Indeterminate Likert Scale in Social Sciences Research

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Abstract

The Likert scale is by far the most popular psychometric tool for collecting data. The ordinal structure and confined style of the Likert scale make it prone to information misinterpretation and loss. Depending on the consumers' moods, replies in the real world are sometimes erratic, imprecise, and ill-defined. Neutrosophy (the study of the implementation of the provisions and indeterminacy) is utilized to accurately portray the answers. This work introduces a neutrosophic-informed, agnostic version of the Likert scale. Clustering users based on their comments is an efficient method of segmenting the population and marketing to them. In this research, we offer a clustering approach for responses received using arbitrary Likert scales. When dealing with real-world events, indeterminate Likert scales are superior in recording replies properly.

Keywords: Likert scale; Neutrosophy; Neutrosophic logic; Indeterminacy Indeterminate; Likert scale;

1. Introduction

The most used psychometric measure for gathering user/customer feedback on the degree of agreement is the Likert scale, which was developed by Likert. Several studies have employed it, including ones on organizational behavior in educational institutions, music education, dental care routine priority, and sports for athlete attributes and results. As a result of its ordinal structure and limited style, the Likert scale has some problems, including an issue with information distortion and a loss of information[1]–[3].

The soft set division is made possible by Zadeh's fuzzy set theory, which is an essential constructive tool. By assigning each component a membership and non-membership level in an intuitionistic fuzzy set (A-IFS), the fuzzy set is given an extension. In Li, the author introduces the concept of a fuzzy Likert - type scale[4]–[7].

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Neutrosophic sets have three distinct memberships: truth, falsehood, and indeterminacy, which are used to represent conflicting, imprecise, and uncertain data from the actual world. TA(x), IA(x), and FA(x) are fundamental features that may be genuine standard or slightly different subsets, and the idea generalizes sets like the classic set, the fuzzy set, and the information available set.

Real-world scientific and technological challenges could not be tackled using this method. For this reason, Wang et al. developed a single-valued neutrosophic set (SVNS). Decision-making, social network analysis, political and social and political problems, etc. are just some of the many.

The indeterminacy inclusion in the neutrosophic set is divided into two types, indeterminacy leaning more toward the truth and indeterminacy pushing more toward the false, to provide more precision and send impulses to inaccuracy in the indeterminacy. By doing so, the scenario's uncertainty is more exact and accurate. That's what Kandasamy called a "double-valued neutrosophic set" (DVNS). In his work, Kandasamy introduced the DVNS distance measure, cross-entropy measure, and clustering technique. Khan et al. advocated using dice as a measurement for DVNS[8]–[11].

The idea of indeterminacy was broken down into three parts—indeterminacy leaning towards truth, indeterminacy, and false memberships—to increase the reliability and validity of the data analysis and to conform to the Likert's scale, the most widely used psychometric scale. The triple polished indeterminate neutrosophic set is the name given to this collection of refined neutrosophic (TRINS). As of late, the TRINS personality test and subsequent personality-based categorization have been employed. To provide the most accurate mapping of Likert Scaling, we recast TRINS as follows: positive member, positive indeterminate affiliation, indeterminate affiliation, negative ambiguous membership, and negative member status[12]–[15].

A real-world application of TRINS may be imagined in the form of a customer's order of four separate things from the restaurant's menu. He may have loved two of the items, been disappointed with the third, and wondered whether the fourth would have been better cooked differently. Using a Likert scale, he would undoubtedly deliver a score somewhere around the middle.

Distance metrics between any pair of things may be used as the basis for hierarchical clustering. This is crucial in research domains including data mining, networking sites, analytical thinking, and computer vision. Clustering analysis, which uses a high degree of difficulty to determine which cluster an item belongs to, has been the norm until recently. Given the loose constraints imposed by the scenario's parts, gentle fragmentation is required. In this research, we provide a clustering approach for processing responses on a fuzzy Likert scale[16]–[21].

The most common kind of psychological scale used to gather data from respondents is the Likert scale. Rather than giving respondents a simple "yes" or "no" option, the usual Likert scale poll will provide them with a range of "agreeing" and "disagreeing" options to choose from. Strongly disagree, disapprove, neither nor disagree (don't know), accept, and strongly agree are the options in the most fundamental 5-column Likert scale format. When in doubt, most people choose the middle ground. Armstrong showed very few differences between "uncommitted" and "positive" as the middle choice on a five-point Likert scale.

An example of a Likert scale for the question "How pleased do you feel with our services?" is shown in Figure 1.

The star system of evaluation is quite close to the Likert scale. The least potential rating is assigned 1, while the highest possible rating is assigned 5. Quality is often evaluated using a star system as a heuristic or experimental tool. figure 1 is an example of a questionnaire used to collect data from a restaurant's patrons using a five-star rating system. Figure 1 provides a similar questionnaire with Likert-scale questions

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Figure 1: Sample Likert scale

Figure 2: Sample Likert scale with 5 stars.

2. Neutrosophic Sets

Neutrosophy is the study of "A" in connection to "Anti-A," "Non-A," and as neither "A" nor "Anti-A," signified by "Neut-A," as introduced by Smarandache.

So long as x is an element of the space of points (objects) X, we may say that X is a space of basic elements. Truth TA(x), indeterminacy IA(x), and falsity FA(x) membership functions describe a single-valued neutrosophic set (SVNS) A in X. At each given x in X, there exist three sets of values: $0 \leq TA(x) + IA(x) + FA(x) \leq 3$. For convenience, let's write A as $A = x, TA(x), IA(x), FA(x) x \in X$. Following Smarandache's definition of refined neutrosophic logic:

Definition 1:
You may break down the truth T into subsets of truths $(T1, T2, \ldots, Tp)$, the indeterminacy I into subsets of indeterminacies $(I1, I2, \ldots, Ir)$, and the falsity F into subsets of falsities $(F1, F2, \ldots, Fp)$. All the numbers p, r, and s1 are integers, and $p + r + s = n$.

In triple refined ambiguous neutrosophic sets, indeterminacy is represented by three distinct new members: indeterminacy favors favorable impression, indeterminacy favors negative impression and indeterminacy. This categorization is tailored to the Likert scale and aids in elevating precision and

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accuracy. For some time now, the TRINS model of personality classification has been in use. The idea of indeterminacy is separated into two parts in the double neutrosophic set (DVNS).

Definition 2:

As stated above, the membership functions of a triple refined indeterminate neutrosophic set (TRINS) A in X are respectively positive for PA(x), indeterminate for IA(x), negative for NA(x), positively indeterminate for IPA(x), and negatively indeterminate for INA(x). Each one carries a value between zero and five on the weight scale denoted by the symbol wm [0,5]. There are X times for every $x \in X$.

You may write

$0 \leq PA(x) + IPA(x) + INA(x) + NA(x) \leq 5 \text{ and}$

$wmP\big(PA(x)\big), wmIP\big(IPA(x), wmI(x), wmIN(x), wmN(x)\big)[0,1].$

$\text{That's why it's possible to symbolize a TRINS } A \text{ as}$

$A = \{\langle x, PA(x), IPA(x), IA(x), INA(x), NA(x)\rangle \mid x \in X\}.$

$PA(x), IPA(x), IA(x), INA(x), NA(x) \in [0,1],$

$wmP\big(PA(x)\big), wmIP\big(IPA(x)\big), wmI\big(IA(x)\big),$

$wmIN(INA(x)), wmN(NA(x)) \in [0,5]$

Take figure 2's questions 1 (quality) and 2 (service) and write them as Q=[q1,q2]. When membership weight is considered, values for q1 and q2 fall between [0, 1], while for q3, values fall within [0, 5]. Consider again the case when the diner places an order for four things. Two of the meals may have been huge hits, while he may be on the fence about the third. If he is asked for his opinion using a Likert scale, he will undoubtedly offer a score somewhere in the middle. To convert this to TRINS, use the following:

The meals he liked the most fall into the "excellent" category, while those he was on the fence about fall into the "good" category, and so on. Dishes that fell somewhere in the middle would be rated as "good" with some uncertainty. The quality of the service provided will also shift and be scored on a sliding scale.

The TRINS A representation of X, in this case, looks like

$$A = \langle 0.5, 0.25, 0, 0, 0.25\rangle / x1 + \langle 0.5, 0.1, 0.1, 0.1, 0.2\rangle / x2.$$

Over TRINS, we developed set-theoretic operators such as associativity, distributivity, commutativity, idempotence, absorption, and DeMorgan's laws.

3. Justification of using Indeterminate Scales

When using a Likert scale, the user is usually only given the option of picking the one that has the most votes. A typical Likert scale question would look something like this:

A. Total disagreement

B. Disagree

C. No, I don't think so

D. Agree

E. Completely concur

Every user has complex emotions and a range of opinions that includes anything from total agreement to complete discord. One individual could prefer to go with the predominant choice of

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"strongly agree" despite the small/meager level of disagreement, while another person would choose to go with the option of "agree" despite the small/meager percentage of disagreement. Someone another, having had a similar terrible experience, could choose the middle option, "neither agree nor disagree." However, it is glaringly evident that different persons would have varied emotional responses to the same survey question. The questionnaire's use of a Likert scale cannot be able to capture the full range of responses, including those with strong agreement, weak accord, no agreement, mild disagreement, and severe disagreement. Because the respondent/person is usually pushed into selecting the most prominent option, the option with which he is currently most identified, or the option that is marginally more prominent than the other choice, the respondent's/degree person's participation with the other options is lost entirely.

Likert only employs a closed format, those above. According to Russell and Bobko, the inherent limits of the Likert scale render it useless for estimating interval data, and as a result, a great deal of information is lost or misinterpreted.

Someone who chooses the "strongly may agree" choice isn't totally in agreement with the statement. Maybe the user had to make a call in the middle of a debate between two of the five traits, or maybe it was only a minor point of contention. TRINS is employed to depict options to precisely record varying levels of membership. By using TRINS and developing a Likert-type scale for the survey, we can record the degree to which respondents were unsure, incomplete, or unsure of their answers.

You won't be pushed into going with the most popular option since all of them will be given equal weight. The gradations and options will be recorded with more accuracy, in a sensitive, precise, and realistic fashion as opposed to an approximation. In the long run, this will help businesses better understand their clients and meet their demands via more targeted marketing.

Likert scales are often used to determine if a respondent is positive or negative to a remark, but scales based on TRINS or DVNS will be able to measure both positive and negative reactions, gathering more nuanced information about respondents' preferences. A more precise and comprehensive picture of the different tiers of membership may then be gleaned. Sometimes an even point scale is used instead of a Likert scale, in which the neutral option of "neither agree nor disagree" is eliminated. In psychology, this is called a "forced choice" experiment. DVNS is a good symbol for this situation. However, the undecided individual often chooses the third choice, neutral. Armstrong conducted research that concluded there was no difference between the use of "undecided" and "neutral" as the midpoint choice on a five-point Likert scale.

Since an equivalent amount of consensus and disagreement may be expressed in the degree of weak accord and degree of weak dissent, respectively, in a TRINS-based Likert scale, a distinct option for uncertainty can be included.

With indeterminate Likert scaling, you won't have to settle for the clear frontrunner or a 'forced' selection that may not be the best fit for you after all. Users' precise sentiments, ideas, and preferences are difficult to represent using Likert scales, however indeterminate Likert scales based on TRINS may get close.

4. Indeterminate Likert scale

Common things on a 5-point Likert scale include:

A. Total disagreement

B. Disagree

C. No, I don't think so

D. Agree

E. Completely concur

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The following is how we'll translate them into an amorphous Likert scale:

A. Disadvantageous membership

B. Negative membership leaning indeterminacy

C. A group whose composition is unknown

D. Uncertainty favoring participation in the positive camp

E. Having a positive membership

There will be a mapping from one star to 5 stars to accommodate the commonly used scale. A negative membership on an indeterminacy-based Likert scale would reflect the strongly disagree level of the conventional Likert scale and the one-star evaluation level of a star rating system. Likewise, the percentage of those who are undecided but lean toward disagreement will accurately represent a two-star rating. The neural/degree of indeterminacy will record the neither concur nor disagree/don't know responses on a standard Likert scale or a three-star rating. The same holds for the degrees of agreement and strong agreement, which will be translated to undecided or neutrally leaning towards good participation and positive membership, accordingly.

Extremely dissatisfied, unsatisfied, neutral, pleased, and very satisfied with separate scales for grading will be represented on an undefined Likert scale as illustrated in Figure 2.

A perfect score, as shown in Fig. 3, is five stars. A person may feel a wide range of emotions when asked to assess the service they received in the restaurant. He'll rate a 0.5 for "extremely pleased," thus it's possible that the wait staff was outstanding. He gave the restaurant a 0.25 out of 5, indicating that he was extremely dissatisfied with the service he received. Perhaps he can't decide if the wait staff was courteous or not, so he gives them a 0.25 on the indeterminate/neural scale.

Figure 3 depicts an instance like this for illustration purposes. The user may simply choose between several levels of the agreement by using the given slider. Similar to Figure 3, a five-star rating system allows the user to indicate their level of engagement by filling in a star. As a result, this is a straightforward addition to mobile programs. After receiving criticism, the user might be prompted to elaborate by way of targeted questions and an interactive feedback mechanism. Because the Likert scale is so open-ended, it's simple to zero in on and isolate a customer's unpleasant experience.

Figure 3: The rating scale of indeterminate

This nebulous Likert scale may be generalized to accommodate any number of scale points. In reality, it's adaptable to meet the requirements of individual studies. Researchers may classify groups into True, Maybe, and False categories. In this case, we get what is known as a multicast indeterminate Likert scale. The door is left ajar for research in this field.

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Likert scales are recognized to have problems such as data distortion and loss. When user input is collected via TRINS, these issues are mitigated. It handles imperfect, imprecise, doubtful, and ambiguous data with the same delicacy, accuracy, and realism with which it records input. When contrasted to the Likert scale, the indeterminate Likert scale provides the client with additional ways to express oneself. Because just the most popular option is picked on a Likert scale, important details are overlooked.
Similarities and differences between fuzzy and Scale of like
Generalizations of neutrosophic sets (TRINS), intuitionistic fuzzy data (neutrosophic information/SVNS sets), and fuzzy data (neutrosophic information) are shown. Therefore, TRINS can give more precision and accuracy in representing the aforementioned uncertain, ambiguous, imprecise, flawed, and misinformation.

As a bonus, it can identify uncertain and untrustworthy data with greater precision. While the SVNS is equipped to handle uncertain and unreliable data, it falls short when it comes to accurately designating the actual degree of uncertainty. It is understood that fuzzy theory and IFS are both incapable of handling uncertain and contradictory data; nevertheless, IFS does have tools for handling and characterizing such data. In SVNS, each member of the truth, indeterminacy, and falsity classes is described independently and may be defined regarding any of the other classes (no restriction). In TRINS, the indeterminacy notion is semi as three separate values, providing greater leeway to deal with the predominant indeterminate and unreliable information. This makes SVNS more suited to handle indeterminate details than IFS. As a result, the uncertainty in the TRINS data is resolved with more precision and accuracy than in SVNS.

Whereas other approaches are unable to handle indeterminacy altogether, TRINS can handle indeterminacy that is more favorable to the positive (the truth), more favorable to the negative (the false), and indeterminacy itself. The information about uncertainty and non-membership is lost when the fuzzy set member is specified in terms of truth T. Members are defined in IFS exclusively in terms of true and false, hence in this case we consider indeterminacy to be what remains after removing these two possibilities. While the IFS does not have a way to encode uncertain or contradictory data, it does have ways to characterize and use such data. Individually, SVNS represents truth, indeterminacy, and falsehood, and each may be defined in terms of the others (no restriction). As a result, SVNS is more effective at handling data than IFS. The indeterminacy notion is categorized as three separate values in TRINS, giving it more freedom to define and deal with both the existing uncertainty and distorted data compared to SVNS/DVNS. In TRINS, indeterminacy is therefore rendered more precisely and with more precision than in SVNS. Fuzzy theory struggles with uncertainty, while TRINS is more prepared to handle it. Uncertain, imprecise, and incomplete information cannot be captured by a Fuzzy Likert scale. When compared to the fuzzy Likert scale, the indeterminate Likert scale based on TRINS provides a more exact, accurate, and realistic depiction of the facts being measured.

5. Conclusion

This work presents a TRINS-based alternative to the Likert scale that is capable of handling inconsistent, unclear, imprecise, and ambiguous data. The nature of consumer feedback is often unclear, inconsistent, inaccurate, or inconclusive since it relies on human emotions. Therefore, an uncertain Likert scale is preferable to a Likert scale for providing feedback. The usage of an open-ended Likert scale is straightforward, making it ideal for use in mobile applications.

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