G53FUZ
Fuzzy Sets and Systems

Non-Standard Fuzzy Reasoning

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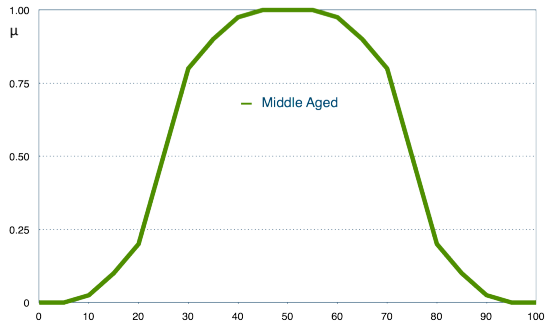
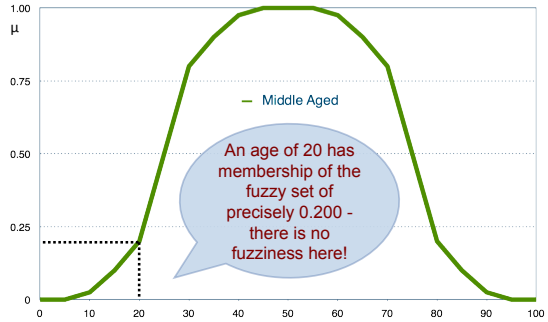
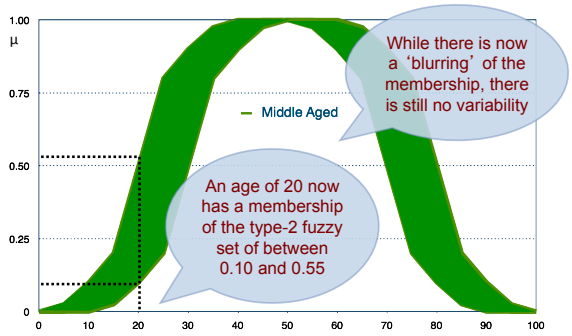
Standard (Type-1) Fuzzy Set



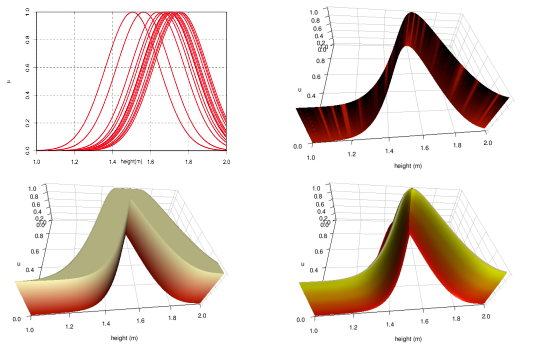
However …



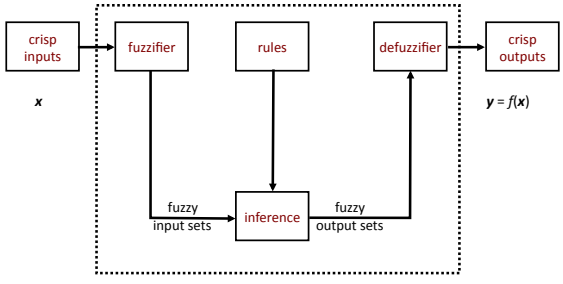
Type-2 Fuzzy Sets



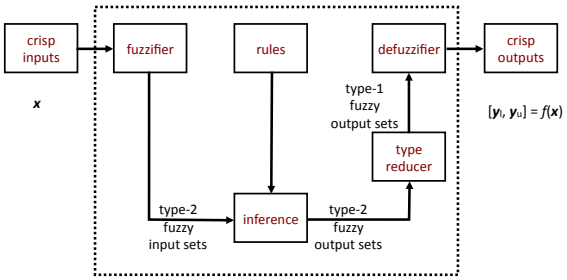
General Type-2



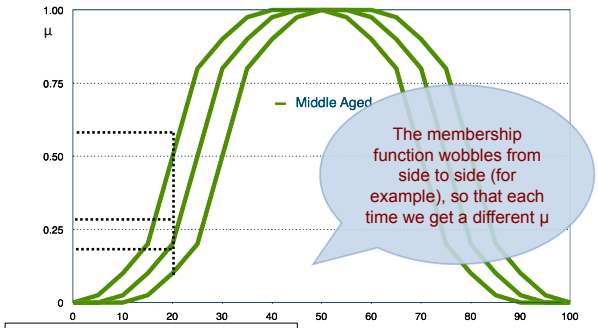
Type-1 Fuzzy Inference Systems



Type-2 Fuzzy Inference Systems



Non-Stationary Fuzzy Sets



Garibaldi, Jaroszewski, Musikasuwan; "Nonstationary Fuzzy Sets"; *IEEE Transactions on Fuzzy Systems*, 16(4), 1072-1086; 2008

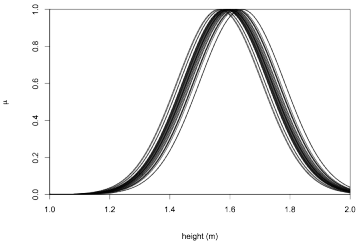
Perturbation Functions

- Firstly, parameterise the membership function
  - then, perturb one (or more) of the parameters

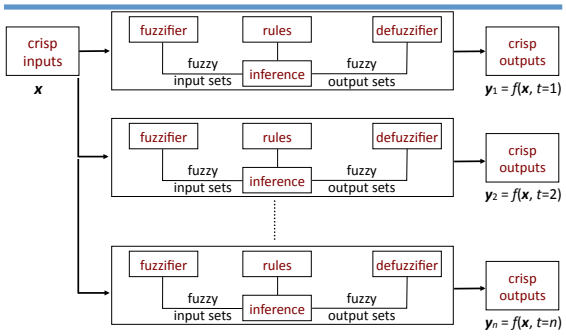
$$p_i(t) = p_i + k_i f_i(t)$$

medium(t)=

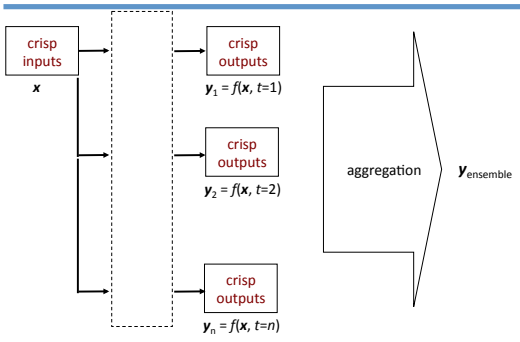
$$\int_1^2 e^{-\frac{(x-c(t))^2}{\sigma^2}}$$



NS Fuzzy Inference Systems

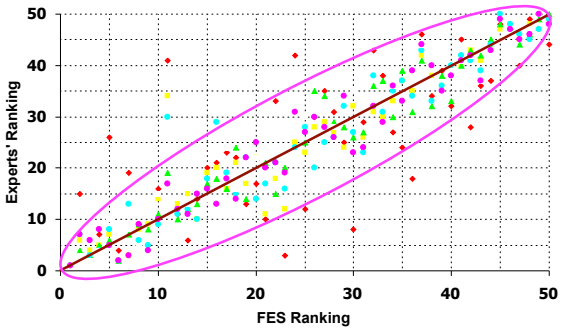


Ensemble Fuzzy Inference Systems

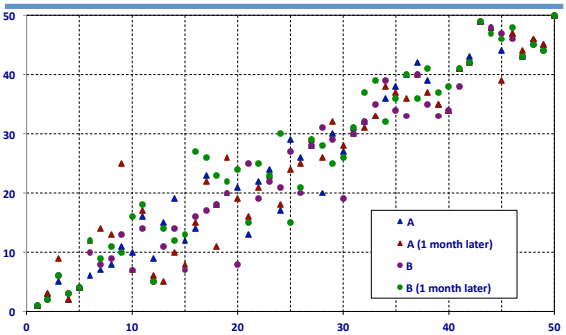


Umbilical Cord Acid-Base Analysis

Variation in Opinion



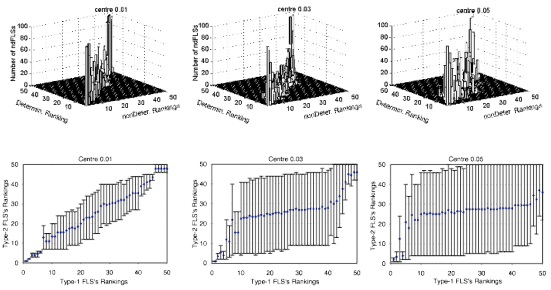
Intra-Expert Variation



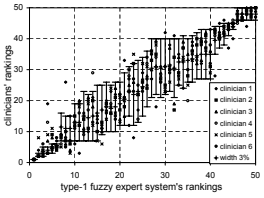
Methodology

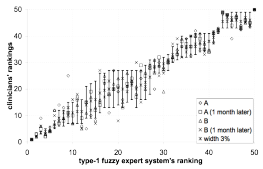
	Input				Type-1 Output		Type-2 Output Lower & Upper Bounds			
ID	pHa	BDa	pHv	BDv	PIAD	Rank	PIAD lower	PIAD upper	Rank lower	Rank upper
A	6.60	25.0	6.72	22.3	0.99	1	0.75	1.00	1	2
B	7.02	12.0	7.08	11.5	0.56	2	0.40	0.80	1	3
C	7.27	4.0	7.35	2.8	0.00	3	0.00	0.40	2	3

Changing Amount of Variation



Best Expert Match – 3%

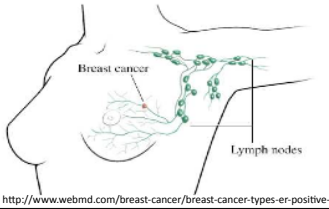




Garibaldi, Ozen; "Uncertain Fuzzy Reasoning: A Case Study in Modelling Expert Decision Making", IEEE Transactions on Fuzzy Systems, 15, 16-30; 2007

Breast Cancer - The Facts

- Worldwide, breast cancer is the most common cancer in women, after skin cancer
  - 16% of all female cancers
- Incidence per 100,000 women
  - East Asia, 18; West Europe, 78; North America, 90



- In 2004, caused 519,000 deaths worldwide
- 7% of cancer deaths; almost 1% of all deaths

http://www.webmd.com/breast-cancer/breast-cancer-types-er-positive-her2-positive

Selection of Adjuvant Therapy

- Breast cancer post operative (adjuvant) treatment decision data
- From City Hospital Nottingham Breast Institute (multidisciplinary team)
- Treatment Decisions
  - hormone therapy
  - radiotherapy
  - chemotherapy
  - further operation
  - follow up

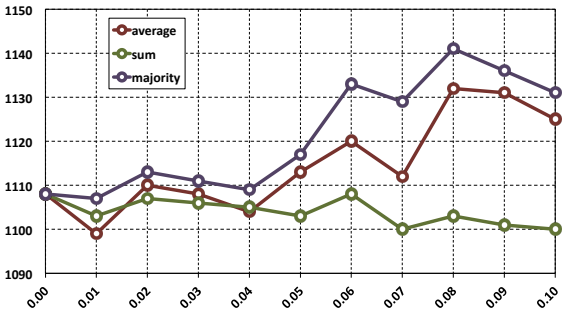
Adjuvant Therapy Guidelines

NPI < 3.0	No Adjuvant Treatment
NPI $3.1 - 3.4$	
ER +ve	Recommend Hormone therapy
ER -ve	Recommend Chemotherapy if VI
NPI $3.4 - 4.4$	
ER +ve	Recommend Hormone therapy
ER -ve	Recommend Chemotherapy
NPI > 4.4	
ER +ve	Discuss Chemotherapy Consider: Recommending Chemotherapy: Age < 40 VI HER-2 +ve Weak ER ($< 100/300$) Recommending Against Chemotherapy: Age > 60 Only 1 LN positive Special type cancer
ER -ve	Recommend Chemotherapy

Fuzzy Rules for Chemotherapy

Rule	Antecedent	Consequent
1	IF (*NPI* is *Low*)	THEN (*Chemo* is *No*)
2	IF (*NPI* is *Medium low*) and (*ER* is not *Negative*)	THEN (*Chemo* is *No*)
3	IF (*NPI* is *Medium low*) and (*ER* is *Negative*)	THEN (*Chemo* is *Maybe*)
4	IF (*NPI* is *Medium high*) and (*ER* is not *Negative*)	THEN (*Chemo* is *No*)
5	IF (*NPI* is *Medium high*) and (*ER* is *Negative*)	THEN (*Chemo* is *Yes*)
6	IF (*NPI* is *High*) and (*ER* is not *Negative*)	THEN (*Chemo* is *Maybe*)
7	IF (*NPI* is *High*) and (*ER* is not *Negative*) and (*Age* is *Young*)	THEN (*Chemo* is *Yes*)
8	IF (*NPI* is *High*) and (*ER* is not *Negative*) and (*VI* is *Yes*)	THEN (*Chemo* is *Yes*)
9	IF (*NPI* is *High*) and (*ER* is *Weak*)	THEN (*Chemo* is *Yes*)
10	IF (*NPI* is *High*) and (*ER* is not *Negative*) and (*Age* is *Old*)	THEN (*Chemo* is *No*)
11	IF (*NPI* is *High*) and (*ER* is not *Negative*) and (*LN* is *Negative*)	THEN (*Chemo* is *No*)
12	IF (*NPI* is *High*) and (*ER* is *Negative*)	THEN (*Chemo* is *Yes*)

Ensemble Improves Agreement



NSFIS Ensemble Agreement

Clinician Decision

Fuzzy Decision	No	Maybe	Yes
No	982	35	64
Maybe	2	2	2
Yes	83	15	124

Original Fuzzy Agreement

1108 (84.8%)

Clinician Decision

Fuzzy Decision	No	Maybe	Yes
No	1024	42	74
Maybe	0	0	0
Yes	43	10	117

Best Non-Stationary Ensemble Agreement

1141 (87.4%)

Summary

- Lecture summary
  - type-1 fuzzy sets model specific sort of uncertainty
    - vagueness in the concept
  - but they do not model differences of opinion, or variations in opinion
  - extensions to standard type-1 fuzzy sets, such as type-2 and non-stationary sets, allow us to model different kinds of uncertainty within a system
- Next lecture
  - module summary and revision