Decision aid, decision advice, decision support: when, why, for whom

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We wish to:

- **Discuss modern approaches to decision making (for complex problems!), notably to decision processes,**
- **All this in the setting of „human centric" problems/systems, i.e. in which the human being is crucial.**
- **Advocate an urgent need for helping the human decision makers by some formal and algorithmic, as well as IT/ICT based solutions,**
- **Discuss the decision aid, decision advice/recommendation and decision support (systems) as possible ways of solving problems,**
- **Discuss for which problems and for which decision makers a particular way of solving problems may be of value,**

All this from the perspective of human-computer interaction (cooperation and collaboration)

In our research and scholarly community (computer scientists, decision theorists and analysts, systems theorists, control theorists, etc.):

move towards more and more complex problems and systems

And sooner or later we proceed:

from inanimate to animate systems

Finally, we encounter:

systems in which the human being (individual or a group) is a key element

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 computer!)

A gap between the human being and the computer!

But they must collaborate to solve tasks so that the gap should be made narrower

Two lines of reasoning:

- **Use human consistent frameworks, paradigms, computing, etc.**
- **Use human consistent models and solution „technology” for the formulation and solution of decision making problems.**

In general, we wish to bridge an inherent gap between the human being and the „machine” (computer) which, in our context, boils down to the following:

- **For the human being, natural language that is the only fully natural means of communication and articulation but not for the computer!**

Many attempts to bridge this gap, a long history

First, those proposed with a broad area of man-machine, human-computer,… interfaces (e.g. Ben Shneiderman)

What is going on in this direction?

Very much!

- **At top universities (MIT, University of California at Berkeley, Carnegie Mellon University, University of Illinois, Georgia Tech, Imperial College, etc.),**
- **An NSF Program: Information and Intelligent Systems: Advancing Human-Centered Computing, Information Integration and Informatics, and Robust Intelligence,**
- **Large industrial projects: IBM, Microsoft, HP, Nokia, Philips/LG…**

Here: mostly MIT and UC Berkeley

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!

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!

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.

- **Human centered computing - a systems view integrating: computational tools, cognitive aspects, social aspects,**
- **Human (based) computation, interactive evolutionary computation – the computer asks a person (group) to solve a problem, then collects, interprets and integrates the solutions obtained (e.g. David Goldberg's works)**
- **Humanistic intelligence (S. Mann): arising from the human in the feedback loop of a computations involving wearable „computers" (e.g. smartphones),**
- **Related: Social computing, social software, symbiotic intelligence, collaborative intelligence etc.**

Moreover, from a different perspective:

- **„human-in-the-loop” which is basically a paradigm (model) that requires human interaction increasing the efficiency of modeling and simulation, machine learning, problem solving (e.g. strategic planning), etc.**
- **„society-in-the-loop” (Rahwan, MIT), a scaled up version of „human-in-the-loop”,**

Basically:

Human-in-the-loop (e.g., MIT, UCBerkeley!):

Human judgments:

goals, constraints, expectations, intentions, preferences, knowledge, etc.

→

Autonomous (AI?) system:

data, algorithms, models, performance functions, etc.

Society-in-the-loop (e.g. MIT):

Human values:

Rights, ethics, law, human/social rights, privacy, equity, fairness, social contract, etc.

→

Autonomous (AI?) system:

data, algorithms, models, performance functions, etc.

Therefore…

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

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

Implementation!!!

Second: towards human consistent decision making

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 decision makers, dynamics, etc.

Recent trends

Decision making process (first mentioned probably by Snyder in the 1950s):

- **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!

Some non-standard elements:

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, 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:

Intuition plays a particular role!

Different views, schools, etc.

For instance:

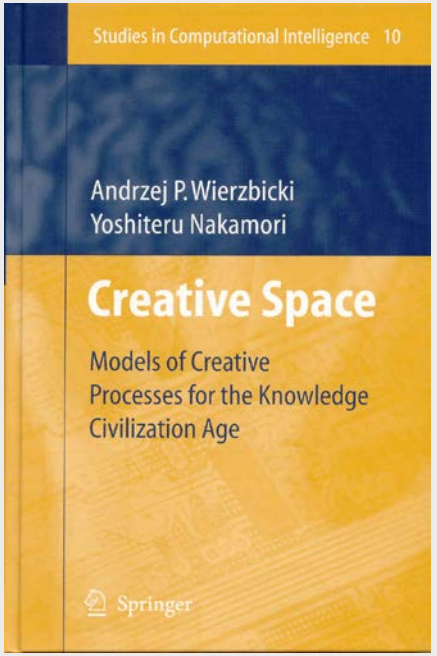
- **Intuition is an unconsious form of knowledge, not open to rational an/or analytical thinking and analyses.**
- **Intuition is thought as the sixth sense. Recent scientific research has found some evidence for the existence of this sixth sense and lots of unconscious processes,**
- **etc.**

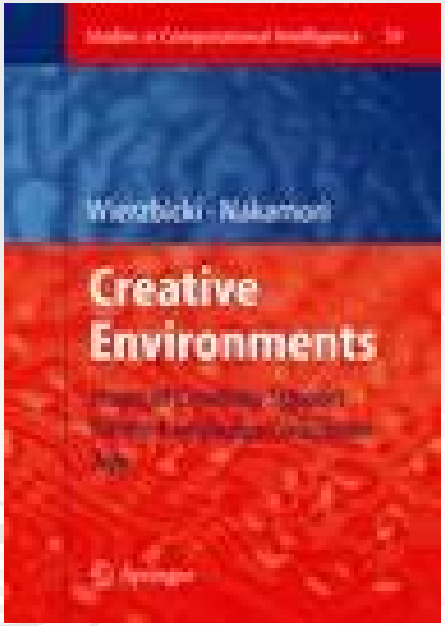
Wierzbicki AP and Nakamori Y. (2005, 2007):

JAIST – Japan Advanced Institute of Science and Technology

Probably, if we ever succeed to arrive at a formalization of intuition, then a different type of mathematics or calculus would be needed

Based on natural language?





Moreover:

Peter Checkland's 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.**

Modern decision making paradigms

- **Heavily based on data, information and knowledge, but also on human specifics (intuition, attitudes,...)**
- **Need number crunching, but also more ‘’delicate” and sophisticated analyses,**
- **Based on how to help the animate decision maker by some inanimate „agent” (e.g. computer),**
- **Heavily relying on computer systems, and capable of a synergistic human-computer interaction/collaboration.**

So: Should be human centric/centered!
Should be human consistent!
…

Here, we will consider the basic forms of helping the decision maker:

- **Decision aid,**
- **Decision advice/recommendation,**
- **Decision support (system),**

and will briefly indicate when, for whom and why a particular form should be recommended.

Decision aid:

- May be generally meant as to help a decision maker to solve (even formulate) a decision problem,
- Meant here basically in the sense of Bernard Roy (the French school) and his followers (e.g. Alexis Tsoukias).

In general, the essence of the decision making proces is:

- In simpler cases, a decision maker can use decision making/analytic… tools to find by himself/herself a solution,
- In realistic, nontrivial cases, the situation is more complex so that a decision maker (client, judge) commissions an agent (analyst) to perform analyses and propose a solution, i.e. is a client to an analyst(s).

Then:

Decision aid (decision aiding process!) is when there are:

At least two acrors:

- **The client/s (decision maker/s),**
- **The analyst/s.**

whose roles, intentions, goals, etc. are different.

However, to cooperate or collaborate effectively and efficiently, there should be some synergy and understanding which will help attain acceptance of the results by the client (decision maker).

Decision aid is applicable to the following main approaches:

- **Descriptive, which derive rationality models by observong how decisions are made,**
- **Prescriptive, which derive rationality models from responses to preference related questions,**
- **Normative, which derive rationality from norms established a priori.**

When can this decison aid framework be proper?

Generally, when:

- **A model is known, utility or preference driven,**
- **The decision maker (client) has a (sufficiently deep) domain knowledge about the decision process considered,**
- **The analyst(s) have(s) a domain independent methodological knowledge, i.e. how and using which tools and techniques to solve problems considered.**

From the perspective of stakeholders in the process, this boils down to the emergence of a new stakeholder, the pair „client – analysts”, whose success is related to a synergistic operation

Generally, the client and analyst are to be qualified…

Decision advice (giving) systems (recommenders)

A recent tendency, a by-product of the popularity of recommenders, also advocated for decision processes

Recommender systems: provide people with suggestions for items which are likely to be of interest, i.e. help people make good choices and decisions

Make it possible to attain a compromise between the accuracy of the solution and cognitive effort to obtain it

Do not deal explicitly with the formulation and solution of decision making models, and not aim at attaining „optimal” results

After receiving suggestion(s), a „real” choice or decision should be made

Ease of use, a lower cognitive and mental load, etc.

But: acceptance of the results obtained is crucial!

Recently:

- **much emphasis on psychological, cognitive, etc. aspects,**
- **intensive research on human decision making, notably from the cognitive and psychological points of view,**
- **coupling of recommendation algorithms with the understanding of human choice and decision making processes.**

But, more importantly, advanced human-computer interaction using human consistent means like natural language or visualization, and new results on argumentation, dialogue, deliberations, etc.

The use of advice giving systems for helping decision makers may be justified for:

- **Difficult cases, when a model is unavalable or to difficult to develop,**
- **For users with a limited knowledge of mathematical models and algorithms,**

Maybe, this will be a preferred solution for a new generation of users for which the use of a recommender type system is a natural choice

Are decision support systems (DSSs) the best option?

DSS: not clearly understood (cf. Acad. F. Filip)!

A very broad concept!

Basically:

- **Decision support systems are a class of computer-based information systems that support decision making activities.**

The term decision support system remains a useful and inclusive term for many types of information systems that support decision making.

Common elements:

- **„information system” and**
- **„un(semi)structured problem”**

Information system (IS) is a system of persons, data records and activities that process the data and information in a given organization, including manual or automated processes.

Usually the term is used erroneously as a synonym for computer-based information systems

What are decision support systems?

Specific interactive computerized information systems that support decision making activities,

A basic philosophy:

- **Non-trivial problems are considered (complex)**
- **Not fully clear how decision making proceeds?**
- **Some support (models, information, …) should help,**
- **Human being is better (in complex situations!) than the computer,**
- **Human being is autonomous**

Roots and history

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

- **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**
- **Developments in interactive computer systems, mainly carried out at the Massachusetts Institute of Technology (MIT) in the 1960s.**

The concept of DSS became an area of research of its own in the middle of the 1970s, before gaining in intensity during the 1980s.

Brief history of DSSs:

Mid-1960s: development of IBM 360 and a wider use of distributed, time-sharing computing

Mid-1960s: MISs (management information systems) first to provide managers with structured, periodic reports,

Late 1960s-early 1970s: attempts to use analytical models, first attempts at interactive systems

Early 1980s: EISs (executive information systems) that used templates

Early 1990s:Use of relational DBMSs, shift from mainframe based to client-server based solutions, object oriented technology,….

Mid-1990s: Data warehouses and on line analytical processing (OLAP) tools, Web based and Web enabled systems

Early-2000s, Web enabled DSSs, AI focused, etc.

Generally, decision support:

Multidisciplinary field including (but not only):

- **database research,**
- **specific domains (e.g. operations research)**
- **tools and techniques (e.g. applied and numerical maths, statistics),**
- **data science,**
- **artificial intelligence,**
- **human-computer interaction,**
- **simulation methods,**
- **software engineering,**
- **telecommunication,**
- **etc.**

Basic elements of a DSS:

Traditionally:

- **the user interface,**
- **the database,**
- **the models and analytical tools, and**
- **the DSS architecture and network.**

Or, in other words:

- **database management software (DBMS),**
- **model base management software (MBMS),**
- **dialogue generation and management software (DGMS).**

Basic types of DSSs:

For our purposes

(cf. Dan Power's: www.dssresources.com):

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

Basically, for our purposes, two general classes:

- **Model driven which require from the decison maker(s) (client/s) and analyst(s):**
  - **knowledge about various aspects of the decision making process,**
  - **Knowledge about solution tools and techniques and computer support (e.g. data handling, interface, presentation of results)**

It is somehow equivalent to decision aid but easier to use, with more support

May be demanding for the client and analyst w.r.t. availability of models, knowledge, etc.

Non-model driven (i.e. data and document driven):

- **Less demanding for the client(s) and analyst(s) because all information and knowledge needed are derived from (big) data using, e.g., data analyses and machine learning,**
- **Models – which are usually difficult and costly to build, identify and test, and need a considerable knowledge and understanding of the cleint(s) and analyst(s) – are not explicitly needed, and are derived by sheer data handling (e.g. using deep NNs),**
- **Fewer types of formal and algorithmic tools and techniques are usually needed so that the solution proces may be easier and cheaper.**

In general:

- **Consistent with modern trends of data driven approaches,**
- **More „democratic", do not need highly qualified analysts and clients,**
- **DSS provides a convenient, easy to use environment.**

All non-models driven DSSs:

- **emphasize access to and manipulation of internal and external data, numerical or textual, even multimedia,**
- **facilitate collaboration between decision makers (analysts),**

The best: a synergistic combination

But models are related to number crunching the humans are not good at

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.

With humans we would rather go for a decision support philosophy for solving (complex) problems because:

- **Human decision makers are good at solving (complex) problems but bad at numer crunching,**
- **For human decision makers 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).**

Conclusions

While solving complex decision making problems we can use 3 paradigms:

- **Decision aid,**
- **Decision advice/recommendation,**
- **Decision support (system).**

Basically,

- **Decision aid may be good for solving more formalized problems, with models available, but needs well prepared clients (decision makers) and analysts,**
- **Decision support is good for everybody, and can facilitate both model driven decision aid type approaches and purely data driven approaches, can be employed by less prepared cleints and analysts, and provide many convenient utilities and additional tools.**

Decision advice/recommendation:

- **may be easy to accept by many clients and analysts, notably of a younger generation, for whim recommenders are in everyday use,**
- **may be not ready yet for tackling common decision making problems which explicitly involve optimization or formal MCDM analyses,**
- **may be the future option.**

But:

the judge-advisor problem emerges

Advice giving vs. advice taking…

For the future…