Closed Domain Question Answering Using Fuzzy Semantics

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Motivation

a small city near San Francisco
(example due to Zadeh)

What does small'(x) mean in terms of population? What does near'(x,y) mean in terms of distance?

How do we deal with the vagueness in ***small*** and ***near*** ?

Motivation

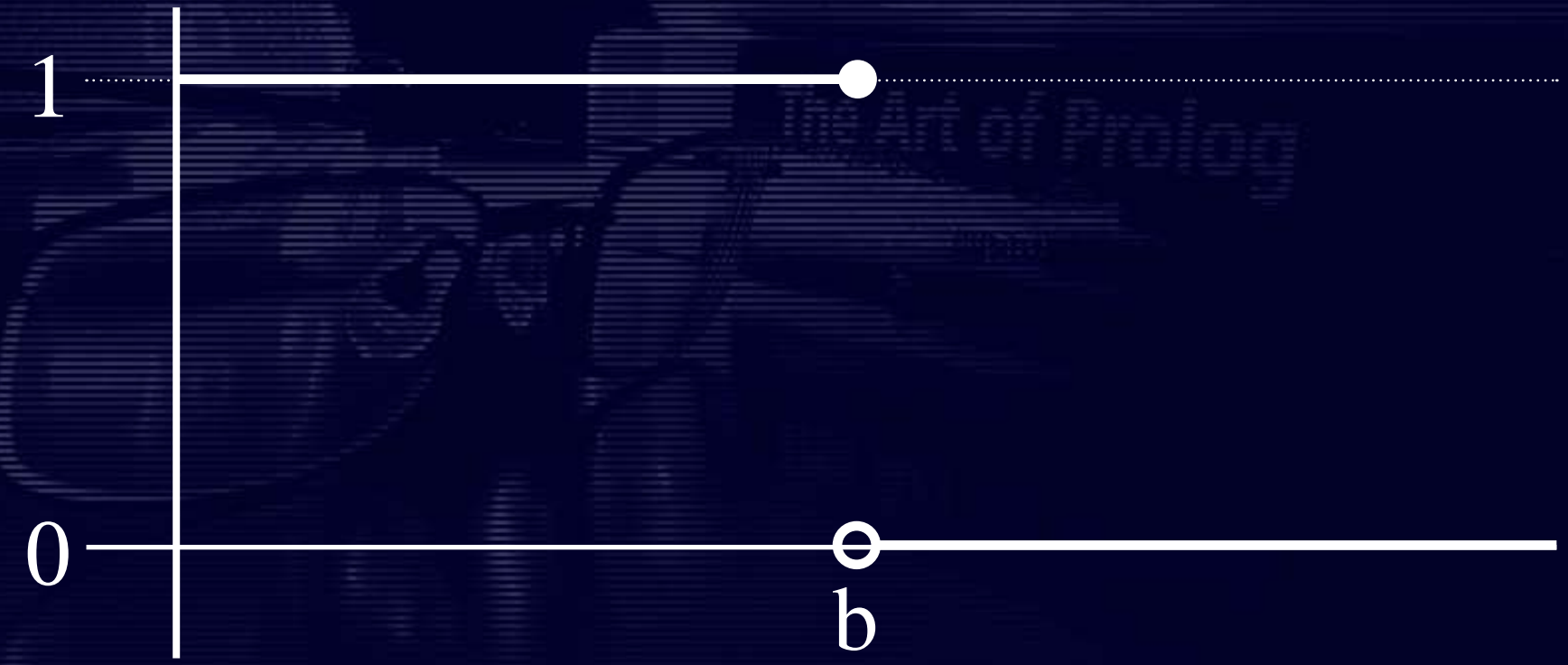
Natural Language Database Demo Interface

Query: hot dry city Submit

dof	mainid	x4.placeid	x4.placename	x4.type	x4.lat	x4.long	x4.pop	x4.temp	x4.wet
1.000	76	76	Blythe	city	984201	-1999974	8428	21	26
1.000	90	90	Brawley	city	995189	-2016437	18923	21	26
1.000	103	103	Calexico	city	1000449	-2015868	18633	20	27
1.000	106	106	Calipatria	city	992616	-2016162	2690	21	26
1.000	218	218	East Blythe	CDP	984161	-1999751	1511	21	26
1.000	233	233	El Centro	city	998552	-2016891	31384	21	26
1.000	326	326	Heber	CDP	999477	-2016206	2566	20	27
1.000	340	340	Holtville	city	998089	-2013714	4820	21	26
1.000	351	351	Imperial	city	997621	-2017094	4113	21	26
1.000	535	535	Niland	CDP	990674	-2016084	1183	21	26
1.000	727	727	Seeley	CDP	998519	-2019000	1228	21	26
1.000	842	842	Westmorland	city	994195	-2017975	1380	21	26
0.950	70	70	Big River	CDP	974939	-1995968	705	20	30
0.950	75	75	Bluewater	CDP	974337	-1994399	261	20	30
0.688	152	152	Coachella	city	982953	-2027239	16896	18	32
0.688	354	354	Indio	city	982274	-2028572	36793	18	32
0.688	483	483	Mecca	CDP	984786	-2025833	1966	18	32
0.625	529	529	Needles	city	963175	-2000378	5191	18	37
0.562	81	81	Bonita	CDP	1000641	-2042556	12542	17	33
0.562	114	114	Camp Pendleton South	CDP	990765	-2048554	11299	17	33
0.562	117	117	Carlsbad	city	992676	-2047024	63126	17	33

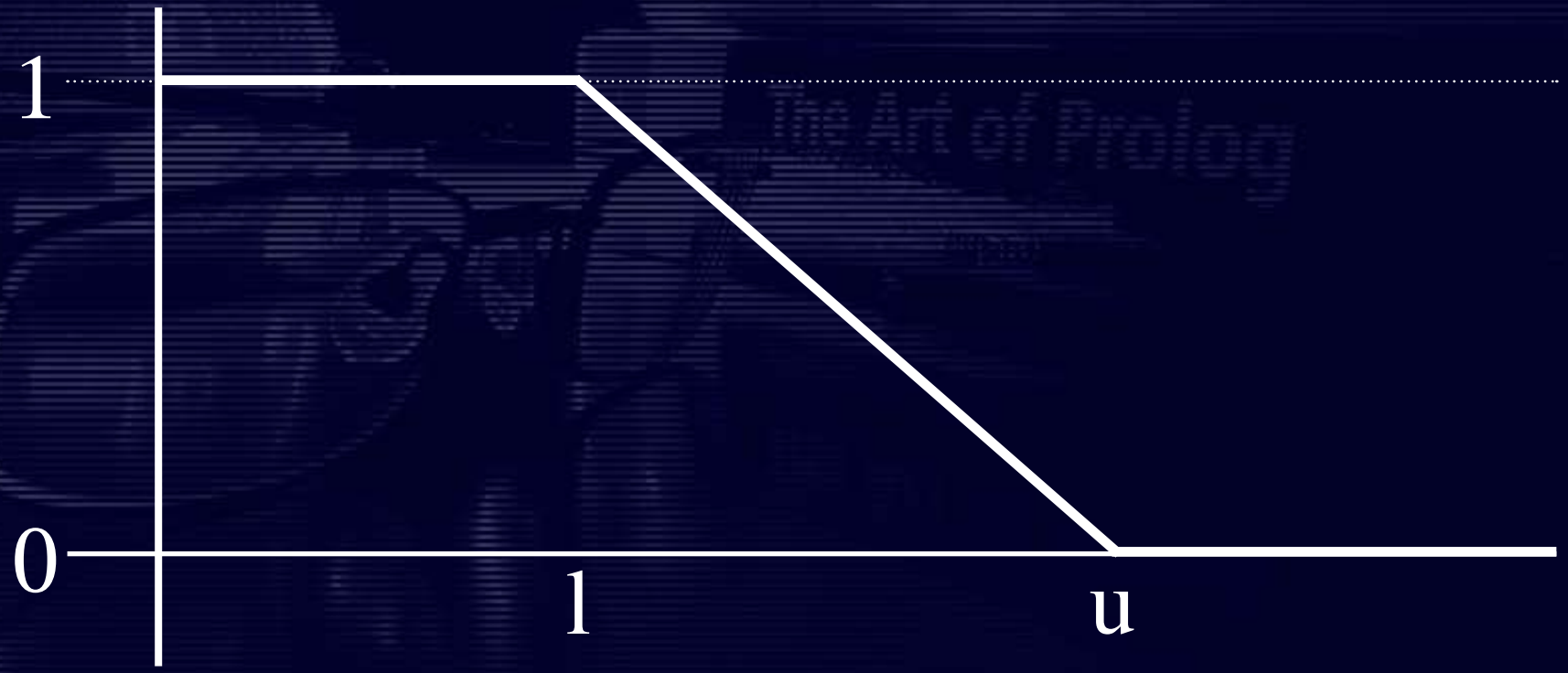
Fuzzy Logic

In classical logic: A is a set on domain X iff $\exists$ characteristic function $\chi_A : X \rightarrow \{0,1\}$ such that $\chi_A(x) = 1$ iff $x \in A$.



Fuzzy Logic

In fuzzy logic: $\mathbf{A}$ is a fuzzy set on domain $\mathbf{X}$ iff $\exists$ characteristic function $\mu_A : X \rightarrow [0,1]$ such that $\mu_A(x)$ is a degree of membership.



Fuzzy Logic

Let $\mathbf{A},\mathbf{B},\mathbf{C}$ be fuzzy sets on $\mathbf{X}$. Then $\mathbf{C} = \mathbf{A} \cap \mathbf{B}$ with $\mu_C(x) = \mu_A(x) \wedge \mu_B(x)$ iff $\wedge : [0,1] \times [0,1] \rightarrow [0,1]$ with

(1) $a \wedge b = b \wedge a$
(2) $a \wedge (b \wedge c) = (a \wedge b) \wedge c$
(3) $a \leq b \Rightarrow (a \wedge c) \leq (b \wedge c)$
(4) $a \wedge 1 = a$

For example: numeric product!

Ordering-based semantics

What exactly is it that a fuzzy set represents in a theory of natural language semantics?

A first approach: The meaning of a vague expression **is** a **fuzzy set**.

Alternatively: meaning is the **ordering imposed** on the domain **by a fuzzy set**.

Ordering-based semantics

Problem: no universal intuitions about sets.

The decision boundary for a ***tiny*** city is sometimes placed higher than for a ***small*** one, for different subjects (Bergmair 2006)

very only shifts decision boundaries when subjects can directly contrast them. (Cliff 1988, Smith et al. 1988, O' Muircheartaigh et al. 1993, Wright et al. 1995)

Conclusions

We've ***introduced fuzzy semantics*** as a new approach to semantics which provides a more adequate model of vague language.

We've ***implemented*** the model in the form of an ***NLID***, and provided ***empirical evidence*** in support of our model.

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