Prevision of Medical Diagnosis Based on Paraconsistent Annotated Logic

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Abstract This paper shows a process of prevision of medical diagnostic based on Paraconsistent Annotated Logic, PAL. Knowing the symptoms reported by the patient, applying the Para-Analyzer Algorithm (Abe & Da Silva Filho 2001), by the Baricenter Analysis Method (Carvalho 2002) we obtain the resultant certainty degree of each illness analyzed (Carvalho, Brunstein & Abe 2004). Looking for the highest value of these certainty degrees we find a sole result that allows to determine the illness with highest certainty degree. We can decide what is the illness with highest favorable evidence by means of the symptoms reported by the patient. This illness will be the prevision of medical diagnosis. It is observed that the method presented is destined to 'adequate' illness, i.e., simple but helpful in emergencies, for instance.
Keywords Prevision, medical diagnosis, symptoms, illness, paraconsistent logic, para-analyzer algorithm.

1 Introduction

Recently, several kinds of non-classical logics have been proposed in order to handle uncertainty and contradictory data without becoming trivial. One class of such logics, the paraconsistent annotated logic, can manipulate uncertain, inconsistent and paracomplete data. These logics have been applied successfully in some areas, v.g. in Robotics and in Artificial Intelligence (Abe 1997).

2 Paraconsistent Annotated Evidential Logic Eτ

The atomic formulae of the paraconsistent annotated logic Eτ is of the type $p_{(a;\ b)}$, where $(a;\ b) \in [0,\ 1]^2$ and $[0,\ 1]$ is the real unitary interval with the usual order relation and p denotes a propositional variable.

There is an order relation defined on $[0,\ 1]^2$: $(a_1;\ b_1) \leq (a_2;\ b_2) \Leftrightarrow a_1 \leq a_2$ and $b_1 \leq b_2$. Such ordered system constitutes a lattice that will be symbolized by τ. A detailed account of annotated logics is to be found in (Abe 1992). $p_{(a;\ b)}$ can be intuitively read: "It is believed that p's belief degree (or favorable evidence) is a and disbelief degree (or contrary evidence) is b". The pair $(a;\ b)$ is called an annotation constant.

So, we have some interesting readings: (1; 0) intuitively means total belief and no disbelief (p is a true proposition); (0; 1) intuitively means no belief and total disbelief (p

is a false proposition); (1; 1) means total belief and disbelief (p is an inconsistent proposition); (0; 0) means total absence of belief and disbelief (p is a paracomplete proposition), and (0,5; 0,5) can be read as indefinite state (Abe 1992).

There is a natural operator defined on $[0, 1]^2$: $\sim(a; b) = (b; a)$ which will work as the "meaning" of the negation of $E\tau$ (Abe 1992). Also, we have the operators $(a_1; b_1)$ OR $(a_2; b_2) = (\max\{a_1, a_2\}; \max\{b_1, b_2\})$ and $(a_1; b_1)$ AND $(a_2; b_2) = (\min\{a_1, a_2\}; \min\{b_1, b_2\})$. We introduce the following concepts (all considerations are made having $0 \leq a, b \leq 1$): Segment perfectly defined: $a + b - 1 = 0$; Segment perfectly undefined $a - b = 0$; Uncertainty degree: $G_{uncert}(a; b) = a + b - 1$; Certainty degree: $H_{cert}(a; b) = a - b$. Observe that the certainty degree increases from 0 to 1, when the point $X(a, b)$ go from the line AB to the point C; and it decreases from 0 to –1, when X go from AB to D. The logical states (extreme and non-extreme) or output consist of 12 states according to the Figure 1.

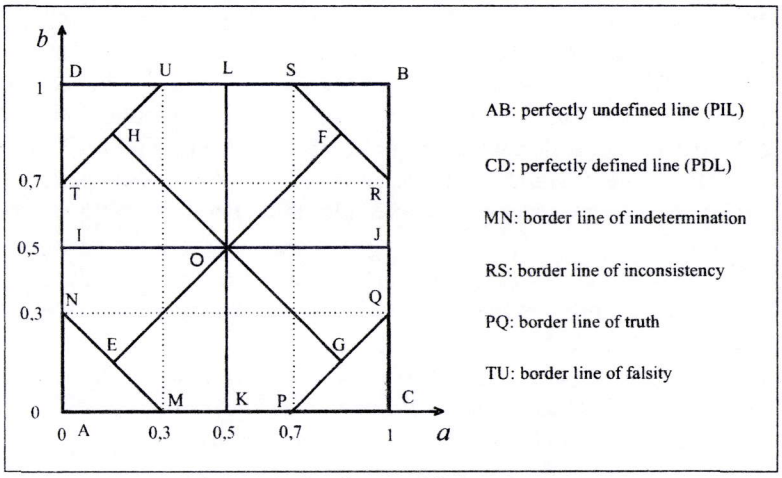

Figure 1: Lattice τ with output states

Table 1: Output states, characterization and symbolization

Region	G_{contr}	H_{cert}	Description	Representation
AMN	[-1, - 0.7]	[- 0.3, 0.3]	Indetermination or para-completeness	$\bot$
BRS	[0.7 , 1]	[- 0.3, 0.3]	Inconsistency	T
CPQ	[- 0.3, 0.3]	[0.7, 1]	Truth	V
DTU	[- 0.3, 0.3]	[-1, - 0.7]	Falsity	F
OFSL	[0, 0.7 [	[- 0.5, 0 [	Quasi-inconsistency tending to falsity	$QT \rightarrow F$
OHUL	[0, 0.5 [	] - 0.7, 0 [	Quasi-falsity tending to inconsistency	$Q F \rightarrow T$
OHTI	[- 0.5, 0 [	] - 0.7, 0 [	Quasi-falsity tending to indetermination	$Q F \rightarrow \bot$
OENI	] - 0.7, 0 [	] - 0.5, 0 [	Quasi-indetermination tending to falsity	$Q\bot \rightarrow F$
OEMK	] - 0.7, 0 [	[0, 0.5 [	Quasi-indetermination tending to truth	$Q\bot \rightarrow V$
OGPK	[- 0.5, 0 [	[0, 0.7 [	Quasi-truth tending to indetermination	$QV \rightarrow \bot$
OGQJ	[0, 0.5 [	[0, 0.7 [	Quasi-truth tending to inconsistency	$QV \rightarrow T$
OFRJ	[0, 0.7 [	[0, 0.5]	Quasi-inconsistency tending to truth	$Q T \rightarrow V$

We observe that the division presented can be adapted according to the applications.

2.1 Rule of Decision

In Figure 1, regions CPQ (region of *truth*) and DTU (region of *falsity*) are called decision regions. The first is called favorable decision (viability) and the second one is the unfavorable decision (not viability). (Carvalho 2002)

In fact, should point X (a; b) belong to one of these regions, there is a strong indication that a decision will be made. We will make a favorable decision (viability) if X belongs to region *CPQ*, or make an unfavorable decision (not viability) if it belongs to region *DTU*.

$H_{cert} \geq 0{,}70 \Rightarrow$ favorable decision (viable enterprise);

$H_{cert} \leq -0{,}70 \Rightarrow$ unfavorable decision (not viable enterprise);

$-0{,}70 < H_{cert} < 0{,}70 \Rightarrow$ non-conclusive

In the example above, we have taken $|H_{cert}| = 0{,}70$ as border lines of truth and falsity. This means that the analysis will only be conclusive when $|H_{cert}| \leq 0{,}70$. Therefore, the 0.70 value translates the minimum value of $|H_{cert}|$ so that it falls in the region of truth or falsity, that is, for making a favorable or unfavorable decision. That is why it is called *Level of Requirement* (L_{req}) of the decision (Carvalho 2002). This means that under these conditions, decisions would be taken with a minimum 70% of certainty. It is easy to observe that the larger the degree of requirement is the smaller the decision regions will be. In a more generic way, the rule of decision can be written as follows (Carvalho 2002):

$H_{cert} \geq L_{req} \Rightarrow$ favorable decision (viable enterprise);

$H_{cert} \leq -L_{req} \Rightarrow$ unfavorable decision (not viable enterprise);

$-L_{req} < H_{cert} < L_{req} \Rightarrow$ non-conclusive.

The level of requirement depends on the safety one will want to have in the decision, which, on the other hand, will depend on the responsibility it implies, the investment at stake, the involvement or not of risk to human lives, etc.

3 Application: Prevision of Illnesses Diagnosis

The basic principle is to anticipate the diagnosis of any illness from the symptoms reported by the patient. This is extremely important to be used, for example, at triage in large hospitals so that it will be easier for the attending staff to determine what illness patients report and to what medical specialty patients must be sent to. Certainly, it is not intended that this prevision should substitute in any way any diagnosis made by a physician or a group of physicians.

To achieve what is intended here one will need to use a database built on the opinion of specialists in medicine. This database will be built with the favorable evidence values (or belief degrees) and the contrary evidence values (or disbelief degrees) that each physician shall attribute to the illness every time a certain symptom is reported by the patient. In order to present the method, we will take into consideration unreal data and a set of 32 possible illnesses (ordered from AA to BF) to be related to another set of 30 symptoms (ordered from S01 to S30), all of which are not specified with reality.

By using this database (Table 2) the process is meant to check with the patient which symptoms he/she reports. After the symptoms are checked and through the application of Annotated Paraconsistent Logic (Table 3) it is possible to determine the degree of certainty of each of the 32 listed illnesses for the symptoms reported by the patient. The resulting illness with the higher degree of certainty will then be considered as the diagnosis prevision.

3.1 Database Construction

Table 2: Database (values of favorable and contrary evidences attributed to the illnesses by specialists for each symptom).

		Expert 1		Expert 2		Expert 3		Expert 4	
ill	symp	a_1	b_1	a_2	b_2	a_3	b_3	a_4	b_4
AA	S01	0,88	0,04	0,94	0,14	0,84	0,08	0,78	0,03
AA	S02	1,00	0,04	0,95	0,15	1,00	0,10	0,85	0,00
AA	S03	0,90	0,10	0,96	0,20	0,86	0,14	0,80	0,09
AA	S04	0,97	0,14	1,00	0,24	0,93	0,19	0,87	0,13
AA	S05	0,98	0,91	0,02	0,13	0,91	0,88	0,00	0,03
AA	S06	0,65	0,48	0,65	0,38	0,55	0,38	0,55	0,48
AA	S07	0,57	0,43	0,67	0,38	0,47	0,53	0,57	0,43
AA	S08	0,57	0,44	0,62	0,39	0,52	0,41	0,52	0,43
AA	S09	0,14	0,86	0,19	0,93	0,28	0,98	0,12	1,00
AA	S10	0,13	0,78	0,14	0,89	0,17	0,90	0,01	0,93
AA	S11	0,94	0,14	0,84	0,08	0,78	0,03	0,88	0,04
AA	S12	0,95	0,15	1,00	0,10	0,85	0,00	1,00	0,04
AA	S13	0,96	0,20	0,86	0,14	0,80	0,09	0,90	0,10
AA	S14	1,00	0,24	0,93	0,19	0,87	0,13	0,97	0,14
AA	S15	0,02	0,13	0,91	0,88	0,00	0,03	0,98	0,91
AA	S16	0,65	0,38	0,55	0,38	0,55	0,48	0,65	0,48
AA	S17	0,67	0,38	0,47	0,53	0,57	0,43	0,57	0,43
AA	S18	0,62	0,39	0,52	0,41	0,52	0,43	0,57	0,44
AA	S19	0,19	0,93	0,28	0,98	0,12	1,00	0,14	0,86
AA	S20	0,14	0,89	0,17	0,90	0,01	0,93	0,13	0,78
AA	S21	0,84	0,08	0,78	0,03	0,88	0,04	0,94	0,14
AA	S22	1,00	0,10	0,85	0,00	1,00	0,04	0,95	0,15
AA	S23	0,86	0,14	0,80	0,09	0,90	0,10	0,96	0,20
AA	S24	0,93	0,19	0,87	0,13	0,97	0,14	1,00	0,24
AA	S25	0,91	0,88	0,00	0,03	0,98	0,91	0,02	0,13
AA	S26	0,55	0,38	0,55	0,48	0,65	0,48	0,65	0,38
AA	S27	0,47	0,53	0,57	0,43	0,57	0,43	0,67	0,38
AA	S28	0,52	0,41	0,52	0,43	0,57	0,44	0,62	0,39
AA	S29	0,28	0,98	0,12	1,00	0,14	0,86	0,19	0,93
AA	S30	0,17	0,90	0,01	0,93	0,13	0,78	0,14	0,89
AA	S99	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
AB	S01	0,02	0,94	0,14	0,88	0,15	1,00	0,18	0,91
AB	S02	0,99	0,06	0,94	0,16	0,99	0,11	0,84	0,01
AB	S03	0,91	0,09	0,97	0,19	0,97	0,13	0,81	0,08
AB	S04	.....	.....	.....	.....	.....	.....	.....	.....
.....	.....	.....	.....	.....	.....	0,13	0,97	0,23	0,87	0,17
BE	S29	0,85	0,10	0,95	0,11	1,00	0,21	0,91	0,15
BE	S30	0,77	0,06	0,87	0,07	0,93	0,17	0,83	0,11
BE	S99	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
BF	S01	0,67	0,38	0,47	0,53	0,57	0,43	0,57	0,43
BF	S02	0,62	0,39	0,52	0,41	0,52	0,43	0,57	0,44
BF	S03	0,19	0,93	0,28	0,98	0,12	1,00	0,14	0,86
BF	S04	0,14	0,92	0,17	0,93	0,01	0,96	0,13	0,81
BF	S05	0,15	1,00	0,18	0,91	0,02	0,94	0,14	0,88
BF	S06	0,99	0,11	0,84	0,01	0,99	0,06	0,94	0,16
BF	S07	0,18	0,02	0,21	0,95	0,05	0,98	0,17	0,83
BF	S08	0,65	0,46	0,55	0,48	0,55	0,50	0,60	0,51
BF	S09	0,93	0,87	0,02	0,02	0,98	0,90	0,04	0,12
BF	S10	0,89	0,06	0,99	0,06	0,89	0,15	0,99	0,15
BF	S11	0,84	0,01	0,99	0,06	0,95	0,16	0,99	0,11
BF	S12	0,81	0,07	0,91	0,08	0,97	0,18	0,87	0,12
BF	S13	0,20	0,98	0,08	1,00	0,06	0,86	0,11	0,93
BF	S14	0,48	0,41	0,48	0,43	0,53	0,44	0,58	0,39
BF	S15	0,48	0,43	0,53	0,44	0,58	0,39	0,48	0,41
BF	S16	1,00	0,04	0,95	0,15	1,00	0,10	0,85	0,00
BF	S17	0,91	0,09	0,97	0,19	0,97	0,13	0,81	0,08
BF	S18	0,93	0,15	0,96	0,25	0,87	0,19	0,81	0,14
BF	S19	0,00	1,00	0,10	0,80	0,90	0,08	1,00	0,15
BF	S20	0,89	0,15	0,99	0,15	0,89	0,06	0,99	0,06
BF	S21	0,93	0,17	0,98	0,12	0,83	0,02	0,98	0,07
BF	S22	0,57	0,44	0,62	0,39	0,52	0,41	0,52	0,43
BF	S23	0,10	0,86	0,15	0,93	0,24	0,98	0,08	1,00
BF	S24	0,13	0,81	0,14	0,92	0,17	0,93	0,01	0,96
BF	S25	0,52	0,44	0,57	0,39	0,47	0,41	0,47	0,43
BF	S26	0,54	0,45	0,64	0,40	0,44	0,55	0,54	0,45
BF	S27	0,98	0,18	0,88	0,12	0,82	0,07	0,92	0,08
BF	S28	1,00	0,24	0,93	0,19	0,87	0,13	0,97	0,14
BF	S29	0,04	0,11	0,93	0,86	0,02	0,01	0,98	0,89
BF	S30	0,55	0,38	0,55	0,48	0,65	0,48	0,65	0,38
BF	S99	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00

In order to build a database, medical experts, especially in general practice, with experience in propaedeutics and familiar with patient anamnesis are then invited to give their opinion. Based on their knowledge, experience and sensitivity they must give values of favorable evidence (or belief degree) and contrary evidence (or disbelief degree) for each of the 32 chosen illnesses before each of the 30 possible symptoms to be reported by the chosen patients in order to build the database.
To illustrate the method, how it was said, we have chosen 32 illnesses and 30 symptoms. We are working with four specialists (from 1 to 4). Therefore, our database will be made of a total of 32 x 30 x 8 = 7,680 datums presented in a chart with 960 lines and 8 columns. From these 7,680 half will represent the values of favorable evidence and the other half will represent the values of contrary evidence. A small amount of data is shown in Table 2, beginning with illness AA and ending with illness BF.

3.2 Certainty Degree

The calculation of the resulting certainty degree for each illness with the symptoms reported by the patient can be done with the help of a computer program – Excel, which looks for data in the database (Table 2) and takes them to the calculation table (Table 3), does the calculation and comes up with the degree of certainty for the symptoms shown by the patient (Table 3, column 17, last line). Then, the same program takes these results to the decision table (Table 4), which points out to the illness with the higher certainty degree. That is the anticipated diagnosis.

As the program does practically everything, from data search to decision making, the only thing to do is to feed the program with information and check on the symptoms shown by the patient and enter them in Table 4.

This is to be made, for instance, by the hospital triage staff in a preliminary interview with the patient. Once the symptoms are reported, they must be put in the decision table (Table 4). As an example, let us assume that the patient reports eight symptoms: S01, S02, S04, S07, S11, S16, S22 and S29. Those symptoms and then entered in column 2 of Table 4. Once the symptoms enter column 2, all the remaining lines must be filled in with S99, which translates the absence of information on the other possible symptoms, that is, this means that in relation to all other symptoms there will be favorable evidence and contrary evidence values equal to zero. In fact, if the patient does not report any other symptoms than the eight previously reported these cannot interfere with the diagnosis of the illness reported by the patient.

Also, the amount of symptoms must be entered in the first line of column 3 in Table 4. Once all data related to the symptoms reported by the patient enter Table 4, the program will transfer them to the calculation table (Table 3: column 2). Then the program will search the database (Table 2) for the specialists opinion on the symptoms reported and transfer them to Table 3 (columns 3 to 10). Then, upon each opinion – for each separate illness, the Paraconsistent Annotated Logic techniques of maximization (operator OR) (columns 11 to 14) and minimization (operator AND) (columns 15 and 16) must be applied.

The Table 3 presented here refers to only one of the 32 illnesses, which is illness AA as an example. However, the program performs the operation for all 32 illnesses.
In order to apply the techniques of Paraconsistent Annotated Logic the experts are distributed in groups according to their own characteristics. For example, should one of the experts be a highly renowned and famous professional; he can be considered as a group; or two experts with the same academic background and experience, can also form a group, etc. In this paper we have decided to divide the experts in two groups: Group A, with experts 1 and 2, and Group B, with experts 3 and 4.

Table 3: Calculation of certainty degree of illness AA (= 0,476), considering the 8 symptoms reported by the patient.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
		Group A				**Group B**				**A**		**B**		A AND B		**H_{cert}**
		Expert 1		**Expert 2**		**Expert 3**		**Expert 4**		**E1 OR E2**		**E3 OR E4**				
ill	**symp**	a_1	b_1	a_2	b_2	a_3	b_3	a_4	b_4	a_A	b_A	a_B	b_B	a_R	b_R	
AA	S01	0,88	0,04	0,94	0,14	0,84	0,08	0,78	0,03	0,94	0,14	0,84	0,08	0,84	0,08	0,76
AA	S02	1,00	0,04	0,95	0,15	1,00	0,10	0,85	0,00	1,00	0,15	1,00	0,10	1,00	0,10	0,90
AA	S04	0,97	0,14	1,00	0,24	0,93	0,19	0,87	0,13	1,00	0,24	0,93	0,19	0,93	0,19	0,74
AA	S07	0,57	0,43	0,67	0,38	0,47	0,53	0,57	0,43	0,67	0,43	0,57	0,53	0,57	0,43	0,14
AA	S11	0,94	0,14	0,84	0,08	0,78	0,03	0,88	0,04	0,94	0,14	0,88	0,04	0,88	0,04	0,84
AA	S16	0,65	0,38	0,55	0,38	0,55	0,48	0,65	0,48	0,65	0,38	0,65	0,48	0,65	0,38	0,27
AA	S22	1,00	0,10	0,85	0,00	1,00	0,04	0,95	0,15	1,00	0,10	1,00	0,15	1,00	0,10	0,90
AA	S29	0,28	0,98	0,12	1,00	0,14	0,86	0,19	0,93	0,28	1,00	0,19	0,93	0,19	0,93	-0,74
AA	S99	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
AA	S99	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
AA	S99	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
AA	S99	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
AA	S99	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
AA	S99	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
AA	S99	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
AA	S99	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
AA	S99	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
AA	S99	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
AA	S99	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
AA	S99	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
AA	S99	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
AA	S99	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
AA	S99	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
AA	S99	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
AA	S99	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
AA	S99	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
AA	S99	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
AA	S99	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
AA	S99	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
AA	S99	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Baricenter W: arithmetic average of the resulting degrees														0,758	0,281	**0,476**

Maximization is applied intra-group, that is, within Group A and within Group B, whereas minimization is applied inter-group, that is, between the results obtained from maximization within Groups A and B. Therefore, below is the rule to apply Annotated Paraconsistent Logic techniques:

[(expert 1) OR (expert 2)] AND [(expert 3) OR (expert 4)]

Thus, it is possible to obtain the favorable evidence degrees and contrary evidence degrees of each illness in relation to each symptom. These resulting values, if plotted in the Para-Analyzer algorithm are translated in points; each one representing the influence of the symptom in the prevision of the illness under consideration. (Figure 2)

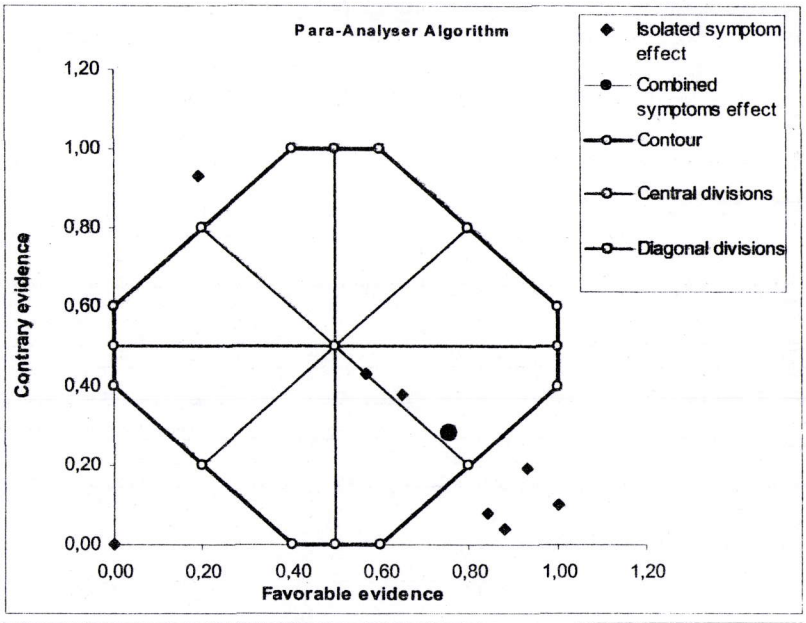

Figure 2: Separate and resulting effects from the 8 symptoms reported by the patient in illness AA.

3.3 Obtaining the probable diagnosis

The arithmetic average of the resulting values of favorable and contrary evidences for each symptom will provide the average values of favorable and contrary evidence of the effects of all symptoms reported by the patient in the illness under consideration (Table 3, columns 15 and 16, last line). The average values translate the 'gravity' center, or 'baricenter' (W) of the points that convey the influence of each symptom over the illness under analysis, that is, the baricenter translates the combined influence of all reported symptoms about the illness being analyzed. With the favorable and contrary evidences of the baricenter, we can calculate the certainty degree ($H_{cert} = a_W - b_W$) of the illness being analyzed for the symptoms reported by the patient (Table 3, column 17, last line).

The average values of favorable and contrary evidences and the certainty degree of all illnesses resulting from all symptoms reported by the patient are then entered to Table 4 (columns 4 and 5) by the program.

For the study case in Table 3 (illness AA with the 8 symptoms reported by the patient) the certainty degree obtained – which is the certainty degree of baricenter W of the points representing each symptom – has been calculated as follows:

$$H_{cert} = a_W - b_W = 0{,}758 - 0{,}281 = 0{,}476$$

The application then compares the resulting certainties degrees for all illnesses and the one with the maximum certainty degree is chosen as an estimate for diagnosis. It is shown in column 8 in Table 4. In our example, the estimated diagnosis is illness BD.

Table 4: Decision table from the reported symptoms by the patient and certainty degrees for each analyzed illness.

1	2	3	4	5	6	7	8
Number of Symptoms presented by pacient		**8**	Baricenter		Degrees of certainty	Maxim of Hcert	Foreseen diagnosis (illness more evident)
Possible symptoms	Presented symptoms	Possible illnesses	belief	disbelief			
			$\mathbf{a_R}$	$\mathbf{b_R}$	$\mathbf{H_{cert}}$	Máx.	
S01	**S01**	AA	0,758	0,281	0,476	0,663	
S02	**S02**	AB	0,603	0,485	0,118	0,663	
S03	**S04**	AC	0,511	0,578	-0,066	0,663	
S04	**S07**	AD	0,650	0,380	0,270	0,663	
S05	**S11**	AE	0,630	0,370	0,260	0,663	
S06	**S16**	AF	0,834	0,208	0,626	0,663	
S07	**S22**	AG	0,629	0,466	0,163	0,663	
S08	**S29**	AH	0,305	0,778	-0,473	0,663	
S09	S99	AI	0,638	0,355	0,283	0,663	
S10	S99	AJ	0,746	0,288	0,459	0,663	
S11	S99	AK	0,661	0,378	0,284	0,663	
S12	S99	AL	0,653	0,426	0,226	0,663	
S13	S99	AM	0,711	0,369	0,343	0,663	
S14	S99	NA	0,768	0,281	0,486	0,663	
S15	S99	AO	0,744	0,276	0,468	0,663	
S16	S99	AP	0,849	0,213	0,636	0,663	
S17	S99	AQ	0,720	0,366	0,354	0,663	
S18	S99	AR	0,454	0,586	-0,133	0,663	
S19	S99	AS	0,649	0,361	0,288	0,663	
S20	S99	AT	0,865	0,204	0,661	0,663	
S21	S99	AU	0,655	0,385	0,270	0,663	
S22	S99	AV	0,653	0,414	0,239	0,663	
S23	S99	AX	0,724	0,349	0,375	0,663	
S24	S99	AY	0,765	0,283	0,483	0,663	
S25	S99	AZ	0,736	0,265	0,471	0,663	
S26	S99	AW	0,850	0,194	0,656	0,663	
S27	S99	BA	0,734	0,346	0,388	0,663	
S28	S99	BB	0,460	0,583	-0,123	0,663	
S29	S99	BC	0,630	0,376	0,254	0,663	
S30	S99	BD	0,859	0,196	0,663	0,663	**Illness BD**
S99		BE	0,783	0,259	0,524	0,663	
		BF	0,610	0,521	0,089	0,663	

Figure 3 shows the effect of all symptoms reported by the patient in all 32 illnesses analyzed, that is, each point of the diagram is the baricenter obtained in the analysis of each illness separately, as done for illness AA in Table 3, for example.

When anticipating a diagnosis for a certain illness one should obtain the maximum certainty degree. One should only consider an estimate of acceptable diagnosis if the certainty degree is bigger than a certain predetermined value. For example, an estimate of diagnosis should only be accepted if the maximum certainty degree is equal or greater than 0,60. Then, this 0,60 value would be adopted as the requirement level, once that the estimate would only be accepted for values of the maximum certainty degree equal or greater than it.

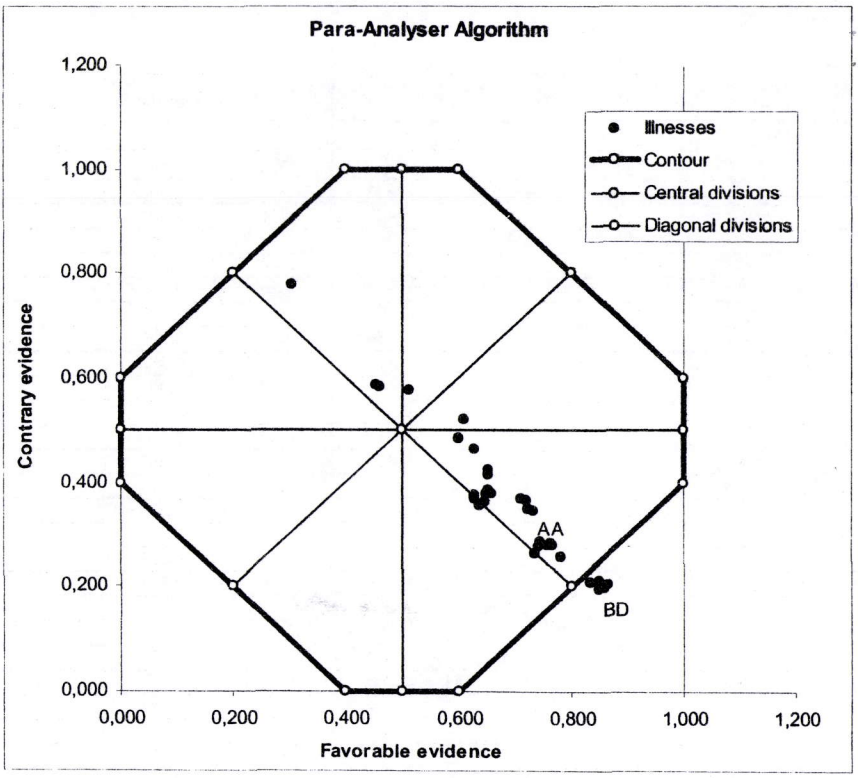

Figure 3: Analyzing the result by the Para-Analyzer algorithm, with $L_{req} = 0.60$.

The result analysis conducted by Para-Analyzer Algorithm, as shown in Figure 3 gives a clear idea of this possible requirement. Therefore, an estimate would only be accepted if W baricenter of points translating the influence of symptoms of the illness, if the illness with the higher degree of certainty should be found in the viability region (True state).

We can observe that, in this analysis, if the level of requirement adopted was equal at 0.80, the result obtained should not be accepted, because the illness with greater certainty degree (BD) should be out side of the viability region.

4. Conclusions

Although the described method is quite simple, it can be useful tool of decision making in some 'simple' diagnosis, when this is possible; as it can be seen the computer implementation, as well as their interpretation are immediate. One questionable point is how to 'translate' favorable/contrary evidences of experts 'feelings'; but this is also a general problem of any logical instrument for computer translating. One favorable point of Paraconsistent Annotated Logic is that we can manipulate mechanically uncertain, inconsistent and/or paracomplete data (Abe 1997). The ideas presented in this paper, although in theoretic phase, awaked interest of same sectors, showing the possibility of several applications of the method. For example, in big hospitals to do the triage of patients, allowing their correct leading for the suitable service; in health's enterprises to evaluate the action (performance) of the physicians that work for them, comparing their results with the standard one presented by the method; etc. We hope to say more in forthcoming papers.

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