Xtractis™

Innovative Fuzzy Modelling Solutions in Sensory Engineering

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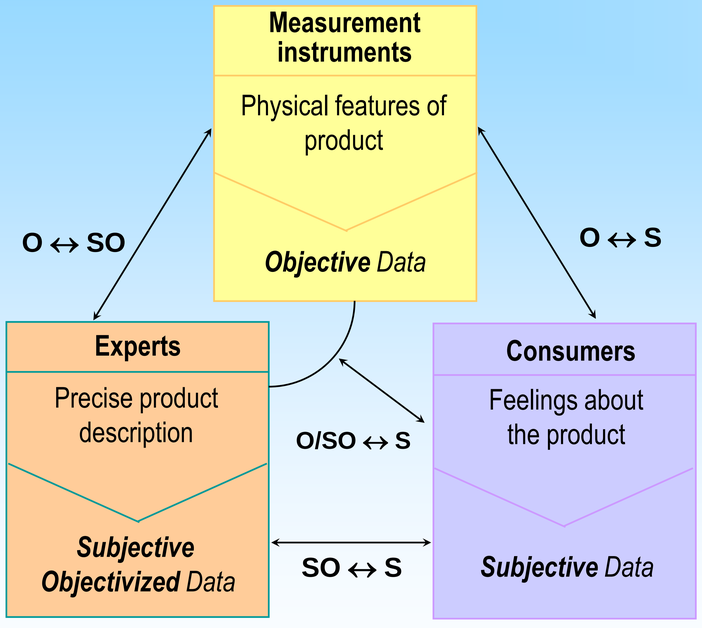
Objectives

To extract interpretable and predictive models from objective and subjective databases (provided by physical and human sensors)
➡ to systematize multi-criteria evaluation / design of products: *Virtual Testing, Virtual Design*



O ↔ SO models for product optimization

To explicit the experts' evaluation strategies

To predict the sensory evaluation of a new or altered product from objective features only: *Virtual Expert Tester*

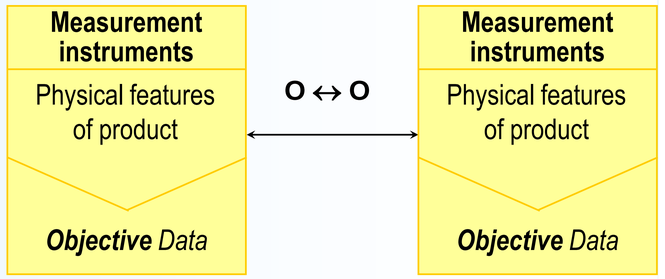
To define preferred values of these features from target sensory profiles: *Virtual Expert Designer*

SO ↔ S models for product pre-design and improvement

To highlight important sensory descriptors explaining consumer preference

To predict consumer preference from the product sensory profile: *Virtual Consumer Tester*

To find target sensory profiles maximizing consumer preference: *Virtual Marketing Expert*



O ↔ O for process tuning

To define process parameters to obtain the desired product quality: *Virtual Process Monitor*

To predict objective product features from other available objective characteristics: *Virtual Physical Sensor*

O ↔ S models for acceptability

To evaluate preference perceived by the final consumer from objective features of product: *Virtual Consumer Tester*

To define preferred values of these features from subjective consumer opinions: *Virtual Marketing Expert*

Advantages for industry

Availability and reproducibility of a virtual tester / expert, Improved conceptualization of consumer perceptions and feelings, Better fit of product to target market

Xtractis™: an IntelliTech's software technology for extraction of fuzzy models

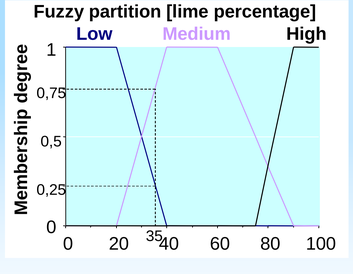
from objective, subjective, subjective objectivized data

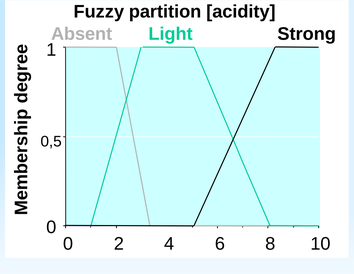
- even when data is sparse or incomplete
- exclusive use of original variables
- for complex non-linear strategies
- even for process with high dimensionnality (> 350)

Fuzzy approach

- **Fuzzy Mathematics**: concepts, techniques and methods to process knowledge and data which are imprecise, uncertain, subjective
- **Approximate reasoning**: Generalized Modus Ponens, FR composition by skeletal slotting of order *n*

Fuzzy sets





Fuzzy relation of order n, Fuzzy rule

if (U_1 is A_{1i}) and … and (U_n is A_{ni}) then (V is B_i)

if [lime%] is High and [sugar%] is Low then [acidity] is Strong

Fuzzy Inference System

- a compilation of fuzzy linguistic rules
- an implicit multidimensional numerical function
- a universal approximator of any non linear function

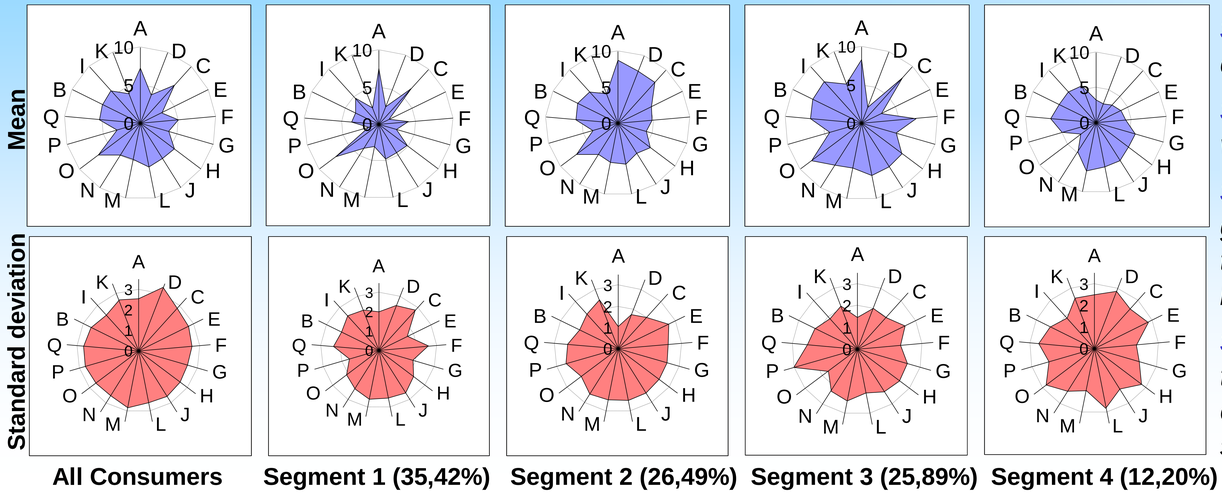
Advantages of FIS-based models

- **Interpretability**: Better understanding of decision-making strategies
- **Locality**: Flexibility in the definition and tuning of non linear models
- **Traceability**: Easier validation
- **Granularity**: Precision in the description of situations and decisions

➡ **Compromise between accuracy and robustness / interpretability**

Evaluation of fresh tomatoes

Segmentation of consumers



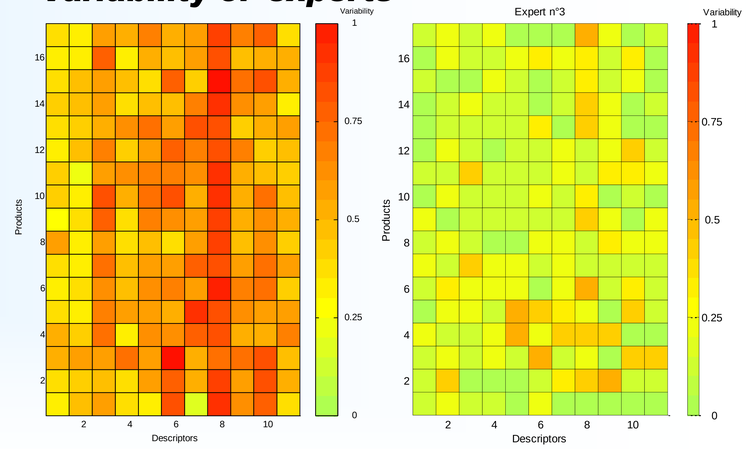
Segment n°1: *Discerning tomato consumers*

Segment n°2: *Purchase linked to variety/type*

Segment n°3: *Evaluations from this group clearly differentiate the various tomato varieties. Purchase strongly linked to colour*

Segment 4: *Fairly low appreciation of tomatoes. Segment highly environmentally aware. Purchase strongly linked to price*

Variability of experts



Strong intervariability

Low intravariabilty

Extraction of models

Failure to induce efficient SO-S

➡O-S (cheaper)

➡hybrid O/SO-S

(often more robust and interpretable)

ID	Sensory Attributes
1	Ext Color
2	Firm Inside
3	Tomato Odor
4	Firm
5	Juicy
6	Melty
7	Mealy
8	Skin Width
9	Sweet
10	Acidity
11	Tomato Flavor

ID	Physical & Chemical Analyses
12	E Colo Code CBT
13	E Average weight (g)
14	E IR (%Brix)
15	M IR (%Brix)
16	G IR (%Brix)
17	E Total Acidity (mEq/100g)
18	M Total Acidity (mEq/100g)
19	G Total Acidity (mEq/100g)
20	% gel = [G/(C+G)]*100
21	E Sum of Sugars
22	M Sum of Sugars
23	G Sum of Sugars
24	E Sum of Acids
25	M Sum of Acids
26	G Sum of Acids

Segment 1

Type	Tech.	Nb. Var.	Inputs	Nb. Rules	Accuracy / Robustness	Hamming	Max. error	% mapped
O-S	C1	6	13,14,21,22,25,26	2	0,968	3,54%	12,99%	100%
	LOO				0,834	6,02%	18,08%	100%
O/SO-S	C2SG	3	9,23,26	3	0,977	2,86%	8,25%	100%
	LOO				0,912	5,17%	16,61%	82%

Segment 2

Type	Tech.	Nb. Var.	Inputs	Nb. Rules	Accuracy / Robustness	Hamming	Max. error	% mapped
O-S	C1	3	13,14,17	3	0,938	3,31%	11,99%	100%
	LOO				0,649	6,95%	24,07%	100%
O/SO-S	C1	5	8,13,14,19,24	3	0,968	2,48%	8,31%	100%
	LOO				0,744	7,73%	17,54%	100%

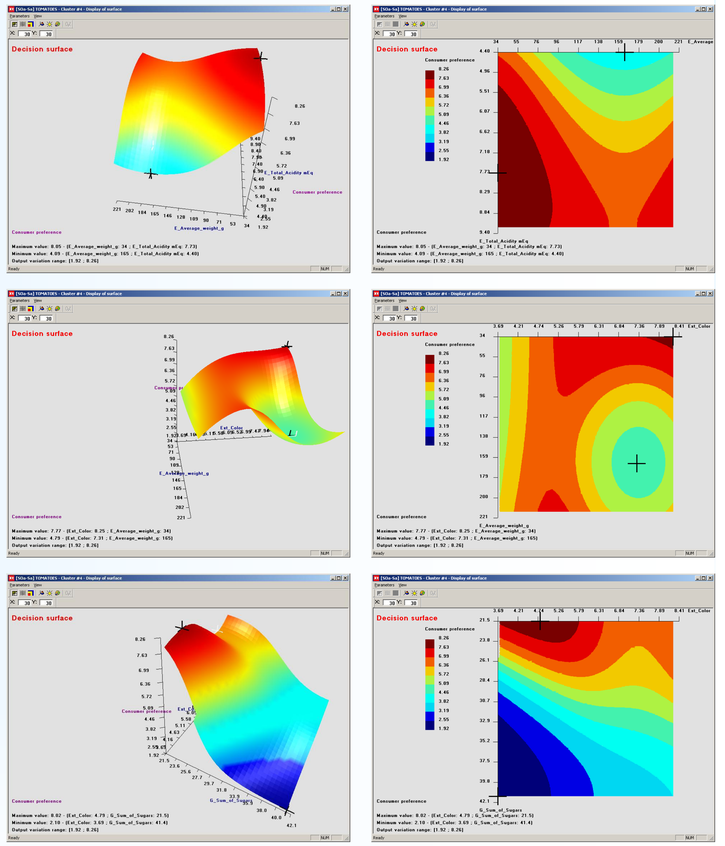
Segment 3

Type	Tech.	Nb. Var.	Inputs	Nb. Rules	Accuracy / Robustness	Hamming	Max. error	% mapped
O-S	C2SG	3	13,14,22	3	0,950	4,19%	8,54%	100%
	LOO				0,553	7,85%	22,23%	94%
O/SO-S	C2SG	5	2,9,13,14,26	3	0,981	2,61%	5,85%	100%
	LOO				0,610	9,31%	26,63%	94%

Segment 4

Type	Tech.	Nb. Var.	Inputs	Nb. Rules	Accuracy / Robustness	Hamming	Max. error	% mapped
O-S	C1	6	12,14,18,19,21,23	2	0,976	2,38%	8,33%	100%
	LOO				0,791	6,78%	13,28%	100%
O/SO-S	C1	4	1,13,17,23	3	0,956	3,33%	10,21%	100%
	LOO				0,861	6,55%	12,78%	94%

Decision surfaces of O/SO-S, Segment 4



Rules of O/SO-S, Segment 4

If [1-Color] is Medium (~5) and [13-Weight] is Medium (~95) and [17-Acidity] is Low (~5) and [23-Sugars] is High (~37) then Preference is Low (1.9)

If [1-Color] is High (~7.5) and [13-Weight] is High (~168) and [17-Acidity] is Low (~5) and [23-Sugars] is Low (~24) then Preference is Medium (3.4)

If [1-Color] is High (~7.5) and [13-Weight] is High (~153) and [17-Acidity] is Medium (~7.2) and [23-Sugars] is Low (~21) then Preference is High (8.3)