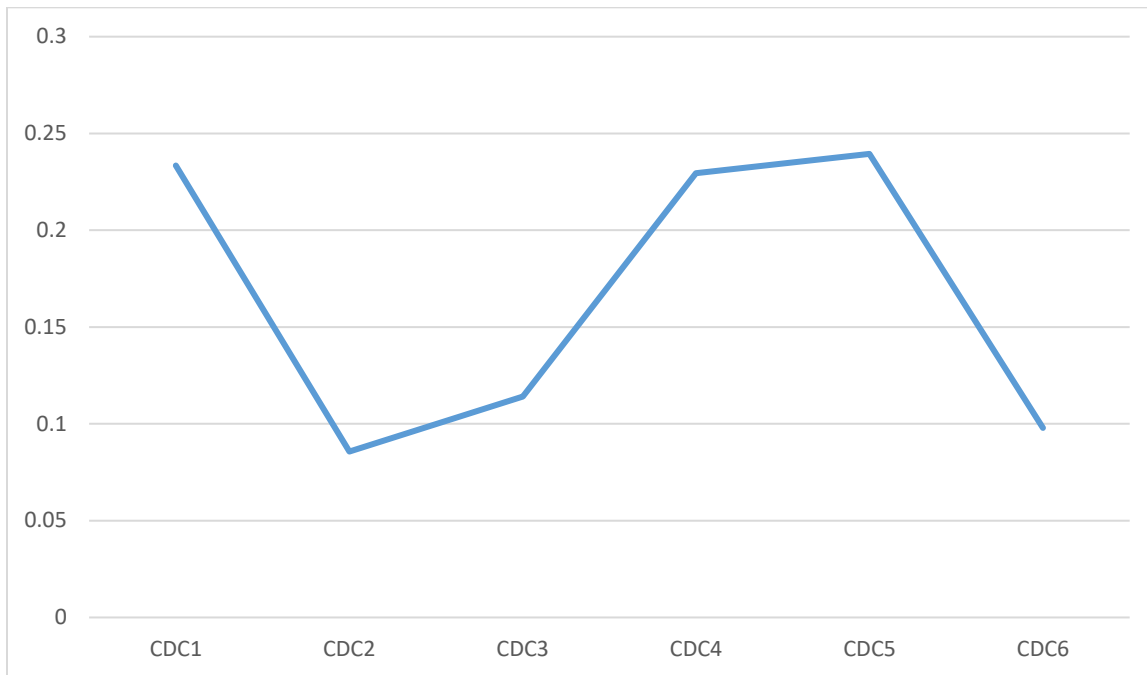


Figure 2: The neutrosophic entropy weights.

Then multiply the weights of criteria by the decision matrix. Then sum of each row to compute the rank of alternatives. Figure 3. Shows the rank of alternatives.

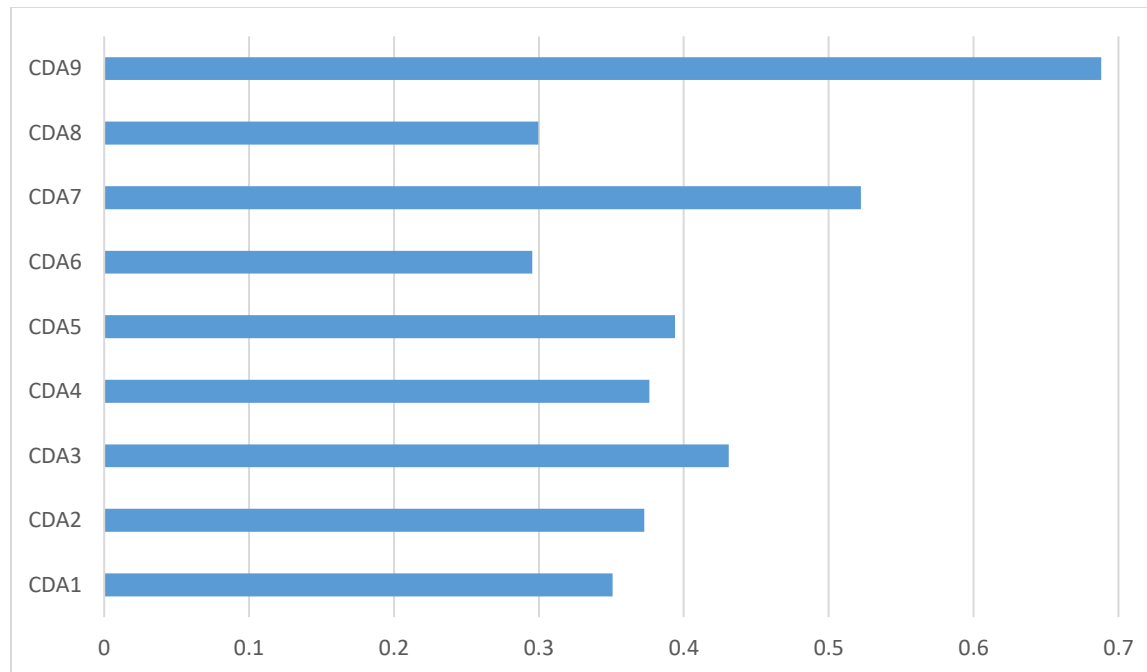


Figure 3: The ordering of the 9 options.

4. Conclusion

In information theory, entropy is a crucial metric for assessing the precision with which a data collection may be described. The distribution theory relies on this metric because of the uncertainty it introduces. Multiple attempts to find a solution to this issue in distribution theory have failed because they relied on numerical examples that were too precise to apply to situations involving interval-valued data. While there are some entropy metrics for interval data, they only work with sets of data and don't allow for the examination of the distribution of chances. This study used the neutrosophic sets under the entropy method to compute the weights of the criteria. The neutrosophic sets are used in this paper to overcome uncertain information. Then the weights of the criteria are multiplied by the decision matrix to rank the alternatives.

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