TOWARDS HUMAN/SOCIAL INSPIRED COMPUTATION

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What is the very purpose of this talk:

- We deal with a human centric/centered system, i.e. a system in which a human being (individual, group, organization) plays a crucial role,
- We have a problem to be solved (of a decision making type, i.e. to find a solution, some „best" option/s),
- We wish to find a „good solution" (acceptable by the human decision maker),
- We argue that for that some inherent human characteristic features should be accounted for,
- We advocate the use of various hybrid and synergistic combinations of tools and techniques,
- We show an implementation – an inexpensive technology

And we wish to use some „computation", not, e.g., a verbal analysis

In particular, we discuss:

- Some new approaches to real world decision making, including intuition, emotions, emergence,
- The role of results obtained in behavioral economics and neuroeconomics that are relevant for us,
- Some aspects of decision support systems that are relevant for our discussion, mostly non-model driven ones,
- Some aspects of new human centric/centered computing, notably those developed at MIT,
- The role of natural language, notably Zadeh's computing with words,
- A central role of data mininng and summarization, and the role of verbalization via computing with words and natural language generation,
- An implementation – an inexpensive technology

That is:

This will be about human/social inspiration because of:

- New decision making models and paradigms
- Emphasis on natural language

And, we will somehow relate our discussion to both:

- Professor Leonid Perlovsky's plenary talk (natural language!)
- Pofessor Edward Tsend plenary talk (different rationalities)
- Professor Qiang Shen's plenary talk (intelligent decision support systems)

because of importance of topics they discuss

The basic purpose of the talk is to try to address the following problem:

What to do when we face a „complex problem" (maybe characterized by a complex dynamics, much uncertainty, etc.) and have to SOLVE IT EFFECTIVELY AND EFFICIENTLY (but, first, to MODEL them!)

So: we have to use whatever approaches, paradigms,tools, techniques, etc. may be useful

Mathematics, social sciences, cognitive sciences, IT,...

A complex system: no clear-cut definition, but maybe:

- Self-organization: a change naturally occurs which leads automatically toward increasing the overall functioning of the system by making parts and sub-processes that work well become stronger, and parts and sub-processes that don't work so well become weaker (natural selection!)
- Non-linearity: all parts of the system affect many other parts throughout the system, and then affects them back, …change, cause and effect are not due to a single one-way sequential line of events, but reflects interactive influence through feedback.
- Chaotic behavior: results inherently become less predictable getting farther from the original conditions,
- Emergent properties: completely unpredictable results can emerge from their original conditions.

Emergence:

- A direct expression of the vitality of complex „non-linear” dynamic systems,
- The most powerful manifestation of a remarkable self-organizing ability of complex dynamic systems,

Something new, unexpected, …

Relations to creativity and innovation

Relations to the so-called „aha” and „eureka” efects

Decision making under conditions of complexity and chaos, which can imply emergence, is very difficult:

- „linear” decision making models are incompatible with „nonlinear” dynamics (chaos),
- valuation of decisions at certain time moments looses its „objective” meaning (what is considered good now can be wrong pretty soon),
- many „non-scientific” aspects like emotions, intuition, etc. can be decisive, etc.

In this presentation, we will:

- advocate a need of decision support for solving complex problems,
- Show that some new computing paradigms" may help,
- Show how that „intelligent systems" can be useful,
- indicate how some elements related to complex problems can be handled,
- Show potentials of natural language,notably Zadeh's computing with words, and natural language processing/generation,
- Show some example of implementation.

Sooner or later:

Transition from inanimate to animate (human centric/centered systems)

This significantly changes the situation because:

even the most complex inanimate systems do not exhibit „nasty" deficiencies of humans, notably various inpredictabilities, inconsistencies, „irrationality", etc.

Moreover, for the humans the only fully natural means of articulation and communications is natural language (strange to the „machine"!)

A gap between the human and the „machine"!

With humans we would rather go for a decision support philosophy for solving (complex) problems, that is we assume that:

- Human decisionmakers are (quite? very?) good at solving (complex) problems, and they know how to solve them,
- For human decisionmakers additional information (decision support) should be helpful while making decisions,
- The human decision makers are autonomous, i.e. they can make decisions by taking into account or not our advice (support).

A (ideal?) solution would be:

- To use new, complexity oriented, human-consistent models of decision making,
- To use modern architectures and implementations of decision support systems,
- To involve some sort of „intelligence”,
- To follow some modern computing paradigms,
- To use proper computation tools to implement those paradigms,
- To explicitly deal withnatural language,
- To show their implementability.

This is our line of reasoning

Point of departure: decision making - Omnipresent!

First formal attempts: a structured problem:

- Set of options X={x},
- A preference structure (utility function), e.g. f(x)
- A simple rationality, i.e. a best decision is chosen (optimization):

$$x^* = \arg\max_{x \in X} f(x)$$

Many extensions: multiple criteria, multiple decisionmakers, dynamics, etc.

But, all are inappropriate for complex problem („linear" thinking!)

Decision making process:

- Use of own and external knowledge,
- Involvement of various „actors”, aspects, etc.
- Individual habitual domains (P.L. Yu),
- Use of explicit and tacit knowledge,
- Use of intuition,
- Non-trivial rationality,
- Different paradigms when appropriate.

Virtually all elements are ''human specific'', best expressible in words!

Habitual domains: a set of ways of thinking, judging and responding, etc. acquired by a person

Knowledge:

- **Tacit knowledge** (Polanyi, 1966) is difficult to articulate, highly personal and hard to formalize, difficult to communicate or to share with others; includes subjective insights, intuitions, and hunches,
- Explicit knowledge is more easily transmitted as it may be codified, and is therefore more easily processed and shared.

In reality, both are often vaguely defined → natural language!

Intuition plays a particular role!

Different views, schools, etc.

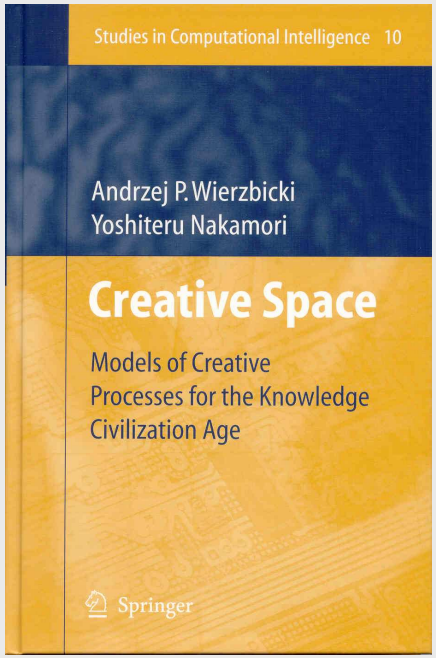
For instance:

- **Intuition** is an unconsious form of knowledge, not open to rational an/or analytical thinking and analyses.
- **Intuition** is thought as the sixth sense. Recent scientific research has found some evidence for the existence of this sixth sense and lots of unconscious processes,
- etc.

Wierzbicki AP and Nakamori Y. (2005, 2007):

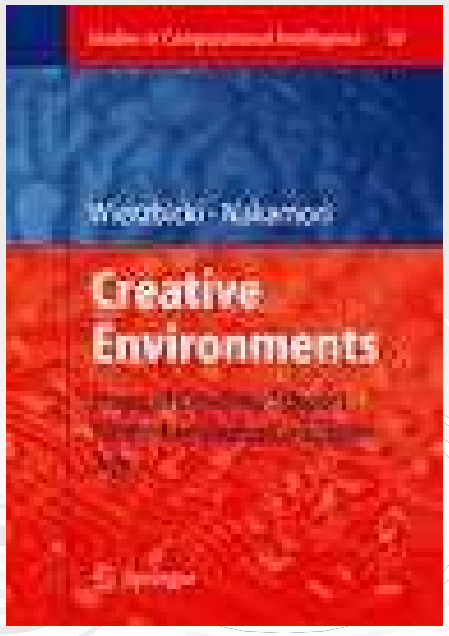
JAIST – Japan Advanced Institute of Science and Technology)

Japan: vital dependence on innovation!



Famous book:

Ikuhiro Nonaka and Hiritaka Takeuchi (1995) The Knowledge-Creating Company: How Japanese Companies Create the Dynamics of Innovation. Oxford University Press.



Peter Checkland's (1975-99) soft approach to systems analysis

and deliberative (soft) decision making:

- To perceive the whole picture,
- To observe it from all angles (actors, criteria,...)
- To find a good decision using knowledge and intuition.

But, if you look at some newer approaches (e.g. neuroeconomics, behavioral decision making): deliberation is somehow undermined, and emotions are more emphasized!

This is a traditional approach:

much emphasis on deliberation, "'rational behavior", etc.

Homo economicus!

„linear" thinking!

In general, inappropirate for complex problems

What to do?

One of the directions:

Maybe the model of a traditional deliberative („rational”) decision maker:

- Greedy (a direct result of the traditional utility maximization that is the basis for optimization, control, etc. or the use of traditional game theoretic solution concepts) is not appropriate?
- Deliberative (a „cold” calculating agent)

is not always a good solution?

New approaches like, for instance:

- Behavioral economics (decision making),
- Neuroeconomics,

advocate, for instance, a „homo neuroeconomicus”:

- less greedy,
- favoring fair solutions,
- more emotional,…

Modern decision making paradigms:

- Heavily based on data, information and knowledge, but also on human specifics (intuition, attitude, emotions...)
- Need number crunching, but also more ‘’delicate” and sophisticated analyses,
- Heavily relying on computer systems, and capable of a synergistic human-computer interaction.

So: Decision support systems!

Should be human centric/centered!

Should be human consistent!

Should be intelligent!

What is a decision support system (DSS)?

Not clearly understood!

- Decision support systems are a class of computer-based information systems that support decision making activities.
- Because there are many approaches to decision-making and because of the wide range of domains in which decisions are made, the concept of *decision support system* (DSS) is very broad.

A basic philosophy:

- Non-trivial (complex) problems are considered (formal models?)
- How decision making proceeds?
- Some support (models, information, …) should help,
- Human being is better (in complex situations!) than the „machine”,
- Human being is autonomous

Roots of DSs:

The concept of decision support has evolved from two main areas of research:

- the theoretical studies of organizational decision making done at the Carnegie Institute of Technology (now Carnegie Mellon University) during the late 1950s and early 1960s, and
- the technical work on interactive computer systems, mainly carried out at the Massachusetts Institute of Technology in the 1960s, and development of IBM 360 and a wider use of distributed, time-sharing computing

The concept of DSS became an area of research of its own in the middle of the 1970s

Multidisciplinary field including (but not only):
database research,

- artificial intelligence,
- human-computer interaction,
- simulation methods,
- software engineering,
- telecommunication, etc.

Basic types of DSSs:

- Communication driven and group DSSs,
- Document driven,
- Model driven,
- Knowledge driven,
- Web based and interorganizational.
- Data driven,

All non-models-based (driven) ones:

- emphasize access to and manipulation of internal and external data, numerical or textual, even multimedia,
- facilitate collaboration between decisionmakers,

Only the model-based (driven) one explicitly uses models to derive solutions that can suggest the human decisionmakers a good (best?) course of action

The best: a synergistic combination

Is a model of a (decision making) problem considered **necessary?**

No! But maybe helpful…

A famous citation:

”All models are wrong, some models are useful”

Box, G.E.P., Robustness in the strategy of scientific model building, in Robustness in Statistics, R.L. Launer and G.N. Wilkinson, Editors. 1979, Academic Press: New York.

Promising DSSs – a „synergistic”, „superadditive” mixture of their different types!

A model of situation is not necessary!

Intelligent(?)!

So far:

- Some non-conventional approaches and models,
- Some promising types and architectures of decision support (decision support systems)

We would like to have something deeper: a proper computing paradigm

More than „human consistent”, rather human centric/centered

Here: mostly the MIT perspectivedue tomy relation (a PhD student at MIT Lincoln Lab)

Human centric computing at MIT

Prof. Michael Dertouzos (1936-2001)

Laboratory for Computer Science, MIT

A great scientist and visionary

- M. Dertouzos (2001) ***The Unfinished Revolution: Human-Centered Computers and What They Can Do for Us***, Harper Collins.
- M. Dertouzos (1997) ***What Will Be: How the New World of Information Will Change Our Lives***, Harper Collins.

  Foreword by Bill Gates!
- 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…"

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 Tech, Carnegie Mellon, 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 by the human(s)

So: the humans help the computer to solve a difficult problem

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

Therefore…

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

So, the very basic philosophy of all of them is similar!

Just how to implement these ideas!

This all is easier said than done because of

a lack of human centric/centered tools!

In my opinion, natural language related Zadeh's computing with words provides 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,

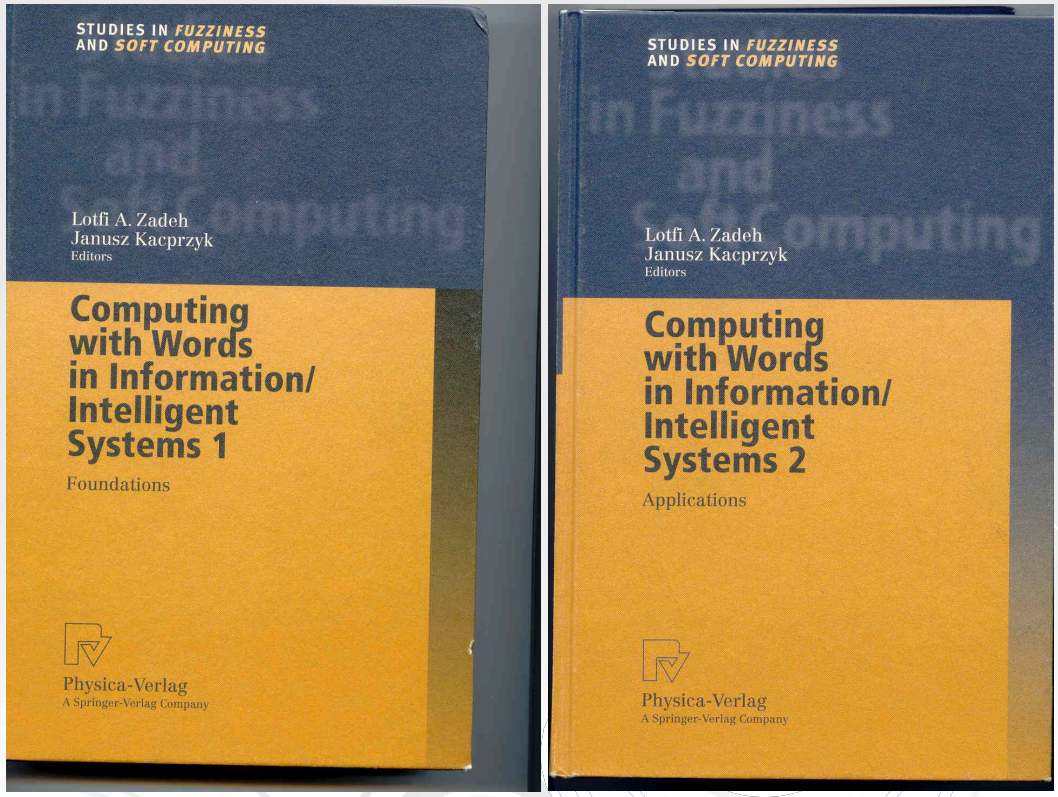
Computing with words and perceptions

Zadeh has advocated since

ca. 1995 his paradigm of

computing with words and perceptions (CWP)

Books by Zadeh and Kacprzyk (1999a, b)



Computing with words (and perceptions):

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: how to communicate fine shades of meaning and allows us to express degrees of (degree – even in traditional approaches!):

- **usuality** – how frequently something occurs or is true,
- 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: obligation, inclination?

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 probabilistic 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

Usuality constraint is 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!

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 systems, decision making, controls, data, etc.

All this in a constructive way, effectively and efficiently

Totally human centric/centered/oriented/…!

Protoforms ⇒ prototypical forms

For instance: most Swedes are tall

almost all old cars are unreliable

In general: QA's are B's

Protoforms: **abstracted summaries!**

Very convenient in linguistic summarization!

Kacprzyk and Zadrożny (2005-…)

Do they have a relation to something relevant in other areas?

Microsoft Research:

Natural Language Processing (NLP): to design and build software that will analyze, understand, and generate languages that humans use so that eventually one will be able to address your computer as though you were addressing another person. This goal is not easy to reach.

"Understanding" language means … knowing what concepts a word or phrase stands for and knowing how to link those concepts together in a meaningful way.

It's ironic that natural language, the symbol system that is easiest for humans to learn and use, is hardest for a computer to master.

The challenges we face stem from the highly ambiguous nature of natural language…

We expect… to enable any area where humans can benefit by communicating with their computers in a natural way.

Close to our human centric/centered computing paradigms!

But, further:

Natural language generation (NLG)

- a subfield of computational linguistics and language-oriented artificial intelligence devoted to studying and simulating the production of written or spoken discourse,
- a multidisciplinary enterprise, requiring expertise in linguistics, psychology, engineering and computer science,
- a central goal is to investigate how computer programs can be made to produce high-quality natural language text from computer-internal representations of information,

Four main categories of NLG techniques:

- Canned text systems for single-sentence and multi-sentence text generation; trivial to create, but very inflexible,
- Template systems, via the application of pre-defined templates or schemas and are able to support flexible alterations; mainly for multi-sentence generation, particularly in applications whose texts are regular in structure,
- Phrase-based systems use generalized templates in which a phrasal pattern is first selected to match the top level of the input, and then each part of the pattern is recursively expanded into a more specific phrasal pattern,
- Feature-based systems so far restricted to single-sentence generation, represent each possible minimal alternative of expression by a single feature; the generation consists in the incremental collection of features appropriate for each portion of the input;.

So:

Zadeh's protoforms have a close relation to the basic, presumably most practically relevant template based natural language generation!

An implementation

Today:

too much data,

too detailed,

still a gap between the „machine" (numeric data, statistical „summaries", ...) and the human being (natural language, visual information,...)

We need:

human centric/centered/friendly/consistent techniques of data summarization

Here:

linguistic summaries in the spirit of Yager (1982)

Fuzzy logic based!

Notably, in implementable version:

Kacprzyk and Yager (2001)

Kacprzyk, Yager and Zadrożny (2000)

For instance, for a relational database:

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}

Problem: find a linguistic summary maximizing T

Therefore: a linguistic summary:

- Intuitive,
- Simple,
- Extendable (Kacprzyk and Yager, 2001),
- Implementable, ...

But:

- Concerns relational (numerical) databases!
- Fully **structured** data!

Today, more and more semi-structured data:

irregular, dynamically changing structure, missing data,...

Common in most data sources:

- Web pages,
- SMSs,
- E-mails, ...

Why?

- Inherent feature of the above,
- Data from multiple sources (different systems, different structure, „machine” and human),

Linguistic data(base) summaries and fuzzy database queries

Kacprzyk and Zadrozny'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: „give me 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:

- Use the FQUERY for Access (Kacprzyk and Zadrożny, 1994 -...) add-in to formulate a fuzzy query as, e.g., find all young workers,
- Run such a query on a database considered,
- Check, how many (e.g. most, almost all, much more than a half, ...) workers fulfill the query with the highest truth (validity).

Thus: a close interaction with the human who formulates through the fuzzy query which atrubutes are of interest!

Example of implementation

A computer retailer in South Poland:

- 15 workers,
- Individual and corporate customers,
- Hardware, software, networks, etc.
- Retail, service, etc.

Owner: must make sophisticated decisions concerning:

- number of employees on Saturday,
- type of advertisement,
- commissions from suppliers, setting prics, etc.

Difficult to formulate!

But: the owner is very busy

$\Rightarrow$ Simple summaries, in natural language!

Inexpensive technology,

add-in without any „touching” his database!

For instance, if we are interested in relations between **commission** and **type of product**

We can obtain linguistic summaries as:

- About 1/2 of sales of network elements is with a high commission
- 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 m
- About 1/2 sales of computers is with a low commission
- ...

So: No problem with accessories and network elements, critical are: elements, software and computers!

Relations between group of products and time of sale:

- About 1/3 of sales of computers is by the end of the year
- About 1/2 of sales of accessories in the the autumn
- Very few sales of software is the beginning of the year
- About 1/3 of sales of peripheral devices is in the spring
- About 1/3 of sales of software in by the end of the year
- Very few sales of network elements is in the autumn
- Very few sales of software is in the summer
- ...

So, e.g.:

Software – autumn and winter but not summer

Extensions (external data - Internet)

Own database only!

But: a company operates in an environment in which many factors are of relevance, exemplified by weather, economic situation, etc.

Can we take into account those external elements (in a **simple and inexpensive way?**)

Yes! **Internet!**

E.g.: Linguistic summaries of own database + **weather data**

We obtain, for instance:

Relations between group of products, time of sale, temperature, precipitation, 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 useful!

Implementation! Cheap technology!

Also in a dynamic context

Project coordinated by the University of Aberdeen, UK, **SumTime**, 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 .uctuations, but such systems have not used advanced time-series analysis techniques."

For example summaries related to wind direction and speed:

- 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.

But: no account for imprecision!

Also in a dynamic context

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"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

Our works:

Kacprzyk, Wilbik and Zadrozny (2005-2008):

Use CWW, notably Zadeh's protoforms,

Lingusitic summaries of time series related to the performance of a mutual (investment) fund:

- Most slowly decreasing trends are of a very low variability
- Almost all increasing trends are short,…

Implementation!

Conclusions:

We wished to show some approaches to develop modern human/social inspired, human centric/centered/consistent/… system based paradigm for solving complex problems,

Emphasis was on:

- A new view of decision making as a not exclusively deliberative and greedy type approach, but combined with emotional and fairness elements,
- The use of the decision support system paradigm,
- A wide use of natural language (in the spirit of Zadeh's computing with words), mainly in terms of NLG (natural language generation).