Towards an extended Zadeh's Computing with Words

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2011 is a very special years for me and this presentation…

First of all: MICAI-2011…

Second:

My mentor and long time friend, Professor Lotfi A. Zadeh, had his 90th anniversary

Third:

The IEEE Computer Society has has for the first time in July/August 2011 chosen as inductees to the inaugural

Artificial Intelligence (AI) Hall of Fame

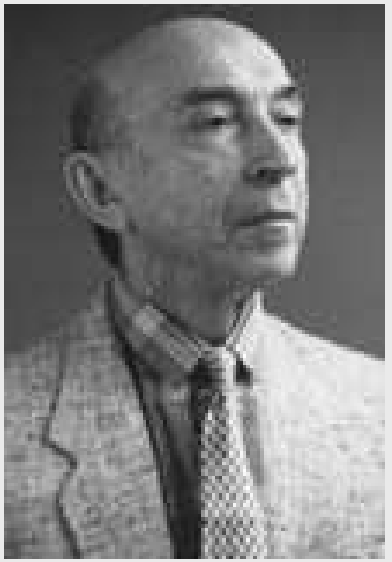
AI Hall of Fame:

Tim Berners-Lee (MIT)
Noam Chomsky (MIT)
Douglas Engelbart (SRI, Stanford, …)
Edward Feigenbaum (Stanford)
John McCarthy (MIT, then Stanford)
Marvin Minsky (MIT)
Nils J. Nilsson (Stanford)
Judea Pearl (UCLA)
Raj Reddy (Carnegie Mellon University)
Lotfi Zadeh (UC Berkeley, MIT graduate)

Zadeh in spite of working on signal analysis, control theory, systems science/analysis, and founder of fuzzy logic – a „heresy" to many AI people

So, this talk will be dedicated to:

Professor Lotfi A Zadeh
on his 90th anniversary



What is this talk about?

Many words in the title:

- **Computing**
- **Words (language, linguistics,…)**
- **Computing with Words (CWW) (computational linguistics)**
- **Fuzzy logic (implicitly)**
- **Zadeh's (reference to his views)**
- **Extended (reference to my views)**

First:

We will operate within computations, that is:

- **Fuzzy logic in the sense of computations, not as a general foundational apparatus to formalize, represent and manipulate imprecise values, concept and relations (like boolean logic in the foundations of maths),**
- **The same for Zadeh's computing with words (Zadeh's but viewed from a sligtly different perspective).**

But, if computations, then:

- **Symbolic,**
- **Numerical.**

A general attitude:

A human/social inspiration

In fact, except for pure maths in which totally abstract concepts and properties, and reasoning, may be acceptable,

in all other areas even „theoretical" we must resort to concepts and properties which are comprehensible by the humans, and follow intuition, like, e.g., in stability analysis in control theory,

But even in pure maths we use abstraction, exemplfication, etc. which are highly human specific!

Traditionally, for instance in evolutionary computing, ant colonies, bacterial and immunological algorithms, etc. a nature inspiration is employed

This boils down to the assumption that:

the (rational? leading to good results?) behavior in „inanimate" systems can be attained by mimicking (imitating) what is going on in nature, driven by some hidden forces (evolution?)

Very often leads to good results

But, the underlying assumption is that the consiousness of the individuals does not count

First:

Maybe good, but…

Suppose we operate in an optimization context

The process concerns rational agents, fully consious, who know what they want (i.e. performance function and min/max), and what they can (i.e. constraints).

In nature inspired computations we have „stupid" agents but use calculations and algorithms mimicking what we (i.e. a „wise" agent) think governs the process (e.g. evolution)

Moreover, we neglect other important elements of real animate systems, like human groups or animal herds, for instance leaders, fairness, altruism, etc.

First:

Many more important aspects, but here we will limit attention to the following perspective:

Human being is a key (or important) element of the systems we del with,

We want to operate in a proper computational framework („architecture”),

We wish to employ some „human tailored”, „human specific” computational solutions in this respect

Then:

For the human being natural language is the only fully natural means of articulation and communication,

Many powerful tools and techniques in:

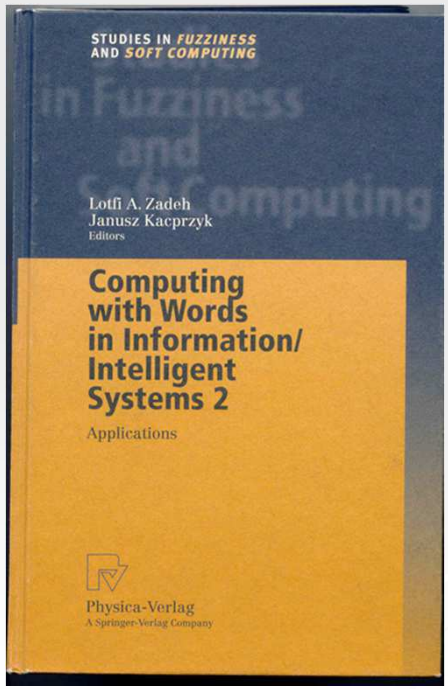
- **Computational linguistics,**
- **NLP, NLG, NLU – natural language processing, natural language generation, natural labguage understanding,…**
- **…**

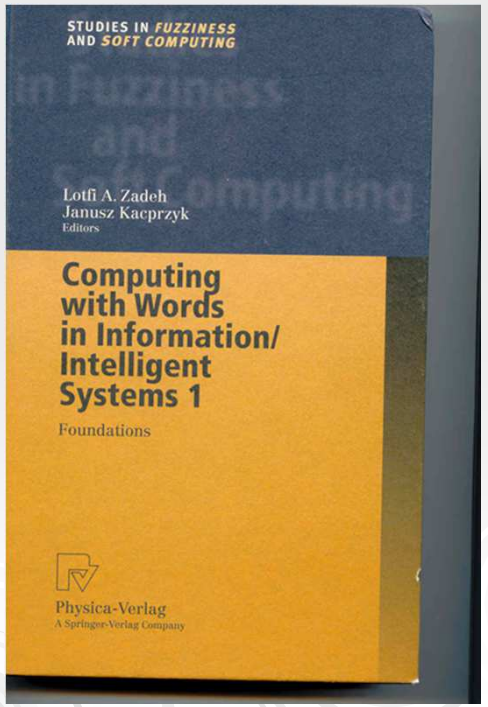
Natural language is imprecise („fuzzy”) but traditional computational linguistics tools have problems with handling imprecision,

We have Zadeh's computing with words paradigm (fuzzy logic based) – since the mid-1990s

L.A. Zadeh (1996) Fuzzy Logic = Computing with Words. IEEE Transactions on Fuzzy Systems, Vol. 4, No. 2, 103-111, 1996

In 1999:





but should be viewed from a different perspective, and set diferently (in my opinion) to really play a role

- J. Kacprzyk, S. Zadrożny: Computing with words is an implementable paradigm: fuzzy queries, linguistic data summaries, and natural language generation, IEEE Transactions on Fuzzy Systems, Vol. 18, No. 3, 461-472, 2010.

i.e. with an explicit relation to computational linguistics.

A somewhat similar attitude will be in the new book:

- **L.A. Zadeh (2012) Computing with words. Studies in Fuzziness and Soft Computing, Springer.**

An unorthodox publication project: Zadeh's most complete set of slides on CWW.

We will use Zadeh's computing with words (CWW) paradigm, but:

- **augmented with a protoform based analysis**
  Kacprzyk and Zadrożny (2005) Inf. Sciences,
- **indicating links of CWW (in the linguistic summarization aspect) to natural language generation (NLG) –**
  Kacprzyk and Zadrożny (2010) IEEE Transactions on Fuzzy Systems
- **indicating a possible power of using elements of Systemic Functional Linguistics (SFL)**
  Kacprzyk and Zadrożny (2010) – IUM-2010

But first: a proper computational framework

The setting asumed here - some „meta”-problems:

- **a growing complexity of social, technological, economic, etc. processes and systems which call for:**
  - **„good (better?) decisions”,**
  - **finding ways to an effective and efficient making those „good decisions”,**
- **a growing discrepancy between the practically constant information/knowledge processing capabilities of the human beings and a growing capabilities of the computers,**
- **A communication/articulation gap between the computer and human being:**

  strings of 0/1s for the computer and

  natural language for the human

Human being is the limiting factor

Human centric computing (M. Dertouzos)!

Prof. Michael Dertouzos (1936-2001)

Laboratory for Computer Science at MIT

- **A great scientist and visionary**
- **A good friend of L.A. Zadeh**

MIT's Laboratory for Computer Science:

- **One of the most famous and influental labs, where, for instance, time share computing was born, and most breakthrough develoments in IT/ICT have been initiated**
- **Top people (recently, Tim Berners-Lee)**

Books:

- M. Dertouzos (2001) ***The Unfinished Revolution: Human-Centered Computers and What They Can Do for Us***, Harper Collins.

  Foreword by Bill Gates!

- M. Dertouzos (1997) ***What Will Be***, Harper Collins.
- M. Dertouzos, R.K. Lester, R.M. Solow (1986) ***Made in America***, MIT Press.

Human centric computing (Dertouzos, 2001):

„…I view human-centric computing as a total commitment to the human as the starting point... I start with the interface, and then I go down to all the applications. In the approach we have had for the last 40 years, there is a machine that has all this number crunching power, and then there is an interface that lets us talk to the machine… In the new approach, you're not talking to the interface, you're talking to the machine -- it doesn't need an interface…"

This would guarantee an easy human-computer cooperation/collaboration!

Different view though similar in spirit to Witold Pedrycz's ideas (his book on human centric computing)!

Human centered computing

cf. A. Jasmine, D. Gatica-Perez, N. Sebe, Th. Huang
Human-centered computing: toward a human revolution. Computer (IEEE), May, 2007

A systems view integrating:

- **Computational tools,**
- **Cognitive aspects,**
- **Social aspects.**

For instance:

HCC: Human-Centered Computing Consortium (Univesity of California at Berkeley)

Georgia Institute of Technology, Carnegie Mellon University, etc.

Some other related ideas:

Human (based) computation (and interactive evolutionary computation) – the computer asks a person (group) to solve a problem, then collects, interprets and integrates the solutions obtained

So: the humans help the computer to solve a difficult problem (e.g. strategic planning)

For instance: University of Illinois at U.-Ch. (David Goldberg's group)

Related: Social computing, social software, symbiotic intelligence, collaborative intelligence. human computer, etc.

Human or human centric/centered/… *computing* try to attain a synergy and amplification between human abilities (e.g. intelligence) and computational power of computers!

Just how to implement these ideas!

Unfortunately, this all is easier said than done

One of the main reasons:

a lack of human centric tools!

Zadeh's computing with words can provide such tools!

It is totally commited to taking advantage of the human being's very characteristic features, mainly:

- **By using natural language as much as possible, and right from the begining,**
- **By advocating computations using human-consistent words not ''artificial" numbers,**

Computing with words and perceptions

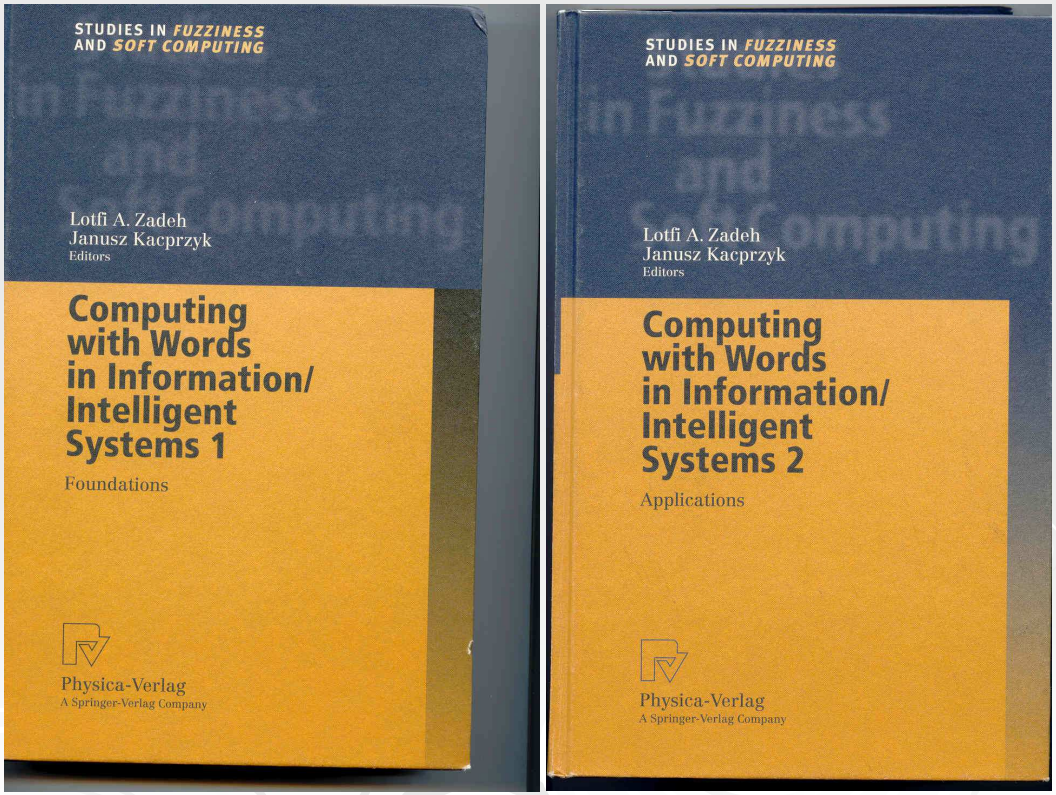
Zadeh has advocated since ca. 1995 his paradigm of

computing with words (and perceptions) -CWW

Books by Zadeh and Kacprzyk (1999a, b)

Can be viewed from different perspectives

Here: a pragmatic one



A rationale for CWW

For a human being, the only fully natural means of articulation and communication is natural language

Therefore, maybe, in many situations:

instead of traditional computing with numbers (from measurements) it would be better to compute with words (from perceptions)?

So, we may skip an ‘’artificial’’ interface (numbers) and try to operate on what is human specific:

natural language!

A key idea in CWP is that the meaning of a proposition, p, in a natural language may be represented as a generalized constraint:

X isr R

where:

- **X is a constrained variable which, in general, is implicit in p;**
- **R is the constraining relation which is in general implicit in p;**
- **r is an indexing variable whose value identifies the way in which R constrains X**

Here: r refers mainly to modality in linguistics

Modality in language:

how to communicate fine shades of meaning, notably:

- **usuality – how frequently something occurs,**
- **probability, possibility or certainty – the likelihood of something happening or being the case,**
- **obligation or necessity – how necessary it is for things to be done or to be a certain way,**
- **ability – the ability of someone or something, to do something,**
- **inclination – the inclination or willingness of someone to do something.**

CWW can well handle probability, possibility or certainty AND usuality! Ability and inclination? Other modalites?

The principal types of constraints are:

- **Equality: X is= R (X=R)**
- **Possibilistic constraint: X is R (R is a possibilistic distribution)**
- **Probabilistic constraint: X isp R (R is a probability distribution)**
- **Usuality constraints: X isu R [usually(X is R)]**
- **Veristic, rough set, etc.**

All are powerful tools for the representation and manipulation of real world uncertain, imprecise, etc. information

Not all are clearly related to modalities so that a linguistic interpretation may sometimes be difficult

Potentials of computing with words:

We can express:

- **Values of variables,**
- **Relations,**
- **Solutions (feasible, good, optimal, etc.)**

in an imprecise way, in a (quasi)natural language.

Provides means for a linguistic representations and analysis of reasoning schemes, systems, decision making, controls, data, etc.

All this in a constructive way, effectively and efficiently

Depending on our interest we can emphasize the power of computing with words from the perspective of:

- **Reasoning schemes,**
- **Systems modeling.**

Mostly some IF-THEN rules augmented with some quantification or qualification, but maybe CWW-type differential equations?

Therefore: we have tools for modelling and solving problems expressed in natural language

BTW: Zadeh, a famous systems and control theorist refers in CWW mostly to reasoning… systems modeling is more important (in „volume”)

Usuality – very important!

≡ in most, almost all, much more than 50%, ... cases

- **In our analyses we seek some „regularities”, „normal/typical” relations in data, i.e. those which usually happen,**
- **Most facts and relations in the real world are at most usually valid, etc.**

Usually valid facts, relations, etc. cannot be or are difficult to be easily handled using traditional means!

Fuzzy linguistic quantifiers!

In linguistic summariation of data, maybe the best example of the power of CWW

What is a linguistic summary of a data set (database)?

Here:

Linguistic summaries in the spirit of Yager (1982)
Fuzzy logic based!

Notably, in an implementable version:

Kacprzyk and Yager (2001)
Kacprzyk, Yager and Zadrożny (2000)

As shown by Kacprzyk and Zadrożny (2009-2010):

have a clear relation to many ideas in computational linguistics and NLG, and SFL

Basically:

- **V - a quality (attribute) with numeric and non-numeric (e.g. linguistic) values - e.g. salary**
- **$Y=\{y_1,...,y_n\}$ - set of objects (records) that manifest V, e.g. workers;**
- **$V(y_i)$ - value of quality V for object y_i, e.g. salary of worker i,**
- **$D=\{V(y_1),...,V(y_n)\}$ - set of data ("database")**

i.e. a traditional, numeric database (relational)

For instance:

			⇓		
Attribute	Sex	Age	Seniority	Salary	...
Worker y_1	male	30	10	20,000	
Worker y_2	female	40	17	18,000	
...	...	...	...	...	
Worker y_n	male	50	25	22,000	

A linguistic summary of a data set (base) consists of:

- **a summarizer S (e.g. young)**
- **a quantity in agreement Q (e.g. most)**
- **truth (validity) T - e.g. 0.7**

E.g.: T(most of employees are young)=0.7

In general:

{most, a few, many,...} of .. are {imprecise property}

Easily comprehensible, even for huge data sets!

Problem: Find a "best" summarizer and quantity of agreement (max T)

Formally: some calculus of linguistically quantified propositions is needed

Calculus of linguistically quantified propositions

[Zadeh (1983)]:

A linguistically quantified proposition, e.g.

"most (Q) experts (y's) are convinced (F)"

$$"Qy's \text{ are } F"$$

Problem:

$$\text{truth}(\ Qy's \text{ are } F\ ) = ?$$

- **Property F is a fuzzy sets in Y, and Q is a fuzzy set in [0,1] as, e.g.**

$$\mu_Q(x) = \begin{cases} 1 & \text{for } x \geq 0.8 \\ 2x - 0.6 & \text{for } 0.3 < x < 0.8 \\ 0 & \text{for } x \leq 0.3 \end{cases}$$

Then, due to Zadeh (1983):

$$\text{truth}(Qy's \text{ are } F) = \mu_Q[\frac{1}{n}\sum_{i=1}^{n}\mu_F(y_i)]$$

For an extended type:

"most (Q) of relevant (B) experts (y's) are convinced (F)"

$$"QBy's \text{ are } F"$$

we have:

$$\text{truth}(QBy's \text{ are } F) = \frac{\sum_{i=1}^{n}[\mu_F(y_i) \wedge \mu_B(y)]}{\sum_{i=1}^{n}[\mu_F(y_i)]}$$

SImple formulas!

Kacprzyk and Zadrożny's (1998 - ...) approach:

Linguistic data summary is closely related to a fuzzy query!

For instance, a summary:

„most young workers are highly qualified" (0.7)

may be derived as:

- **A fuzzy query: „retrieve all young workers who are highly qualified"**
- **Check a meaningful linguistic quantifier for which the proportion of those workers to all the workers gives the highest validity (here „most" and 0.7)**

So, we have tools:

Fuzzy queries with linguistic quantifiers (Kacprzyk and Zadrożny, 1986 – 2011)

Therefore:

Linguistic summaries make it possible to provide a vehicle for the use of verbalization in data analysis/mining

Usually, visualization is advocated (one picture is worth thousand words…)

It is true but…

Visualization distracts attention because people must look at visual representation

This is not possible in many applications like those in the military, intelligent transportation systems, etc.

So: verbalization can be decisive for an effective and efficient human-computer collaboration!

Example of own work (implementation!):

A Data Driven DSS – linguistic summaries of a database, implemented at a small-to-medium computer retailer

Kacprzyk and Zadrożny (1999 – 2007)

An example of:

- **A non-model driven approach to decision support,**
- **A human centric/centered computing paradigm,**
- **Computing with words,**
- **Verbalization of data mining results.**

Has been implemented and used for many years!

Example:...

Relations between commision and type of product:

About 1/2 of sales of network elements is with a high ommission
Much sales of accessories is with a high commission
Much sales of elements is with a low commission
About 1/2 sales of software is with a low commission
About 1/2 sales of computers is with a low commision

So:

- **No problem with accessories and network elements,**
- **Critical are: elements, software and computers!**

Extensions (external data from WWW)

Own database only!

But: a company operates in an environment (e.g. weather)

So, e.g., Irelations between group of products, time of sale, temperature, precipitacion, and type of customers:

Very few sales of software in hot days to individual customers
About 1/2 of sales of accessories in rainy days on weekends by the end of the year
About 1/3 of sales of computers in rainy days to individual customers

Very positive experience!

- **Very useful fo „decision support”**
- **Easy to use (aft er the initial setup stage, calibration, etc.),**
- **Intuitively appealing results,**
- **Inexpensive technology,**

The use of natural language gives a new human centric type quality!

Verbalization is powerful!

Collaboration of the human decision maker and the DSS is very natural and easy

But the generation of linguistic summaries may be computationally difficult, notably for large data sets

A next step:

What is strange with CWW?

Though the power of computing with words can be immediately seen, and the idea is „natural”, there has been no interaction with the huge and powerful communities of:

- **computational linguistics**
- **natural language processing/generation/… (NLP/NLG)**

No mutual citations, no cross-fertilization, etc. though the University of California, Berkeley is famous both for CWW and computational linguistics, and Professor Zadeh is a close friend of top linguists there!

Recently, we try to bridge that detrimental gap in the context of natural language generation (NLG)

Different approaches in NLG:

- **Text – to – text: a simpler textual summary of a longer, more complicated text (normaly written but maybe spoken)**
- **Numbers – to – text: a simple natural language summary of the very essence of a (large) set of numerical data – HERE!**

J. Kacprzyk, S. Zadrożny: Computing with words is an implementable paradigm: fuzzy queries, linguistic data summaries, and natural language generation, IEEE Transactions on Fuzzy Systems, Vol. 18, No. 3, 461-472, 2010.

A strong relation between the concept of a linguistic database summary, and the way of their derivation, and natural language generation (NLG) is clear

However, for strange reasons this path has never been explored until Kacprzyk and Zadrożny (2009) at IEEE Symposium Series in Nashville, TN, USA

Maybe the first indication was in Kacprzyk, Wilbik & Zadrożny (2006-2008) where some reference to an NLG based linguistic summarization of time series, the SumTime project at the University of Aberdeen (Reiter et al.) was indicated

SumTime:

Project coordinated by the University of Aberdeen, UK

Headed by Professor Ehud Reiter

an EPSRC Funded Project for Generating Summaries of Time Series Data:

www.csd.abdn.ac.uk/research/sumtime/

„Our goal is to develop technology for producing English summary descriptions of a time-series data set.

…

Currently there are many visualisation tools for time-series data, but techniques for producing textual descriptions of time-series data are much less developed.

…

Some systems have been developed in the natural-language generation (NLG) community for tasks such as producing weather reports from weather simulations, or summaries of stock market fluctuations, but such systems have not used advanced time-series analysis techniques.

Our goal is to develop better technology for producing summaries of time-series integrating leading-edge time-series and NLG technology data by "

Some results (concerning wind):

- **WSW (West of South West) at 10-15 knots increasing to 17-22 knots early morning, then gradually easing to 9-14 knots by midnight,**
- **During this period, spikes simultaneously occur around 00:29, 00:54, 01:08, 01:21, and 02:11 (o'clock) in these channels.**

Similar linguistic summaries have been obtained for time series data concerning blood pressure, gas turbines, etc.

Do not fully account for imprecision (only intervals)

,Generate automatically weather forecasts for some weather Web sites!

More standarized than by human weatherpersons, people prefer them

NLG may be viewed from many perspectives and for us it may be expedient to consider independently:

- **the *tasks* of generation, and**
- **the *process* of generation.**

One can identify three tasks of generation:

text planning, sentence planning, and surface realization

- **Text planners select what information to include in the output, and use it to form a proper text structure,**
- **Sentence planners organize the content of each sentence, notably ordering its parts,**
- **Surface realizers convert sentence sized chunks of representation into grammatically correct sentences.**

We are mainly concerned with the text planning aspect since our approach is protoform based.

But sentence planning is also somehow involved as we can use different protoforms tailored to specific domains or users

In principle, our approach is similar in spirit to template based systems.

One can say that Zadeh's protoforms can be viewed as playing a similar role to templates.

However, the protoforms are much more general and may represent various "templates" that maybe it would be more proper to call them:

meta-templates

On the other hand, it seems that our approach to linguistic summarization can be viewed as a very simple phrase-based system

As protoforms may form hierarchies, both the phrase and its subphrases can be properly chosen protoforms

The calculi of fuzzy linguistically quantified statements can be extended to handle such a hierarchic structure of phrases (statements) though with problems

Domain modeling is very relevant. The main problem is that it is very difficult to link a generation system to a knowledge/data base that was originally developed for some nonlinguistic purpose – there may be a considerable mismatch

Construction of appropriate taxonomies or ontologies can be of help.

J. Kacprzyk and S. Zadrożny (2010) Soft Computing

In our approach, domain knowledge is so far – at the conceptual level – in the specification of appropriate protoforms which are comprehensible or traditionally used (as structures of, say, business reports) in a specific domain

To summarize relations between our protoform base approach to the linguistic summarization and NLG:

- **on the one hand, we can find much inspiration from recent developments in NLG, notably in the adjusting of protoforms to what is comprehensible and/or commonly used in a specific domain by using some sentence and text planning tool,**
- **we can find a deep justification for the power of Zadeh's protoforms by showing their intrinsic relation to (meta) templates.**

On the other hand, NLG can benefit from our approach by getting simple, yet effective and efficient means to deal with the imprecision of meaning.

NLG may provide us software, open source and commercial – EXTREMELY IMPORTANT!

Therefore:

- **We found a close relation between linguistic summarization (a key „product” of CWW) with a big, well developed, popular area of natural language generation, with powerful results and software.**

Next: is there something interesting in computational linguistics, NLP or NLG, or related areas, that can be of use for us?

Yes:

J. Kacprzyk, S. Zadrożny: Computing with words and systemic functional linguistics: linguistic data summaries and natural language generation. In: V.-N. Huynh et l. (Eds.): Integrated Uncertainty Management, AISC 68, pp. 23-36, Springer, 2010.

Invited paper for the retirement of Professor Michio Sugeno

We think that elements of Halliday's Systemic Functional Linguistics can be of use!

Michio Sugeno's vision and first noticable event:

Matthiessen Ch. (1995) Fuzziness construed in language: a linguistic perspective. Proceedings of FUZZ-IEEE/ IFES '95 (Yokohama). pp.1871-1878.

Then, many influential works by Sugeno, Kobayashi, etc. (in the 1990s and 2000s)

But: in contrast to Sugeno's grand vision of SFL as a general vehicle to formulate, model, solve, implement complex „intelligent" and „human centric" tasks (which failed…)

we advocate the use of SFL just for natural language generation related tasks!

Basically, in traditional approaches to formal languages, computation linguistics, etc. language is considered as an abstract, separate entity, viewed:

formally and syntactically

Systemic Functional Linguistics (Halliday, 1960s-…):

- **language should be studied in a context, and**
- **with respect to a purpose (e.g. in business to communicate financial matters to interested parties).**

A pragmatic perspective:

language is a resource used by people to accomplish their tasks and purposes by expressing and communicating meanings in contexts

functionally and semantically

The description of language can be considered on different levels, or strata, of language:

- **context,**
- **semantics,**
- **lexicogrammar, and**
- **phonological.**

SFL is a general purpose paradigm but was considered particularly well suited for natural language generation (Henrici's paper in the mid 1960s!)

Exactly what we mean and need!

SFL is a general purpose paradigm but was considered particularly well suited for natural language generation (Henrici's paper in the mid 1960s!)

Texts express meanings "understandable" and relevant in a particular context

The analysis of context is broken down to:

- **Field: what is happening, the nature of the social interaction, what is it that the participants are engaged in, etc.**
- **Tenor: who is taking part; the status, social roles and relationships of participants,**
- **Mode: the symbolic organization of the text, rhetorical modes (persuasive, expository, didactic, etc); the channel of communication (spoken/written, monologue/dialog, visual contact, computer-mediated communication, etc.)**

Briefly, in our context of linguistic summarization (i.e. natural language generation):

- **Various fields (purposes): day to day managerial and puchasing decisions, negotiations with suppliers, mutual fund investment decisions, etc.**
- **Various tenors: the owner of the computer retailer, mutual fund investment advisor, mutual fund investors with different familiarity with products, risk, etc.**
- **Various modes: linguistic summaries for the explanation, for persuading to purchase shares in particular mutual funds, etc.**

SFL seems to provide very useful tools and techniques!

Therefore, we:

- **Started with the use of Zadeh's computing with words, notably linguistic data summarization,**
- **We arrived at relations between CWW and developments in powerful and rapidly developing fields of computational linguistics and natural language generation through:**

  - **First, an intrinsic relation between our aproach to linguistic data summaries and natural language generation,**
  - **Second, a possible contribution of some tools of Systemic Functional Linguistics for our works on natural language generation, from the point of view of linguistic data summarization meant in the context of computing with words.**

And, more generally:

- **Computing with words (fuzzy logic based) can provide tools to handle imprecision,**
- **Computing with words can be made easier implementable by using tools of natural language processing and generation,**
- **Some contribution can also be expected by using some other tools, exemplified by systemic functional linguistics.**

This is extremely important for fuzzy logic!

Why?

I will quote an excerpt from my talk at the Roundtable Discussion on Uncertainty at WConSC-2011 in San Francisco

"It's the economy, stupid"

a famous phrase widely used during Bill Clinton's successful 1992 presidential campaign against George H.W. Bush

The phrase, made popular by Clinton's campaign strategist James Carville referred to the fact that Clinton was a better choice because Bush had not adequately addressed the economy, in recession

In our case, in science:

”It’s the applications, stupid”

because, sooner or later our success will be judged by the usefulness of what we will be doing

Therefore, my message is:

Sound and high level research but focused on usefulness (implying potential applications) is what is needed in any areas, also in our case of fuzzy logic, CWW, etc.