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Round table Discussion

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Intelligent Control and Cognitive Control : Issues and Challenges

Professor Peter P. Groumpos

Director of the Laboratory for Automation and Robotics Department of Electrical and Computer Engineering, University of Patras

groumpos@ece.upatras.gr

PANEL MEMBERS

- Prof. Claude Frasson,
- Prof. George Kostopoulos,
- Prof. Kyriakos Sgarbas,
- Prof. Peter P. Groumpos

WHY THIS RTD??!!

- Intelligent Control
- Cognitive Control
- TWO WELL DEVELOPED SCIENTIFIC FIELDS TWO DIFFERENT KOSMOS-UNIVERSES

PARALLEL??!! CAN THEY BE COMBIDED??!!

CAN THEY GET MARRIED TO PRODUCE NEW **BABIES**??

MAY BE YES MAY BE NOT!!

WHY ?? (1/4)

- No matter what,!?! Decisions are made everyday and by different people BY ALL OF US!!!
- CAN WE RELATE DECISIONS TO CONTROL ACTIONS?? AND WHAT WOULD BE THE HUMAN INVOLEVMENT??
- How Intelligent are they??
- Intelligence Control (IC)??
- How can we consider Cognitive Control (CC)?
- How CC can be related to IC?
- Can we combine "wisely" (with Sophia): ICT, Advanced Systems and Automation theories, as well as Neuroscience to solve everyday's problems on many scientific fields?
- How Cognition and Intelligence can help in this approach??

WHY ?? (2/4)

- Since the dawn of the computer age, academicians, researchers and people in general have speculated about how computers might be used to help humanity.
- The formulation of Expert Systems, Artificial Intelligence and robotics gave hopes for the birth of new "independent human systems".
- Early predictions were so positive that they were often dismissed as science fiction or fantasy.
- Otherwise, they led to fears about what the new technologies could mean for human identity.
- Some of the early visionary thinkers were ignored, especially where they predicted that AI systems would be able to behave in ways that we normally think of as particularly human.

WHY ?? (3/4)

- Recently, however, progress in AI and many related fields has come to the point that the phenomena of emotion, innovation and of creativity, cannot be neglected and which are now taken more seriously.
- This can be seen in the steady growth of publications in these areas, and more recently in research funds directed towards computational creativity(CC), fuzzy control (FC), software computation, intelligent systems, fuzzy cognitive maps (FCM), cognition and cognitive control, Cognitive Neuroscience and Action Control, Neurofeedback, Cognitive & Behavioral.....

WHY ?? (4/4)

Today's problems need multidisciplinary solutions

BUT WE NEED to UNDERSTAND VERY WELL

INTELLIGENCE
INTELLIGENT CONTROL
LEARNING
COGNITIVE CONTROL
CREATING NEW KNOWLEDGE
CREATIVITY, INNOVATION AND ENTREPRENEURSHIP
......

►

INTELLIGENT CONTROL

- a fusion of a number of research areas in systems and control, computer science and operation research among others, coming together, merging and expanding in new directions.
- a class of *Control techniques* that use various artificial intelligence computing approaches like neural networks, Bayesian probability, fuzzy logic, machine learning, deep learning, evolutionary computation and genetic algorithms

COGNITIVE CONTROL

- defined as the ability to flexibly adapt behavior to current demands, by promoting task-relevant information and behaviors over temporally-extended periods and in the face of interference or competition.
- considered to be an enabler for novel technologies in many diverse application areas. Field robotics, space and sea exploration systems, and next generation of unmanned aerial vehicles will achieve a higher degree of autonomy through cognitive functions. Cognitive control systems for manufacturing plants will be partners to plant operators and engineers; less human intervention will be necessary even as the safety and performance of plants improve.

WHY??

We have arrived at a very critical and challenging point. We are faced with a dilemma. We need to decide between two important control scientific concepts . Which is better: Intelligent Control or Cognitive Control? And with which criteria one will make a decision, especially when a critical situation is under consideration. (a medical problem, an energy or environment urgent situation). Unfortunately there are quite a few terms such as: proactive, reactive, pre-active and inactive controls which are all associated with Cognitive Control



Raphael, detail of Plato and Aristotle, *School of Athens*, 1509-1511, fresco (Stanza della)

THE TRIANGLE OF KNOWLEDGE



FUZZY COGNITIVE MAPS (FCMs)

Modeling a system as a collection of concepts and causal links between them.

- **Nodes**: Represent the system's concepts. Concepts correspond to the characteristics of the system.
- Arrows: Interconnection between nodes. Show the cause-effect relationship between them.



WHY FUZZY COGNITIVE MAPS

There are four main reasons (at least) that require the utilization of Fuzzy Cognitive Maps (FCMs):

- a) Complexity
- b) Nonlinearities
- c) Uncertainty
- d) Fuzziness

The majority of the real world systems include these three parameters. The conventional control methods for such systems cannot confront these parameters as the FCMs do. Thus, FCMs are about to play a major role in the future regarding the modeling, analysis, and control of complex systems.

FUZZY COGNITIVE MAPS

Between concepts, there are three possible types of causal relationships that express the type of influence from one concept to another:

a)
$$W_{ij} > 0 \ (C_i \uparrow \Rightarrow C_j \uparrow)$$

b)
$$W_{ij} < 0 \quad (C_i \uparrow \Rightarrow C_j \downarrow)$$

c)
$$W_{ij} = 0$$
 ($C_i, C_j \Rightarrow \text{not correlated}$)

Attention: Causality vs. Correlation



MATHEMATICAL THEORIES OF FCMs

The value of each concept at every simulation step is calculated by applying the following calculation rule:

$$A_{i}^{(k+1)} = f(k_{2}A_{i}^{(k)} + k_{1}\sum_{\substack{j\neq i\\j=1}}^{N} A_{j}^{(k)}w_{ji})$$

 A_i^{k+1} : the value of the concept C_i at the iteration step k+1

 $\mathbf{A_i^k}$: the value of the concept C_i at the iteration step k

 W_{ji} : the weight of interconnection from concept C_i to concept C_j

f: the sigmoid function
$$f = \frac{1}{1 + e^{-\lambda x}}$$

LEARNING OF FCMs

<u>Training methods for the weights (W_{ij}) :</u>

- a) Active Hebbian Learning algorithm
- b) Nonlinear Hebbian Learning algorithm
- c) Evolutionary algorithms
- d) Experts exclusion algorithm

Basic concept of the abovementioned methods is the minimization of specific criteria functions in order to control the desired output region of the system.

DEVELOPING FCM (partial)

In order to construct a more accurate model of the complex Knowledge on the behavior of a complex system is rather subjective and in stem it is proposed to utilize, the experience of a group of experts. Experts are polled together and they examine the relevant factors that stand as nodes of an FCM.

So, they decide the number of concepts, which consist the FCM and what characteristic of the system each concept represents. Then, the experts are individually asked to express the causal relationship among these concepts. *The result of this procedure will be a collection of individual FCMs, with the same nodes but different links among concepts or/and different weights of interconnections.* The individual FCMs must be combined into one collective FCM and a method to combine the individual maps.

CHALLENGES ON MODELLING COMPLEX SYSTEMS(1/2)

Complex Systems Sciences- Basic aim: Understanding the complex phenomena of the real world that surround us

<u>Secret</u>: Complex behavior \rightarrow simple rules

Why have the systems <u>CONTROL theories</u> become more crucial? a) Complexity of modern systems b) Uncertainty of their nature c) Heterogeneity of related information

CHALLENGES ON MODELLING COMPLEX SYSTEMS (2/2)

Variety of description of complex systems:

a) Deterministic equations, b) Stochastic equations, c) Statistical mechanics equations, d) Neural network models, e) Cellular automata, f) Finite state machines, g) Multi-agent systems, h) Fuzzy Systems, i) Intelligent Control, etc.

Most of the complex real world phenomena are modeled as dynamic systems enriched by artificial intelligence resources.

MISSING SCIENTIFIC AREA IS FCMs

Advantages of the abovementioned models:

Coping with incomplete information and uncertainty, predicting system's behavior, reasoning on qualitative level, knowledge representation and modeling, where computer simulations and information systems play an important role and facilitate the process of decision making.

IMPORTANCE OF CONTROL





Control

Control

Be Not Afraid Of Falling Be Afraid Of Not Trying

OPEN DISCUSSION



Go Ahead With Question



Our Challenge:??!!

To Build the new ICC platform and Wise Systems Ourselves

TOGETHER WE CAN DO IT DIVIDED WE WILL FAIL

Critics to our Today's Decisions and Actions will be the Unborn Dead

Kostas Palamas Greek Poet

CONTROLS?? WHY??

AND DO THEY EXIST OR THEY ARE JUST LIKE THE DELTA FUNCTIONS

DO WE KNOW??!!

 \succ INTERVENSION(S) ≻CORRECTION(S) ≻DECISION(S) >DEVELOPMENT(S) ► MANAGING-MANAGEMENT ►DESTRUCT ≻CONSTRUCT ≻REGULATION(S) ≻CREATION(S) \geq PERMISION(S) ► APPROVING ►ACCOMODATING **≻**COPLYING

CONFORMING
HARMONIZING
CONFIGURATING
GRANTING
LOVING AND MAKING FAMILIES
????????????
????????????
YOU NAME IT

MY OWN PERCPECTIVE

For Humans Intelligence Decision (ID) is no more than TAKING a right-wise decision at right time

And

For Machines ID is no more than CHOOSING a right (wise? Useful?) decision at right time

We need to make Wise decisions for the Benefit of Humankind

I think Wise-Intelligent Cognitive Control-Decision is the new scientific revolution ever to exist



NO MAN IS WISE ENOUGH BY HIMSELF (Plato)

A MAN SHOULD DEVOTE EIGHT(8) HOUR TO SLEEP, EIGHT(8) HOURS TO WORK AND EIGHT(8) HOURS TO HIS MIND (Aristotle)

OUR VISION TO THE WORLD OF 2050???!!! EXPECT:

♦ FEED 9-10 BILLION PEOPLE ✤MANAGE CLIMATE CHANGE **SECURE ENERGY SYPPLY TO ALL COUNTRIES** ♦ PROVIDE FOOD (SAFE??!!) TO EVERYBODY **WORLD TO BE:**

- BETTER EDUCATED
- MORE INNOVATIVE,
- \triangleright HEALTHIER
- \triangleright RICHER
- MORE SUSTAINABLE
- MORE SECURE
- \triangleright LESS INEQALITY BETWEEN RICH AND POOR AND BETWEEN MAN AND WOMEN

♦ QUESTION: ARE WE HAPPY WITH ALL THE ABOVE??

CONCLUSIONS (CONTINUE)

May you live in interesting times",

often referred to as the **Chinese curse**, is the purported translation of an ancient <u>Chinese</u> proverb and curse.

Your future is determined by your deeds today. "Study the past if you would like to divine the future." ~ <u>Confucius</u>