Fuzzy logics and medical diagnosis of nursing assessment

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Abstract

This paper argues that fuzzy representations are appropriate in applications where there are major sources of imprecision and / or uncertainty. Case studies of fuzzy approaches to specific problems of medical diagnosis and classification are described in support of this argument. The solutions use a variety of fuzzy methods including clustering, fuzzy set aggregation and type- 2 fuzzy set and Type-2 fuzzy relation modeling of linguistic approximations. It is concluded that the fuzzy approach to the development of artificial intelligence in application systems is beneficial in these contexts because of the need to focus on uncertainty as a main issue.

Keywords: Intervention; Antibiotics; Intravenous analgesia; Anti-emetics; Frail; Sedation; Linguistic; Paradigm; Complicating factor; Moderate; Overall condition

Introduction:

In this paper. We will show how fuzzy representations are useful for taking uncertainty into account and can be applied to model the acquisition of knowledge by experts. Steimann and co-workers (Steimann and Adlassnig 2001) have presented a strong case for using fuzzy sets to support heuristic methods of diagnosis based on placing a major emphasis on the uncertainty in the information in the nursing process. This paper considers further case studies in different diagnostic domains defined by Steimann and Adlassnig on scoring. We show how fuzzy representation and processing supports these activities by allowing uncertainty and imprecision to be taken into consideration.

We have used type- 2 fuzzy relations to capture nursing perceptions in nursing assessment as an alternative to a numerical scoring approach. The detail of the work is published in (John and Lake, 2001) and from a nursing perspective (Lake and John, 2000) and also in a Ph.D. Thesis (Dev Utpalandu, 2014).

In Nursing are we use type- 2 fuzzy set and get a good scoring grade to fulfill the purpose of improving our patient's health. We hope we will proceed this analysis in future and fullfill the major needs of patient's Nursing Assessment.

Preliminaries

Definition 1

For any fuzzy set A, the function μ_A represents the membership function for which $\mu_A(x)$ ndicates the degree of membership that x, of the universal set X, belongs to set A and is, usually, expressed as a number between 0 and 1:

$$\mu_A(x) \, X \rightarrow [0, 1].$$

For a discrete fuzzy set A, with members $x_1.....x_N$ the usual notation is to write $A = \mu_1/x_1 + \mu_2/x_2 + ...\mu_N/x_N$ In this case the + means union.

Definition 2

A type-2 fuzzy set is characterised by a fuzzy membership function. i.e. the membership value (or membership grade) for each element of this set is a fuzzy set in 0,1, unlike type-1 fuzzy set where the membership grade is number in 0,1.

Definition 3

A type-2 fuzzy relation is a type-2 fuzzy set defined on the Cartesian product if the crisp sets X_1, X_2, ..., X_n where the tuples $(x_1, x_2, ... , x_n)$ have varying degrees of membership which are type-1 fuzzy sets.

In other words, the type-2 fuzzy relation indicates a degree of membership which is itself a type-1 fuzzy set – not a number in 0,1. In our work we use type-2 relation to modelling the nursing paradigm.

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The medical context

The clinical reality of nursing requires nurses to make decisions arising from an ongoing holistic assessment of the patient need for nursing care, based on an extensive range of knowledge. Nurses concurrently assess patient need for nursing before deciding where the primary focus of nursing attention should be directed. Holistic nursing assessment takes a number of environmental domains of patient need into account, as well as the need for clinical intervention. For the purposes here we simplify the framework for assessment to five domains.

1. Nursing is often carried out in conjunction with medical diagnosis and treatment. A primary focus of nursing concern is the physical/medical   condition or diagnosis of the person. Therefore the initial domain of assessment is named 'Physical/Medical Condition'.

2. A domain named 'Complicating Factors' which may affect the initial condition, is then also considered and taken into account.

3. The physical capability or 'Dependency' domain of the individual is always assessed.

4. The patient's ability to understand and co-operate with suggested interventions and support available to the persons from their family and environtiment will also affect the amount and type of nursing intervention that will be provided. This domain has been summarised as the 'Psycho-Social' domain.

5. The requirement for the more obvious array of nursing clinical interventions as titrated to patient need and condition, are combined in the 'Clinical Intervention' domain.

It is suggested that these five domains provide the context of the patient need nursing care intervention. These 'top level' domains are clearly imprecise and subjective and are difficult, if not impossible to measure. Added to this imprecision, there is, within each domain, a degree, or priority, of need to be determined before any required intervention is applied.

To demonstrate the translation of such a framework into Fuzzy Logic a hypothetical patient requiring elective surgery is considered. The assessments are made over a period of four to five days during the pre-operative and post-operative recovery, and a summary of two separate daily assessments made. The patient is a frail 48yrs old, admitted for relief of symptoms of cancer by the insertion of a celestin tube under anesthetic to anable parenteral feeding. On return from theatre, his post-operative Physical/Medical condition is assessed as 'potentially unstable' requiring routine regular observations. Complicating factors of nausea and pain/comfort are also assessed as 'potentially unstable' also requiring regular observation. His requirements for Clinical Intervention are assessed as 'complex', as antibiotics, intravenous analgesia and anti-emetics are administered as necessary. His Dependency needs are assessed as ' heavily dependent', both due to his generally frail physical condition, plus the necessity or added assistance in the Psycho-Social domain is assessed as 'moderate' somewhat eased by post operative sedation. This denotes a 'more acutely unwell' patient in the context of surgery on a person with cancer and secondary spread, who requires frequent nursing assessment, clinical intervention and physical support in the post-operative period. A summary might be: "Frail, requiring frequent intervention for relief of symptoms."

Both the domains and the degree of need within each domain are imprecise using nursing perceptions to define or explain the nursing assessment. The imprecision in the linguistic perceptions granulates the complexity of patient need into recognisable fragment of knowledge. To simplify this to the summation of numerical scores requires translation from linguistic terms to numbers. Our modelling of this problem removes the need for translation.

3.1 Nursing Assessment

The approach is to model the five nursing domains using type-2 fuzzy sets. The expert nurse provided the diagrams like that in Figure 7 to show how the words could be represented on a linear domain.
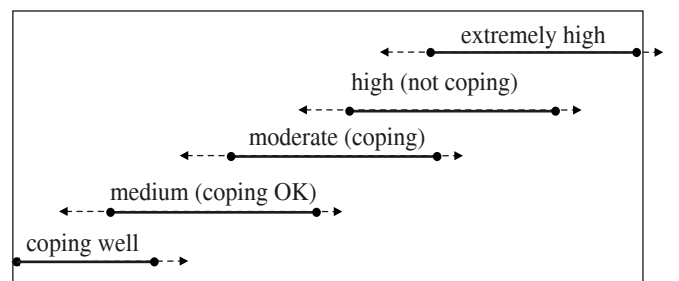
Psycho-social Needs

Fig. 3.1 (1) : The Phycho- Social Domain

These diagrams were translated into type-2 fuzzy sets. For example we have 'Dependency' which would have possible membership graces (type-1 fuzzy sets) 'independent', 'becoming independent', 'dependent', 'heavily dependent' and 'totally dependent'. These membership grades have to be

determined somehow. In this instance nurses who were expert in nursing assessment provided ranges for coverage of the words. Gaussian membership functions were used to represent the type-2 membership grades. Figures 2 and 3 show the representation of the type-2 fuzzy sets Physical/Medical and Complicating Factors.

we label 'Overall Condition'. The nursing understanding of the range of patient acuity for overall condition from 'stable' to 'critical' is also imprecise. However nursing assessment pays attention to all as aspects or domains of the patient's well being to create the summary. Let us consider a patient with membership in the type-2 sets as potentially unstable in
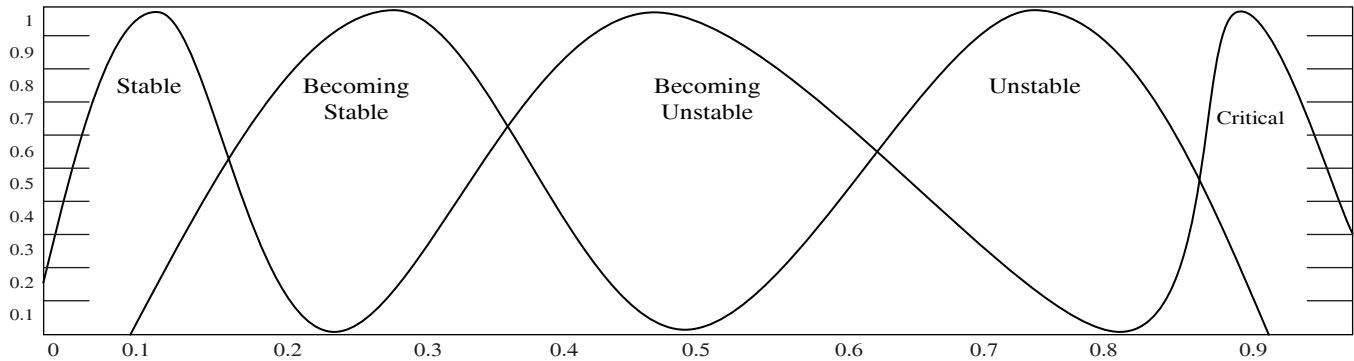
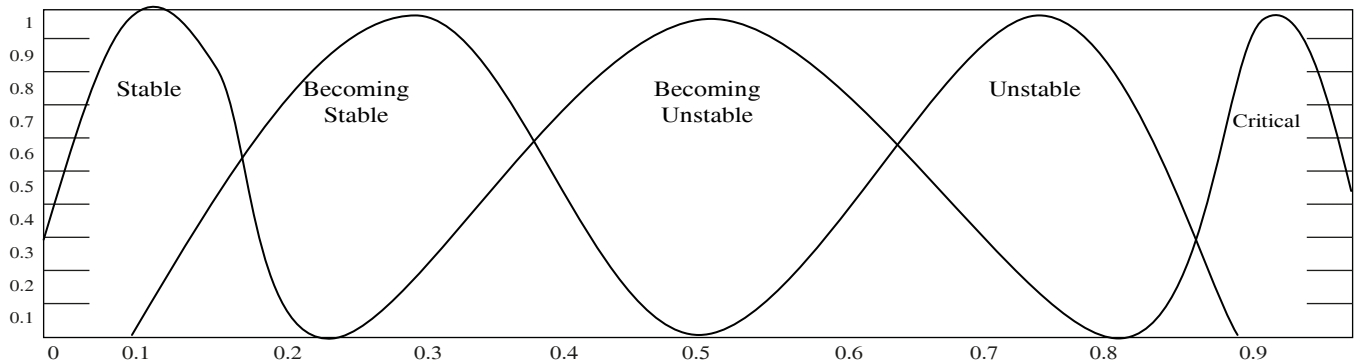**Figure 3.1 (2) : The Type- 2 Fuzzy Set Physical / Medical**

Figure 3.1 (3) : The Type- 2 Fuzzy Set Complicating Factors

These Type-2 fuzzy sets for the five domains can then be combined using type-2 relations to produce a type-2 set that

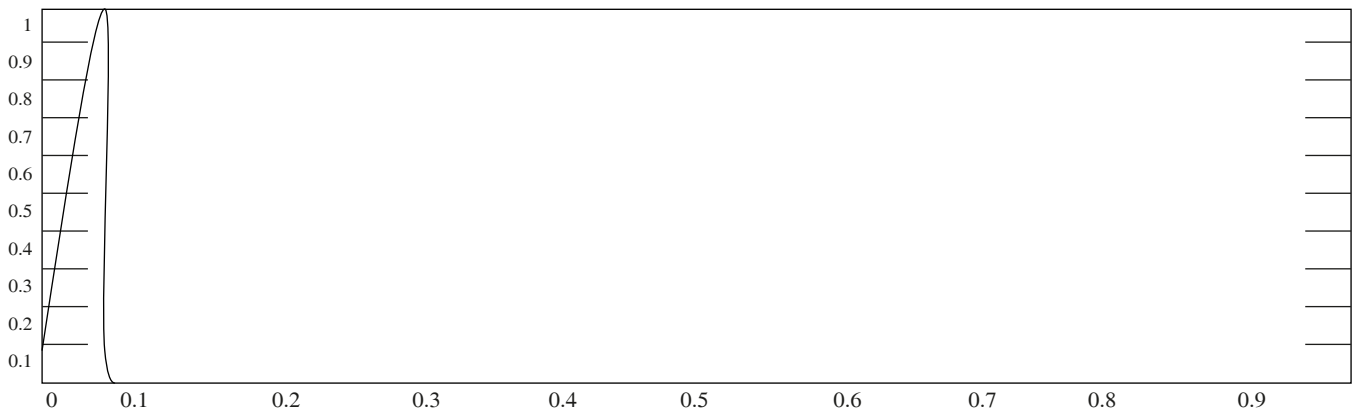the Physical/Medical domain, becoming unstable in Complicating Factors, complex in Clinical Intervention,

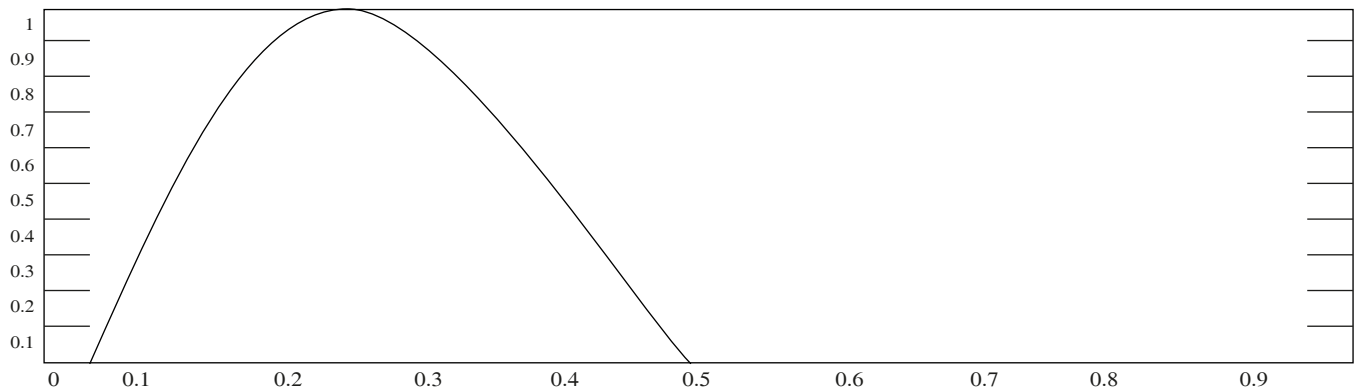**Figure 3.1 (4) : The Membership of the First Patient in Overall Condition**

Figure 3.1 (5) : The Membership of the Second Patient in Overall Condition

heavily dependent in dependency and moderate needs in Psycho-social. The overall condition is described as unstable. For this particular patient we carry out the 'meet'. Figure 4 provides the resulting membership grade of this particular patient in the type-2 fuzzy sets 'Overall Condition'.

Suppose we now have a patient who has different membership in each type-2 fuzzy set critical in Physical/Medical, unstable (Complicating Factors), critical (Clinical Interventions), totally dependent (Dependency) and moderate (Psychosocial needs). In this case we get the result in Figure 5. The overall condition is described as critically ill.

The shape of the membership grades for each patient is quite different. The ordering is intuitively correct although one would perhaps expect the critically ill membership grade to be further along the axis.

Conclusion

It appears that type-2 relations have much to offer in nursing assessment. The work is not as mature as that discussed in the fuzzy precious sections but nevertheless offers an insight into the role that type-2 fuzzy sets and relations can play in medical diagnosis. In particular we would argue that this approach offers a more intuitive approach than scoring systems especially in an inherently imprecise domain such as nursing.

The use of fuzzy approaches has been successful in our work so far, which has addressed particularly difficult problems in the medical field involving classification and perception by experts of uncertain measured parameters, and visual and linguistic information. We see future directions developing fundamental methods such as supervised learning of type-2 (linguistic) fuzzy sets and exploring their applicability in the very rich and important area of medical diagnosis and analysis in Nursing Assessment.

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