SUPPORT INNOVATIONS in decision TELEMEDICINE with ROC CURVES READ by PARACONSISTENT LOGIC ANNOTATED 2v (PARABAYES)

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Paulo Roberto Schroeder de Souza

Rubens Lara College of technology (BS) – CEETEPS
f.rlara.dir@centropaulasouza.sp.gov.br

2.3.3. - nature of work

B - Description of the project in progress
2.3.4. -Class
1 - Scientific Research (TC)

Abstract

This paper was prepared through an analog study between the quantitative and qualitative methods to be used in telemedicine in which we apply the representative lattice of Paraconsistent Logic with notes of two values (LPA2v). This new concept of medical decision support was one of the works developed during the research thesis which will be better clarified throughout this article. The proposal offered is the creation of a new theory applied to ROC[1] curves in the lattice LPA2v. What was surprising in this technique is the coincidence of the equivalence of paraconsistent logic with the textual names of Health as false-positive, false-negative, ill and not ill presented among other classifications. We will obtain an overview of the analysis of the disease outcome allowing a favorable or unfavorable degree of evidence in this study. (In final experience).

Keywords: *telemedicine; Paraconsistent; LPA2v; ROC; false-positive; false-negative.*

1-Introduction

Let's start this article boldly setting the word ***telemedicine*** as being "***the distance medical assistance".***

According to the ATA (*American Telemedicine Association*), telemedicine is: "*the use of medical information conveyed from one location to another, by eletronic means of communication, aiming the health and education of patients and the medical professional to improve health care*".

THE Who, World Health Organization affirms: "*The provision of services related to health care, in which the distance is a critical factor ..."*
ATA, *American Telemedicine Association* adds: "*in addition to the provision of services related to health care also includes remote education for the physician and patient*."

Let's adopt as telemedicine definition: "*The set of clinical and educational services that are performed remotely and aimed at the improvement and efficiency of health care delivery."*

Following this reasoning, this work is an improvement of Medical Decision support in specific area as follows below [11].
As we know, the statements of clinical examinations, for example, can be true in a situation and false in another. So, considering the all truth is uncertain, you can establish connections between certain uncertainties. All rational logical process would be precisely designed as a pass with certainty an uncertainty to another. To abandon the "certain logical truths" that, when brought to scientific reality, do not correspond to the facts, we bring the idea that the truth is something cumulative, therefore, its truth and its falsity can be marked by Favorable and Unfavorable Degrees of Evidence, defined by sensitivity and specificity respectively [1].

Every time we try to diagnose more prematurely a disease that has no gold standard of diagnosis, the burden we have would be a greater number of people diagnosed wrong carrying the stigma of the disease (false positive) and bearing a costly and unnecessary treatment. When we say that a diagnostic approach has 90% specificity, it means that 10% of patients would have a positive diagnosis wrong. This situation has even greater value when we work with population segments in which the prevalence of the disease is low and, thus, the positive predictive value of smaller test (probability of a positive test being in fact). The predictive value, as has been said, depends not only on the test, but the prevalence of the disease in question. The more sensitive for a test, the better your negative predictive value and the more specific for the test, the greater the certainty that the ophthalmologist will have to confirm a positive result. But, back to the problem of prevalence (and remember that we are dealing with a disease which increases with age): positive results even a test

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[1] *ROC = (Receiver Operating Characteristic)*

very specific, when referring to patients with low probability of disease, will be largely false-positives. Therefore, trace examinations should be applied to populations at risk [2].

The purpose of this paper is to implement logic applications to the field of medical sciences and for this we tried to link certain structural value: "true", "almost-true", "false", "almost-false", "Inconsistent", "almost-Inconsistent", "undefined" and "almost-undefined" through Degrees of certainty and uncertainty. With this goal, we attempt to define logical principles not in abstract terms, but, in the form of procedural terms applicable to medical diagnosis.

Uncertain knowledge is the one which is questionable and which normally associates a measure of uncertainty that somehow describe beliefs for which there are certain supporting evidence. Paraconsistent logic Annotated, with annotation of two values (LPA2v) is a class of Paraconsistent Logic that works with evidence and that admits contradiction in a non-trivial way. Annotations are representative of *beliefor disbelief degrees* and assigned to the proposition, giving it connotations of valuation that we will establish along the work [3].

2-Methodology

The methodology of this research is to develop methods of "interpretation" of Bayes in LPA2v for medical diagnosis, considering its theoretical structure presented in relevant work of previous research in this article [11]. From these "interpretations" modes of applications that will make treatment of uncertain knowledge are developed, translating these theoretical concepts in practical and leaving new references to other fields of application. In the real world, inconsistences are important and cannot be neglected because they are the conflicting information that bring facts modifying, sometimes, the result of the analysis completely. The existence of inconsistency is that induces the system that is under consideration to promote searches, looking for new and enlightening information queries to other informants, to obtain a more reliable conclusion [2]. At the moment, we will describe the analogy of ROC curves, values calculated by Bayes, can be applied in the sub-areas of the lattice of Paraconsistance, trying to describe the existing templates.

In table 1 there are cells that define the values used for calculations of sensitivity, specificity, predictive values and others as definition.

Patient \ Examination	**Sick (d)**	**Not sick (d \)**	**Total**
positive	Truly Sick (The)	False Positive (B)	Total Positive A + B
negative	False negative (C)	Truly not sick (D)	Total Negative A + C
	Total sick A + C	Total not sick B + D	Total population A + B + C + D

Table 1 - Showing the array of Confusion,
Disease vs. Evidence

With values considered for a period of evidence and applied on the model of table 1, we can get through calculations by the theory of Bayes, multiple values of sensitivity and specificity and thus apply the chart from Figure 1 that is the ROC curve [5].

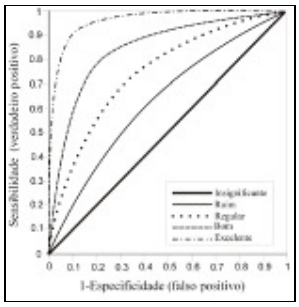

Figure 1 – ROC Curve with levels of
diagnostic quality [7]

In the graph in Figure 1, the curves define the quality of the test. For each curve we have several points to be examined.

As **Sensitivity,** we consider the probability of the examination to be positive, a positive test, given that the individual is Truly Sick = present.

Measures how widely the examination hits between patients.

Sensitivity ↑ = false-negative ↓

On **Specificity**, we consider the probability of the examination to be negative, negative test, given that the individual is Truly non-sick = absent.

Specificity = *p (test negative\absent) = d/(b + d)*

Measures how widely the examination hits among non-patients.

Specificity ↑ = false-positive ↓

So we have as false positive = 1-specificity [6]

Sensitivity = p (positive\present test) = a/(a + c)

The side of the theory of Logic Paraconsist (LPA), we can say when we observe QUPC (unit square of the Cartesian Plan) (Figure 2) and we have one of the ways to represent the LPA.

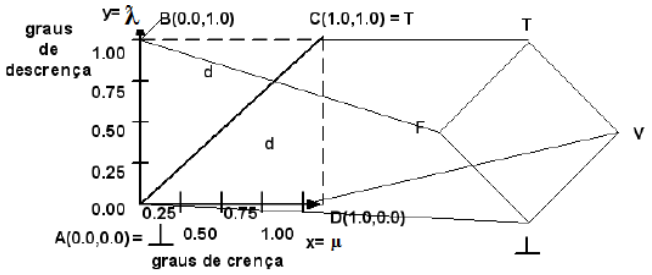

Figure 2 - Unit square of the Cartesian plan of LPA – QUPC [10]

The LPA can be studied in a unit square in the Cartesian plan (Figure 2) in which the Favorable Evidence Degrees (Belief) and the Unfavorable Evidence Degrees (Disbelief) λ are inserted, in which we define two specialists, and through these values the degrees of certainty (Gc) and contradiction (Gct) are calculated. (Figure 3). Observe the equations below:

Being:

1 specialist:

μ = Favorable Evidence Degree

2 specialist:

Unfavorable Evidence Degree$_1$= μ μ-$_2$= λ

where: μ Є [0,1]

Pμ = Proposition Annotated

λ = 1 – μ λ Є [0,1]

From the unit square we can compute the values of the Degree of contradiction (Gct) and degrees of certainty (Gc) as the equations below.

Gc = μ - λ and Gct = (μ + λ) -1

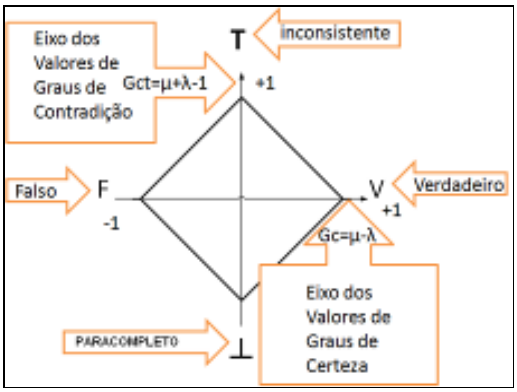

Figure 3-axes of the contradictiondegrees and certainty degrees (Hasse diagram). [2]

From the diagram, we can allocate 12 subareas in this subdivision which will be called resolution solutions from the LPA according to Figure 4.

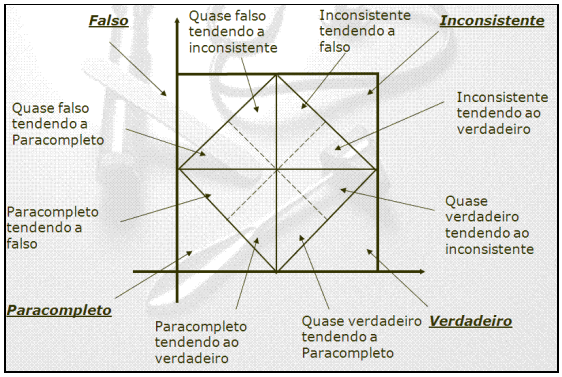

Figure 4-definition of the 12 States with their respective classifications [5]

3-Implementation

In this research presented in [5], it was found that an analogy of LPA with Bayes principle ould be made, so a comparative table was prepared, as in table 2. We call this new conversion of ParaBayes.

By Figure 4 shown previously, we put this analogy in figures 5 and 6.

FALSO	1	NÃO DOENTE = ESPECIFICIDADE = VALOR PREDITIVO NEGATIVO
QUASE FALSO TENDENDO A PARACOMPLETO	2	QUASE NÃO DOENTE TENDENDO A FALSO NEGATIVO
PARACOMPLETO TENDENDO A FALSO	3	FALSO NEGATIVO TENDENDO A NÃO DOENTE
PARACOMPLETO	4	FALSO NEGATIVO = 1 - SENSIBILIDADE
PARACOMPLETO TENDENDO AO VERDADEIRO	5	FALSO NEGATIVO TENDENDO AO DOENTE
QUASE VERDADEIRO TENDENDO A PARACOMPLETO	6	QUASE DOENTE TENDENDO A FALSO NEGATIVO
VERDADEIRO	7	DOENTE – SENSIBILIDADE = VALOR PREDITIVO POSITIVO
QUASE VERDADEIRO TENDENDO AO INCONSISTENTE	8	QUASE DOENTE TENDENDO AO FALSO POSITIVO
INCONSISTENTE TENDENDO AO VERDADEIRO	9	FALSO POSITIVO TENDENDO DOENTE
INCONSISTENTE	10	FALSO POSITIVO= 1 - ESPECIFICIDADE
INCONSISTENTE TENDENDO A FALSO	11	FALSO POSITIVO TENDENDO A NÃO DOENTE
QUASE FALSO TENDENDO A INCONSISTENTE	12	QUASE NÃO DOENTE TENDENDO A FALSO POSITIVO

Table 2 – interpretation of the Transition and Adaptation of Parabayes

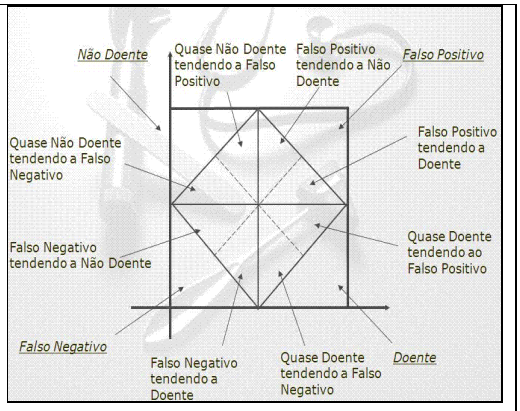

Figure 5 – QUPC of LPA Applying ParaBayes [5]

The degree of certainty is provided by the sensitivity and the degree of contradiction has 1-specificity.

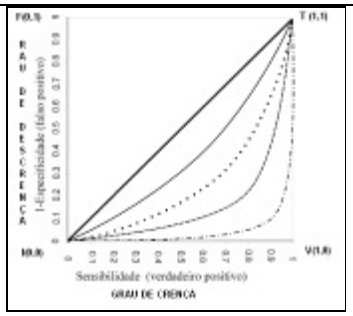

Figure 6 – invertionof axes x-y of the ROC curve [5]

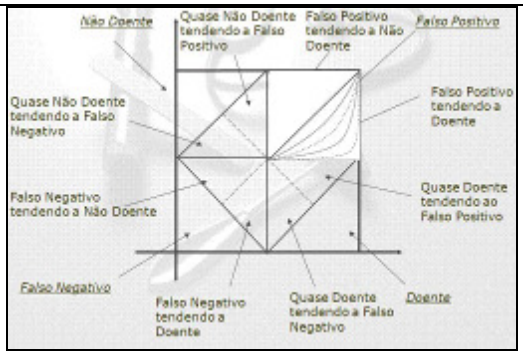

Figure 7 – ROC curve in the LPA

Now we also reversed the representation of the ROC curve and substituted their nomenclature by the area of health as Figure 6 and 7.

4-Results

Let's sort the ROC Curve parameters that will serve as a reference of analysis as the following table.

.Area (AUC)	Quality of diagnosis
0.9 to 1.0	Excellent
0.8 to 0.9	Good
0.7 to 0.8	Regular
0.6 to 0.7	Bad
0.5 to 0.6	Insignificant

Table 3: quality of diagnosis on ROC curve area [7]

We realized also by the table that the value .5 is insignificant, almost zero, i.e. the value of diagonal square is irrelevant.

In Figure 8 below we can see two diagnosis test results and asked what would be the more appropriate.

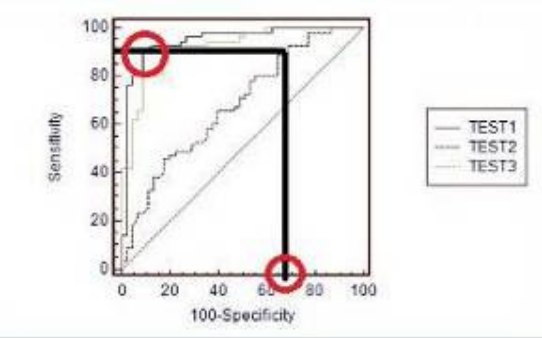

Figure 8- ROC curve example comparing two diagnostic tests. Note that the test has an area on the curve a lot grater than the test B [1].

This (Figure 8), considering two experts, test A and test B, values that will be defined as the Favorable Evidence Degree (sensitivity) and Unfavorable Evidence Degree (false-positive = (1-specificity)), degree of certainty in sensitivity and degree of contradiction in False-positive, applied in Figure 9.

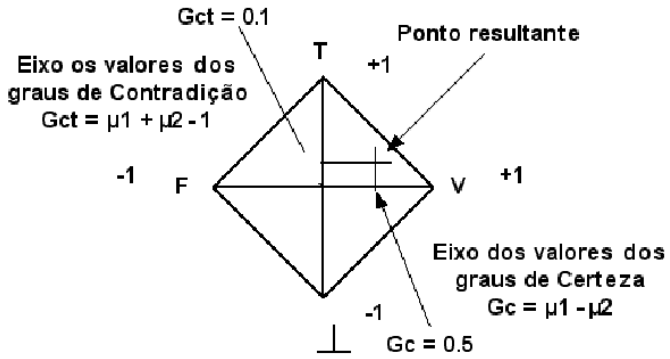

Figure 9-2 Demonstrating any values of Gc and Gct.

At this moment we have two experts, a single value to respond conveniently to support the decision.

5-Discussion and conclusions

The application techniques of ParaBayes found previously may be used in the future to support the decision in telemedicine. You can use the inversions of the

axes that will determine the AUC areas in ROC curve. Taking the AAC area (the area above (*above*) the curve) and AUC (area under (*under*) the curve) and reversing them, the considerations made through pre-defined areas applied in the lattice LPA2v can be applied as analysis of results. One can thus make a diagnostic control, given the specified transformations of the 12 pre-defined areas as exemplified above.

Extends this principle, we have the idea of Parabayes as a tool to be developed in the future, to be applied in Modeling of signals (data) for the health area.

This work is a contribution for the advancement of medical research and by being available in the worldwide network of computers (Internet), hopefully the directions for applications and the findings presented here and planned to may serve as a basis for new and promising studies in healthcare.

At this stage of research we become closer to inaccurate values for results we denominate almost-truth, instant that defines itself around the truth [8,9].

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