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(Dis)Similarities between formant charts as global topological objects

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Appendix 1

Comparisons among speakers of the same dialect

We list the topological transformations, the related equations, and SI concerning the *Polygon-S* of the speakers of Montaquila, Alvito, Veroli, and Formia. The arrow indicates the direction of the transformation.

1.1. Alvito

T (EL → PAS)

x ranges between -2.5 and +2.5; and y ranges between -2.5 and +2.5

$F((0.000x^2 + 0.000xy - 0.229y^2 + 1.000x + 0.000y), (0.000x^2 + 0.000xy + 0.000y^2 - 0.150x + 1.000y))$

SI = (0+0+0+0+0.229+0.150) = 0.379

T^{-1} (PAS → EL)

x ranges between -1.5 and +2.5; and y ranges between -2.5 and +2.5

$F((0.107x^2 + 0.065xy + 0.168y^2 + 0.959x + 0.002y), (0.000x^2 + 0.142xy + 0.035y^2 + 0.000x + 1.000y))$

SI = (1+0+0+0+0.383+0.177) = 1.56

T (EL → ROS)

x ranges between -2.5 and +2.5; and y ranges between -2.5 and +2.5

$F((-0.148x^2 - 0.094xy - 0.199y^2 + 1.000x + 0.000y), (0.000x^2 + 0.000xy + 0.000y^2 + 0.000x + 0.602y))$

SI = (0+0+0+0+0.441+0.398) = 0.839

T^{-1} (ROS → EL)

x ranges between -2.5 and +2.5; and y ranges between -2.5 and +2.5

$F((0.002x^2 + 0.386xy + 0.000y^2 + 1.000x + 0.620y), (0.000x^2 + 0.054xy + 0.150y^2 + 0.000x + 1.791y))$

SI = (0+0+0+0+1.008+0.995) = 2.003

T (PAS → ROS)

x ranges between -2.5 and +2.5; and y ranges between -2.5 and +2.5

$F((-0.240x^2 + 0.000xy + 0.000y^2 + 1.000x + 0.000y), (0.000x^2 + 0.000xy + 0.000y^2 + 0.000x + 0.531y))$

SI = (0+0+0+0+0.240+0.469) = 0.709

T^{-1} (ROS → PAS)

x ranges between -2.5 and +2.5; and y ranges between -2.5 and +2.5
$F((0.000x^2 +0.265xy +0.000y^2 +1.000x +0.000y), (0.000x^2 +0.000xy +0.000y^2 +0.000x +1.781y))$
SI = (0+0+0+0+0.265+0.781) = 1.046

1.2. Montaquila

T (LOR → SER)
x ranges between -2.5 and +2.5; and y ranges between -2.1 and +2.5
$F((-0.140x^2 -0.101xy +0.000y^2 +1.000x +0.161y), (0.000x^2 +0.000xy -0.107y^2 +0.000x +0.713y))$
SI = (0+0+0.4+0+0.402+0.394) = 1.196

T^{-1} (SER → LOR)
x ranges between -2.5 and +2.5; and y ranges between -3.3 and +0.8
$F((-0.014x^2 +0.000xy +0.000y^2 +1.000x +0.000y), (0.000x^2 -0.104xy +0.000y^2 +0.000x +1.071y))$
SI = (0+0+0.8+1.7+0.014+0.175) = 2.689

T (LOR → MAR)
x ranges between -2.5 and +2.5; and y ranges between -1.4 and +2.5
$F((-0.136x^2 +0.000xy +0.000y^2 +1.000x +0.000y), (0.000x^2 +0.055xy -0.029y^2 -0.033x +0.760y))$
SI = (0+0+1.1+0+0.136+0.357) = 1.593

T^{-1} (MAR → LOR)
x ranges between -2.5 and +2.5; and y ranges between -2.8 and +1.6
$F((0.000x^2 +0.000xy +0.000y^2 +1.000x +0.000y), (0.000x^2 +0.000xy +1.149y^2 -0.054x +0.844y))$
SI = (0+0+0.3+0.9+0+0.359) = 1.559

T (LOR → ID)
x ranges between -2.5 and +2.5; and y ranges between -1.3 and +2.5
$F((-0.057x^2 +0.000xy -0.028y^2 +1.000x +0.000y), (0.000x^2 +0.000xy -0.027y^2 +0.034x +0.735y))$
SI = (0+0+1.2+0+0.085+0.326) = 1.611

T^{-1} (ID → LOR)
x ranges between -2.5 and +2.5; and y ranges between -2.5 and +1.8
$F((0.000x^2 +0.126xy +0.000y^2 +1.000x +0.000y), (0.000x^2 -0.300xy +0.371y^2 +0.000x +1.270y))$
SI = (0+0+0+0.7+0.126+0.941) = 1.767

T (LOR → GI)
x ranges between -2.5 and +2.5; and y ranges between -1.4 and +2.5
$F((0.000x^2 +0.007xy +0.000y^2 +1.000x +0.180y), (0.000x^2 +0.041xy +0.000y^2 +0.000x +1.000y))$
SI = (0+0+1.1+0+0.187+0.041) = 1.328

T^{-1} (GI → LOR)

x ranges between -2.5 and +2.5; and y ranges between -2.9 and +2.5
$F((-0.065x^2 +0.074xy +0.062y^2 +1.109x -0.609y), (0.000x^2 -0.076xy +0.033y^2 +0.000x +0.982y))$
SI = (0+0+0.4+0+0.919+0.127) = 1.446

T (SER → GI)
x ranges between -2.5 and +2.5; and y ranges between -2.6 and +1.5
$F((0.000x^2 +0.000xy +0.000y^2 +1.000x +0.000y), (0.000x^2 -0.057xy -0.079y^2 +0.000x +1.453y))$
SI = (0+0+0.1+1+0+0.589) = 1.689

T^{-1} (GI → SER)
x ranges between -2.5 and +2.5; and y ranges between -2.5 and +2.5
$F((0.000x^2 -0.182xy +0.000y^2 +1.294x -0.336y), (0.000x^2 -0.044xy +0.000y^2 +0.000x +0.517y))$
SI = (0+0+0+0+0.812+0.527) = 1.339

T (SER → ID)
x ranges between -2.5 and +2.5; and y ranges between -2.5 and +2.5
$F((0.000x^2 -0.144xy +0.000y^2 +1.000x +0.264y), (0.000x^2 +0.000xy +0.000y^2 +0.000x +1.000y))$
SI = (0+0+0+0+0.408+0) = 0.408

T^{-1} (ID → SER)
x ranges between -2.5 and +2.5; and y ranges between -2.5 and +2.5
$F((0.000x^2 +0.191xy +0.000y^2 +1.000x +0.000y), (0.000x^2 +0.000xy +0.000y^2 +0.000x +1.000y))$
SI = (0+0+0+0+0.191+0) = 0.191

T (SER → MAR)
x ranges between -2.2 and +2.7; and y ranges between -2.5 and +2.5
$F((0.000x^2 +0.000xy +0.000y^2 +1.000x +0.000y), (0.000x^2 +0.000xy +0.000y^2 +0.000x +1.000y))$
SI = (0.3+0.2+0+0+0+0) = 0.5

T^{-1} (MAR → SER)
x ranges between -2.5 and +2.5; and y ranges between -2.5 and +2.5
$F((0.000x^2 +0.000xy +0.000y^2 +1.000x +0.000y), (0.000x^2 +0.000xy +0.099y^2 +0.000x +1.000y))$
SI = (0+0+0+0+0+0.099) = 0.099

T (GI → ID)
x ranges between -2.5 and +2.5; and y ranges between -2.5 and +2.5
$F((-0.073x^2 -0.182xy +0.030y^2 +1.294x -0.396y), (0.000x^2 -0.033xy +0.016y^2 +0.000x +0.581y))$
SI = (0+0+0+0+0.975+0.468) = 1.443

T^{-1} (ID → GI)
x ranges between -2.5 and +2.5; and y ranges between -2.5 and +1
$F((0.000x^2 +0.390xy +0.000y^2 +1.000x +0.000y), (0.000x^2 +0.000xy$

$+0.000y^2$ $+0.000x$ $+1.000y$))
SI = (0+0+0+1.5+0.390+0) = 1.89
T (GI → MAR)
x ranges between -2.5 and +2.5; and y ranges between -2.5 and +2.5
F(($-0.085x^2$ $-0.170xy$ $-0.008y^2$ $+1.337x$ $-0.379y$), ($0.000x^2$ $-0.051xy$ $-0.016y^2$ $+0.034x$ $+0.761y$))
SI = (0+0+0+0+0.979+0.34) = 1.319
T^{-1} (MAR → GI)
x ranges between -2.5 and +2.5; and y ranges between -2.6 and +2.3
F(($0.000x^2$ $+0.304xy$ $+0.000y^2$ $+1.000x$ $+0.000y$), ($0.000x^2$ $+0.000xy$ $+0.374y^2$ $+0.000x$ $+1.875y$))
SI = (0+0+0.1+0.2+0.304+1.249) = 1.853
T (ID → MAR)
x ranges between -2.5 and +2.5; and y ranges between -2.5 and +2.5
F(($0.000x^2$ $+0.303xy$ $+0.000y^2$ $+1.000x$ $+0.000y$), ($0.000x^2$ $+0.000xy$ $+0.000y^2$ $+0.000x$ $+1.000y$))
SI = (0+0+0+0+0.303+0) = 0.303
T^{-1} (MAR → ID)
x ranges between -1.9 and +2.5; and y ranges between -2.5 and +2.5
F(($0.000x^2$ $-0.140xy$ $+0.000y^2$ $+1.000x$ $+0.000y$), ($0.000x^2$ $+0.000xy$ $+0.000y^2$ $+0.000x$ $+1.000y$))
SI = (0.6+0+0+0+0.140+0) = 0.74

1.3. Veroli
T (AZ → AS)
x ranges between -2.5 and +2.5; and y ranges between -2.5 and +2.5
F(($0.152x^2$ $+0.000xy$ $+0.000y^2$ $+1.000x$ $+0.069y$), ($0.000x^2$ $+0.000xy$ $+0.000y^2$ $+0.420x$ $+1.000y$))
SI = (0+0+0+0+0.221+0.420) = 0.641
T^{-1} (AS → AZ)
x ranges between -2.5 and +2.5; and y ranges between -2.5 and +2.5
F(($-0.027x^2$ $+0.000xy$ $-0.108y^2$ $+1.000x$ $+0.000y$), ($0.000x^2$ $+0.000xy$ $+0.000y^2$ $-0.397x$ $+1.000y$))
SI = (0+0+0+0+0.135+0.397) = 0.532

1.4. Formia
T (AN → VIN)
x ranges between -2.9 and +2.7; and y ranges between -2.5 and +2.5
F(($0.000x^2$ $+0.283xy$ $+0.000y^2$ $+1.000x$ $+0.000y$), ($0.000x^2$ $+0.209xy$ $+0.000y^2$ $+0.000x$ $+1.000y$))
SI = (0.4+0.2+0+0+0.283+0.209) = 1.092
T^{-1} (VIN → AN)

x ranges between -2.5 and +2.5; and y ranges between -2.9 and +2.5
$F((0.000x^2 -0.154xy +0.000y^2 +1.000x +0.000y), (0.000x^2 -0.169xy +0.000y^2 +0.000x +1.000y))$
SI = (0+0+0.4+0+0.154+0.169) = 0.723

Appendix 2

Comparisons among dialects (mean formant charts)
We list here the topological transformations, the related equations, and SI concerning the *Polygon-D* of the dialects of Montaquila, Alvito, Veroli, and Formia. The arrow indicates the direction of the transformation.

T (Montaquila → Alvito)
x ranges between -2.8 and +2.5; and y ranges between -2.5 and +2.1
$F((0.000x^2 +0.000xy +0.047y^2 +1.000x +0.000y), (0.000x^2 +0.000xy +0.000y^2 +0.000x +1.000y))$
SI = (0.3+0+0+0.4+0.047+0) = 0.747
T^{-1} (Alvito → Montaquila)
x ranges between -2.5 and +2.5; and y ranges between -2.7 and +3.0
$F((0.063x^2 +0.051xy +0.000y^2 +0.946x +0.000y), (0.000x^2 +0.000xy +0.000y^2 +0.000x +1.000y))$
SI = (0+0+0.2+0.5+0.168+0) = 0.868
T (Montaquila → Veroli)
x ranges between -2.1 and +2.9; and y ranges between -2.3 and +2.0
$F((0.000x^2 +0.047xy +0.000y^2 +1.065x -0.015y), (0.000x^2 -0.015xy +0.000y^2 -0.108x +1.000y))$
SI = (0.4+0.4+0.2+0.5+0.127+0.123) = 1.75
T^{-1} (Veroli → Montaquila)
x ranges between -3.3 and +2.9; and y ranges between -3.1 and +3.4
$F((0.000x^2 +0.000xy +0.000y^2 +0.955x +0.000y), (0.000x^2 +0.131xy +0.000y^2 -0.071x +1.000y))$
SI = (0.8+0.4+0.6+0.9+0.45+0.202) = 3.352
T (Alvito → Veroli)
x ranges between -2.1 and +2.1; and y ranges between -2.1 and +2.1
$F((0.000x^2 +0.000xy +0.000y^2 +1.000x -0.130y), (0.000x^2 +0.000xy +0.000y^2 -0.168x +1.000y))$
SI = (0.4+0.4+0.4+0.4+0.206+0.168) = 1.974
T^{-1} (Veroli → Alvito)
x ranges between -2.9 and +2.5; and y ranges between -2.5 and +2.5
$F((0.000x^2 -0.080xy +0.000y^2 +1.000x +0.036y), (0.000x^2 +0.000xy$

$-0.066y^2 + 0.159x + 0.890y$))
SI = (0.4+0+0+0+0.116+0.335) = 0.851

T (Formia → Alvito)
x ranges between -2.5 and +2.5; and y ranges between -3.7 and +2.5
F(($0.000x^2 - 0.134xy + 0.000y^2 + 1.000x + 0.000y$), ($0.000x^2 + 0.149xy + 0.000y^2 + 0.000x + 1.000y$))
SI = (0+0+1.2+0+0.134+0.149) = 1.483

T^{-1} (Alvito → Formia)
x ranges between -2.5 and +2.9; and y ranges between -2.5 and +2.5
F(($0.000x^2 + 0.148xy + 0.000y^2 + 1.000x + 0.000y$), ($0.000x^2 - 0.110xy + 0.000y^2 + 0.000x + 1.000y$))
SI = (0+0.4+0+0+0.148+0.110) = 0.658

T (Formia → Veroli)
x ranges between -2.5 and +2.5; and y ranges between -2.5 and +2.5
F(($0.000x^2 - 0.139xy + 0.000y^2 + 1.000x + 0.000y$), ($0.000x^2 + 0.000xy + 0.000y^2 + 0.000x + 1.000y$))
SI = (0+0+0+0+0.139+0) = 0.139

T^{-1} (Veroli → Formia)
x ranges between -2.9 and +3.1; and y ranges between -2.5 and +2.5
F(($0.000x^2 + 0.232xy + 0.000y^2 + 1.000x + 0.000y$), ($0.000x^2 + 0.000xy + 0.000y^2 + 0.000x + 1.000y$))
SI = (0.4+0.6+0+0+0.232+0) = 1.232

T (Formia → Montaquila)
x ranges between -2.5 and +2.5; and y ranges between -2.5 and +2.5
F(($0.000x^2 - 0.111xy + 0.000y^2 + 1.000x + 0.000y$), ($0.000x^2 + 0.105xy + 0.000y^2 + 0.000x + 1.000y$))
SI = (0+0+0+0+0.111+0.105) = 0.216

T^{-1} (Montaquila → Formia)
x ranges between -2.5 and +3.1; and y ranges between -2.5 and +2.5
F(($0.000x^2 + 0.238xy + 0.000y^2 + 1.000x + 0.000y$), ($0.000x^2 - 0.103xy + 0.000y^2 + 0.000x + 1.000y$))
SI = (0+0.6+0+0+0.238+0.103) = 0.941

The calculation of the *SImd* gives the following results:

T (Montaquila → Alvito): SI = (0.3+0+0+0.4+0.047+0) = 0.747
T^{-1} (Alvito → Montaquila): SI = (0+0+0.2+0.5+0.168+0) = 0.868
SImd (Montaquila-Alvito): 0.807

T (Montaquila → Veroli): SI = (0.4+0.4+0.2+0.5+0.127+0.123) = 1.75
T^{-1} (Veroli → Montaquila): SI = (0.8+0.4+0.6+0.9+0.45+0.202) = 3.352

SImd (Montaquila-Veroli): 2.551

T (Alvito → Veroli): SI = (0.4 + 0.4 + 0.4 + 0.4 + 0.206 + 0.168) = 1.974
T^{-1} (Veroli → Alvito): SI = (0.4 + 0 + 0 + 0 + 0.116 + 0.335) = 0.851
SImd (Alvito-Veroli): 1.412

T (Formia → Alvito): SI = (0 + 0 + 1.2 + 0 + 0.134 + 0.149) = 1.483
T^{-1} (Alvito → Formia): SI = (0 + 0.4 + 0 + 0 + 0.148 + 0.110) = 0.658
SImd (Formia-Alvito): 1.070

T (Formia → Veroli): SI = (0 + 0 + 0 + 0 + 0.139 + 0) = 0.139
T^{-1} (Veroli → Formia): SI = (0.4 + 0.6 + 0 + 0 + 0.232 + 0) = 1.232
SImd (Formia-Veroli): 1.6855

T (Formia → Montaquila): SI = (0 + 0 + 0 + 0 + 0.111 + 0.105) = 0.216
T^{-1} (Montaquila → Formia): SI = (0 + 0.6 + 0 + 0 + 0.238 + 0.103) = 0.941
SImd (Formia-Montaquila): 0.5785

Appendix 3

Example of Hz-Mel-Bark comparisons in the case of the dialect of Alvito.
In §4.3.1 we have shown (Tables 1, 2, 3, 4; Figure 11) the values in Hz of F_1 and F_2 concerning three speakers from Alvito. Here we present the same analysis in Mel and in Bark (Tables 1-bis, 2-bis, 3-bis, 4-bis; Figures 11-bis, 11-ter).

Words	Occurrences	Vowels	F1 Bark (Mel)	F2 Bark (Mel)
trite (‘crushed’)	4	i	2.97 (395)	14.83 (1758)
deva (‘he gave’)	3	e	4.13 (522)	13.73 (1612)
fame (‘hunger’)	5	a	7.12 (846)	11.19 (1302)
criatura (‘child’)	4	u	3.38 (441)	8.71 (1020)
avema (‘we have’)	4	ɛ	6.41 (769)	12.72 (1486)
tosta (‘hard’)	3	ɔ	4.59 (572)	8.85 (1035)
sciote (‘unpackaged’)	3	o	4.17 (527)	8.85 (1035)

Table 1-bis. F_1 and F_2 (in Bark and Mel) of stressed vowels (underscored) by PAS (Alvito).

Words	Occurrences	Vowels	F1 Bark (Mel)	F2 Bark (Mel)
risa ('laughs')	6	i	2.76 (372)	14.86 (1761)
abbedeva ('he lived')	3	e	4.37 (548)	14.91 (1769)
levate ('taken off')	3	a	6.54 (783)	11.77 (1371)
revenuta ('come back')	3	u	2.32 (324)	4.73 (587)
severe ('harsh')	4	ɛ	5.75 (698)	13.24 (1551)
madonna ('madonna')	5	ɔ	6.24 (750)	9.72 (1133)
chemenione ('holy communion')	4	o	3.17 (418)	9.17 (1071)

Table 2-bis. F_1 and F_2 (in Bark and Mel) of stressed vowels (underscored) by EL (Alvito).

Words	Occurrences	Vowels	F1 Bark (Mel)	F2 Bark (Mel)
rite ('rituals')	3	i	3.98 (505)	15.11 (1796)
sendeva ('he heard')	3	e	4.73 (587)	13.11 (1534)
incontravamo ('we met')	4	a	5.64 (685)	11.02 (1282)
menuto ('minute')	5	u	3.98 (505)	9.17 (1071)
festa ('holiday')	5	ɛ	5.43 (662)	12.76 (1491)
Antonio ('Antonio')	2	ɔ	5.43 (662)	8.59 (1007)
stagione ('summer')	3	o	4.54 (566)	9.01 (1053)

Table 3-bis. F_1 and F_2 (in Bark and Mel) of stressed vowels (underscored) by ROS (Alvito).

Vowels	F1 Bark (Mel)	F2 Bark (Mel)
i	3.24 (425)	14.94 (1772)
e	4.4 (552)	13.96 (1642)
a	6.45 (773)	11.33 (1319)
u	3.24 (425)	7.73 (912)
ɛ	5.87 (711)	12.91 (1509)
ɔ	5.44 (663)	9.06 (1059)
o	3.98 (505)	9.01 (1053)

Table 4-bis. Mean values of the formants F_1 and F_2 (in Bark and Mel) of stressed vowels in Alvito (by EL, PAS, and ROS).

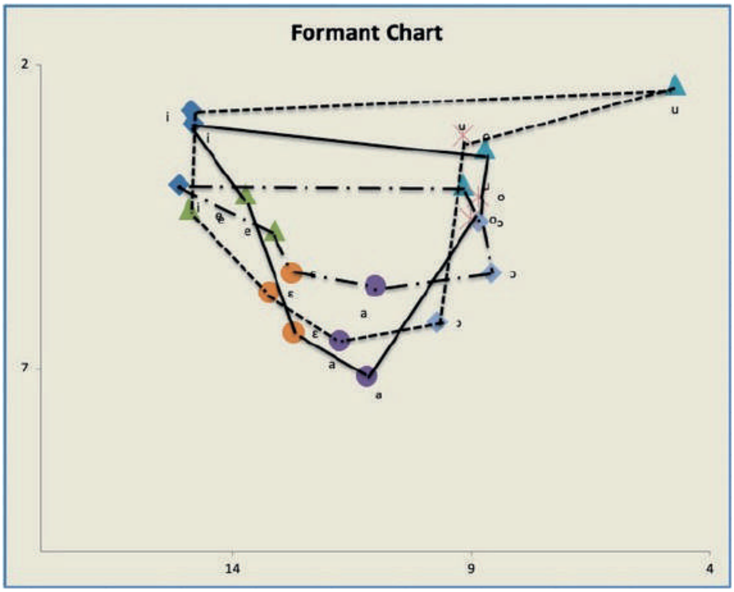

Figure 11-bis. Formant chart in Bark of Alvito: EL (dashed-line), PAS (solid line), ROS (dash-dot line).

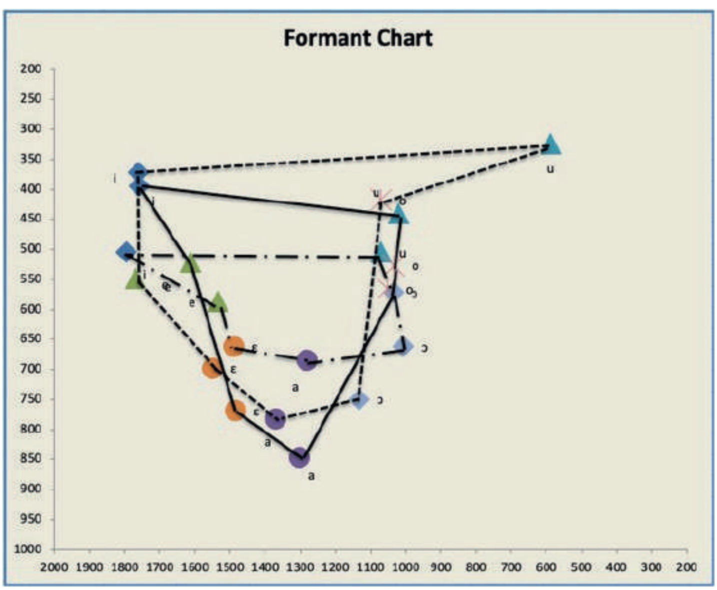

Figure 11-ter. Formant chart in Mel of Alvito: EL (dashed-line), PAS (solid line), ROS (dash-dot line).

The polygons in Figure 11 and their corresponding ones in Figures 11-bis and 11-ter are the same. Thus the topological equations (see Appendix 1: §1.1) are also the same: the transfer functions (T) remain the same, both in Hz and in Bark or Mel, because in T the starting functors (or starting polygons) and the final functors (or final polygons) have been homotopically modified.

Instead of Hz we could also use MFC coefficients (MFCC), stemming from the Mel values. The number of these coefficients (or vectors) varies from 2 to 14. Of course, in order to benefit from MFCC and obtain a better spectral definition of the formants, we should use more than two coefficients. However, in this case the topological approach would involve a multidimensional geometry: a multidimensional space is algebraically definable but not geometrically representable. As a consequence, a special topology, suitable for multidimensional spaces, should be applied. Such a topology is a very interesting perspective, but beyond the scope of the present research.