Studies in Systems, Decision and Control 534

Valentina Emilia Balas
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Decision Making and Decision Support in the Information Era

Dedicated to Academician Florin Filip

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Preface

The purpose of this book is to present a small token of great appreciation of the broadly perceived decision making and decision support systems in international communities to Prof. Florin Gheorghe Filip, member of the Romanian Academy, for his important research and scholarly achievements, of great results and inspiration, and a life long service to research and scholarly the community. Academician Filip has been, since the beginning of his long and illustrious career, a driving force for the entire research community in his areas both in his country, and then worldwide due to decades of his involvement in the activities of many global societies and organizations exemplified by many European research agencies and the International Federation of Automatic Control (IFAC), to mention just a few.

Over the years, Prof. Filip's pioneering contributions have, on the one hand, shaped first the fields of the broadly perceived systems and control in their cybernetic synergy with communications and computing, and then decision making and decision support systems. On the other hand, he has always been sharing his knowledge and vision with other people, notably his young collaborators in several countries for whom he has not only been a mentor and a great teacher, but also a colleague and friend, in the very European old academic legacy and tradition. The lives and careers of many younger researchers and scholars have been inspired and shaped by him. An important aspect has been here his numerous visits to national and foreign universities.

He has been for years a driving force for research in many high-tech fields that have shaped both scientific and technological progress, such as modern computation architectures and paradigms, decision making, and decision support, just to mention a few. Many other fields, exemplified by automation, robotics, management science, etc. have also greatly profited from his pioneering research. His great impact on research and careers of many people has been at a national, European, and worldwide scale. Moreover, which is so important for any researcher and scholar, he is considered to be a mentor to many younger scientists. This special volume is therefore just a little appreciation for what he has done for the entire scientific community.

As a tribute to Prof. Filip's long-time activities and great contribution to the entire scientific community, it has been decided to co-edit this special volume with many top contributors in the fields of his interests and activities. This is clearly just a small

token of appreciation by the entire research and scholarly community for his great achievements and vision.

The volume is divided into three parts which constitute chapters.

The first part, *Systems and Networks*, is concerned with a comprehensive presentation of some basic issues, their formalizations, and solutions that are relevant to the topic of the volume.

Boldur-Eugen Barbat, "21st Century Artificial Intelligence Tackling Climate Instability. Cybernetic Modelling of Living Systems", discusses some issues related to the prospective 21st Century Artificial Intelligence meant in terms of cybernetic modelling of living systems, to mitigate the deadly effects of climate instability. It is shows a relationship between man-made pollution and climate (in)stability which is based on (falsifiable) factual truths that are accepted as working assumptions. Cybernetic modelling is advocated with a shift from numbers to words, i.e., with AI in paleolinguistics and Computing With (old) Words.

Ion Stoica, "Sky Computing: Opportunities and Challenges", explore the potential evolution of the cloud computing ecosystem, emphasizing the similarities and differences to the developmental trajectories of telephony, the Internet, and PCs. The cloud computing market has been dominated by proprietary interfaces from its early entrants, like Amazon Web Services, Windows Azure, and Google Compute Engine. However, in recent years, there has been an increasing drive from organizations towards enhanced compatibility so that they can manage their workloads across various clouds. Unfortunately, unlike the emergence of universal technology standards in previous tech domains, we argue that a comprehensive compatibility standard for the cloud is neither imminent nor necessary for facilitating workload mobility across clouds and could potentially hinder innovation. This approach, "Sky Computing," is anticipated to lower entry barriers to cloud usage, spur technical innovation through specialized clouds, facilitate comprehensive integration of computational options, and enhance compliance, security, and resilience via cross-cloud deployments.

Horia-Nicolai L. Teodorescu, "Resilience of Networks—A Partial Review", discusses the problem of risks and resilience of networks merging the probabilistic approach with graph-based tools. Relationships between the network topology and networks' resilience are analyzed. The main examples comprise some very important and challenging aspects exemplified by computer and communication networks, biological, knowledge transfer, utility, and transportation networks (pipeline networks, railways, and subways). The main goal is to establish and clarify "metrics" of resilience for the networks.

Florin Gaiseanu, "Information and Informational Organization of the Living Structures: From Decision Making to Decisional Big Data-Assisted Informational Era", deals with a new concept defined as matter-related information that makes it possible to coherently approach the structuring and functioning of living organisms. The author concentrates on the development of informational concepts for the modeling of the fundamental processes in living organisms, starting with the eukaryotic cell, the living constituent unit of humans, animals, and plants, and going up to the human being, the most complex/developed organism on the organizing/evolutionary

scale. Specifically, the typical processes of structuration/destructuration in cell and the reactive informational response on the associated pathway/circuit are described in informational terms, starting from surface receptors as info-input sensors to terminal target, the genes, using the transitory chain of informational reactions acting as transduction, decision, and command of execution.

Mădălin-Dorin Pop and Velmani Ramasamy, "Sensor Networks as a Support Mechanism in Intelligent Transportation Systems", are concerned with an increased mobility of humans which implies a need for many undertakings and the expansion of road infrastructure alone is not enough. It should include efficient solutions for traffic monitoring and control to reduce travel times, avoid collisions and traffic congestion, etc. A promising solution is the transition of traditional transportation infrastructures to intelligent transportation systems. A critical analysis of sensor networks used in intelligent transportation systems is provided. It emphasizes the role of sensor networks in decision-making processes related to real-time traffic monitoring and control. Current limitations and future research directions are mentioned.

The second part, *Intelligent Systems and Decision Support-General Issues and Critical Applications*, presents the main aspects related to a very important and widely employed class of systems that can support human centric decision making processes, usually known as the decision support systems.

Ana-Maria Suduc and Bizoi Mihai, "A Quantitative Perspective on the Evolution of Decision Support Systems", review the development of the decision support systems (DSSs) since their inception in the turn of the 1940s and 1950s with the advent of operations research, behavioral and scientific theories of management and statistical process control, combined with rapid development of information systems. In this work, a quantitative perspective on the research area of decision support systems is provided using a critical literature search.

Luminita Duta and Dumitru Enache, "Decision Support Systems for Reverse Logistics in Industry 4.0", deals with reverse logistics that closes the loop of product life cycles, making possible the transition to the Circular Economy. This represents the key element to achieve the sustainable development goals. In the Industry 4.0 Era, reverse logistics operations are increasingly improved with the use of the internet of things (IoT), cyber-physical systems (CPS), and artificial intelligence (AI). New emergent technologies are used to implement intelligent and reactive platforms that allow managers and stakeholders to collaborate in their decision-making process. This chapter aims to review some characteristics of decision support systems used in reverse logistics in the fourth industrial revolution.

Irina Andra Tache and Dumitru Popescu, "Medical Decision Support System for Lung Damage Classification", are concerned with digital medical imaging that has opened a new multidisciplinary field of research in which medical staff as long as engineers are struggling to solve the problems of accurate detection and treatment of different kinds of diseases. Their chapter reveals applications of decision support systems in managing COVID-19 patients based on machine learning and classical image processing techniques.

Smaranda Belciug and Dominic Gabriel Iliescu, "How Can Intelligent Decision Support Systems Be Applied in Obstetrics?", show how the field of obstetrics has

changed with the advent of Intelligent Decision Support Systems A special emphasis is on the very special role of the above modern decision making and decision support technology in reading fetal morphology scans, and in trying to predict the type of birth. Practical examples are shown.

Adriana Alexandru, Marilena Ianculescu and Elena Anca Paraschiv, "Harnessing the Capabilities of IoHT-Based Remote Monitoring Systems for Decision Making in Elderly Healthcare", are concerned with the aging of the population which implies a need for additional elderly care and assistive services to support seniors living in their residencies transformed into smart homes. Remote Monitoring Digital Solutions (RMDSs) providing here cost effective and on time healthcare services. Artificial Intelligence (AI) in healthcare helps gain insights for evidence-based clinical decision making. Data related to location, activity intensity, sleep patterns, social interaction, medication use, and vital signs from environmental and wearable sensors and smart devices are subject to data analysis and then used for better decision making and progress tracking. The role of Internet of Health Things (IoHT) devices and solutions is discussed, with an analysis of architectural aspects of the RMDSs used in smart homes for delivering healthcare services for increasing seniors' quality of life and wellness, notably the capabilities of the Non-invasive Monitoring System and Health Assessment of the Elderly in a Smart Environment (RO-SmartAgeing) to provide support to physicians in decision making.

Aiste Gulla, Ieva Jankiunaite, Kestutis Strupas, Ivona Juchneviciute and Gintautas Dzemyda, "Surgical Decision Making in a Successful Liver Allograft Survival: Problem State" deals with liver transplantation which is one of the most effective treatments for acute liver failure, chronic liver cirrhosis, and even hepatocellular. Though the survival rate after liver transplantation has recently strongly improved, factors associated with long-term survival have not yet been well defined. Though the Model for End-stage Liver Disease (MELD) score is commonly used to prioritize patients, with its high values linked to the worse outcome, most studies failed to show an accurate prediction rate between the pretransplantation MELDs and the post-transplantation survival outcomes. A model is proposed for this purpose, and results are shown.

Aurelian Buzdugan and Capatana Gheorghe, "Advances in Developing a Decision Support System for Cyber Risk Management", deals with an innovative decision support system for cyber risk management in critical infrastructures. The research topic had increased attention and importance due to the increased number of incidents in critical infrastructure. The final results consisted of solutions on methods to effectively identify and manage cyber risks in critical infrastructures. A refined model has been developed that helps evaluate cybersecurity maturity in critical infrastructures. The model includes a knowledge base and is complemented by a formal intelligent metric system, and a software prototype with a user-friendly interface and easy-to-understand metrics for efficient identification, classification, and management of cybersecurity risks. The model's theoretical significance lies in its ability to provide both external and self-assessment of cybersecurity maturity in critical infrastructures. The applicative value of the model is twofold as it allows also to evaluate the efficiency of the decision support system.

Dana Rad, Valentina Emilia Balas, Adela Redeş, Csaba Kiss and Gavril Rad, "An RBF Neural Network Approach to Predict Preschool Teachers' Integrative-Qualitative Intentional Behavior Based on Marzano's Model of Teaching Effectiveness", deals with the relational, social, psychological, affective, intellectual, cultural, and moral milieu that determines educational and administrative activities at the level of an educational organization, The theory of planned behavior framework and Marzano's Model of Teaching Effectiveness is employed to assess preschool instructors' deliberate integrative-qualitative behaviors. Marzano's Model defines educational practices and provides resources to teachers and administrators to assist them in becoming more effective. The four domains measured by Marzano's Model of Teaching Effectiveness are assumed to effectively predict preschool teachers' integrative-qualitative intentional behavior which is analyzed employing a Radial Basis Function Neural Network approach. Data from an online survey of preschool instructors from Romania are used to validate the model with promising results.

Maria Beldiga, Alexandru Beldiga and Gheorghe Căpăţână, "Intelligent e-Learning Support Oriented on the Family of Decision Problems", discuss theoretical and practical aspects of developing intelligent support systems (ISS) oriented on a family of decision problems for the automation of generating and solving laboratory personalized tasks and personalized items for evaluation based on generic models and importing them on e-Learning platforms in traditional and distance training. A new mathematical model for automatic composition of personalized tasks oriented on the developed family of decision problems, integration of algorithms into the system, synthesized educational technology, etc.

The third part: *Data Analysis, Decision Making and Control*, provides an account of some important prerequisites and basic tools and techniques to develop, analyze, and implement the broadly perceived decision support systems.

Jan W. Owsiński "Reverse Clustering: A New Perspective in Data Analysis", presents the so-called reverse clustering, a conceptually new approach, that can shed light on some data structuring problems that can be ultimately framed in terms of cluster analysis, although not necessarily from the very start. The essence of reverse clustering can be summarized as follows: for some data set describing a definite set of entities, and some given partition of this set of entities, find a clustering procedure which, when applied to this set, would find a partition as similar as possible to the source partition. The paper outlines both the fundamental message of the approach and the significant cases of its application, especially when the partition is treated as a kind of hypothesis, with conclusions of a pragmatic as well as a more general character.

Ion Ganea and Gheorghe Căpăţână, "Intelligent Support System "Biostatistical Modeling of Data in the Field of Plant Physiology"", is concerned with the purpose of assisting complex biological research to optimize the process of discovering relevant knowledge for optimizing the performances of biological and agricultural systems. Results were obtained regarding: (a) the formal language of the field "Biostatistical modeling of data in the field of plant physiology"; (b) developing and validating models for intelligent analysis of biological data; (c) data processing to quantify the effects of treatments on plants; (d) using advanced technologies to optimize

the discovery of relevant results for optimizing the performances of biological and agricultural systems; (e) creation of the Graph Data Warehouse for biological and agricultural research; et al.

Sorin Nadaban and Dan Deac, "Fuzzy Functional Analysis—A General View", is concerned with the use and role of fuzzy sets theory to develop fuzzy functional analysis. It is shown that, in this process, many important steps have been exemplified by the new concepts of a fuzzy topological vector space, a fuzzy norm, a fuzzy normed linear space and algebra, a fuzzy inner product, a fuzzy operator theory, etc.

Ismat Beg, Dheeraj Kumar Joshi and Sanjay Kumar, "Interval-Valued Intuitionistic Hesitant Uncertain Linguistic Set and Choquet Integral Based TOPSIS Method to MCGDM Problems", define a new class of interval-valued intuitionistic hesitant uncertain linguistic sets (IVIHULS) to combine the uncertainty, fuzziness, and hesitancy in decision making problems, both qualitatively and quantitatively. This new class of set is an extension of both uncertain linguistic term set (ULTS) and interval-valued intuitionistic hesitant fuzzy set (IVIHFS). A Choquet integral based TOPSIS method for multi-criteria group decision making (MCGDM) with IVIHUL environment considering interactive characteristics among decision criteria and preferences of decision makers (DMs) is proposed using tte new concepts of the Choquet averaging and Choquet geometric mean operators for IVIHULS. A practical application is shown.

Raul-Cristian Roman, Elena-Lorena Hedrea, Radu-Emil Precup, Claudia-Adina Dragos and Alexandra-Iulia Szedlak-Stînean, "Iterative Feedback Tuning Algorithms for Two Rotor Aerodynamic Systems", discuss Iterative Feedback Tuning (IFT), which is one of the earliest algorithms from the data-driven class, pioneered by Hjalmarsson et al. The current book chapter aims to propose and validate via experiments the IFT algorithms on the Two Rotor Aerodynamic System (TRAS) laboratory equipment for Single Input-Single Output (SISO) control structure. Therefore, the IFT algorithm is applied in SISO control system configuration specifically in the context of IFT-based tuning of Proportional-Integral controllers by controlling separately the azimuth and the pitch position of the TRAS.

Doina Banciu, "The Digital Transformation of the Libraries Toward a Digital Knowledge Hub", presents the main objectives regarding digital transformation in European Commission documents. The work described the initiatives of an international body regarding libraries and analyzed the tendencies and their impact on library activity. It also described the policy and strategy adopted by the same large libraries all over the world. A large part of the chapter is dedicated to the libraries as knowledge hubs for improving the digital skills of citizens. The chapter touches on the main subject of digital transformation from the library management perspective and citizen behavior as library users. The work presents a schema of the documents and data flux in the library, digital products, and services for users, all of them from a digital transformation point of view. Special attention is paid to data protection and cyber security for library data collection and for citizens privacy. The work shows a schema model of digital library transformation. The work conclusions try to demonstrate that libraries play a very important role in the digital transformation of entire society with a direct effect on economic development.

We strongly believe that the high quality, interesting and inspiring contributions, included in this volume, will be of much interest and use for a wide research community in all areas of decision making and decision support, as well as more generally in cybernetics and systems sciences as well as for systems engineering applications.

We wish to thank the authors for contributing their great works to this monograph and for their active participation in support of this editorial project. Special thanks are due to anonymous peer reviewers whose deep and constructive remarks and suggestions have helped to improve even more the quality and clarity of the high-quality manuscripts received.

And last but not least, we wish to thank Dr. Tom Ditzinger and Ms. Zainab Liagat for their dedication and help in implementing and finalizing this important publication project on time, while maintaining the highest publication standards.

Arad, Romania — Valentina Emilia Balas
Vilnius, Lithuania — Gintautas Dzemyda
Craiova, Romania — Smaranda Belciug
Warsaw, Poland — Janusz Kacprzyk

About Florin Gheorge Filip

Florin Gheorge Filip, Member of the Romanian Academy, was born in 1947 in Bucharest, Romania. He graduated with an M.Sc. degree in *Control Engineering* at the *Politehnica* University of Bucharest in 1970 and received his Ph.D. degree from the same university in 1982 with a thesis on *Hierarchical Control and Optimization of Complex Systems* He was elected as corresponding member of the Romanian Academy in 1991 and became full member of the Academy in 1999. During 2000–2010, he was the vice-president of the Romanian Academy (elected in 2000, re-elected in 2004, and 2006). In 2010, he was elected as the president of the *Information Science and Technology* section of the Academy (re-elected in 2015, and 2019). He was the managing director of *National Institute for R&D in Informatics-ICI*, Bucharest (1991–1997). In 200, he was elected as an honorary member of the *Romanian Academy of Technical Sciences*, and *Academy of Sciences of Republic of Moldova.*

He was the chair of the IFAC (*International Federation of Automatic Control*) Technical Committee 5.4 (*Large-scale Complex Systems*) from 2002 to 2008. He has been a distinguished scholar of Purdue's PRISM Center (since 2021) and a Fellow of the *International Academy for IT and Quantitative Management* (since 2022).

His main scientific interests include optimization and control of large-scale complex systems, decision support systems (DSS), technology management and foresight, and IT applications in the cultural sector.

He authored/co-authored over 400 papers published in prominent international journals (IFAC J. Automatica, IFAC J. Control Engineering Practice, Annual Reviews in Control, Computers in Industry, Large-Scale Systems, Technological and Economic Development of Economy and so on) and contributed papers and chapters in volumes printed by international publishing houses (Pergamon Press, Elsevier, Kluwer, Chapman & Hall, Springer, and so on). He is also the author/co-author of thirteen monographs (published in Romanian, English, and French by Editura Tehnică Bucharest, Hermès-Lavoisier, Paris, J. Wiley & Sons, London, Springer) and editor/co-editor of 33 volumes of contributions (published by Editura Academiei Române, Pergamon Press, North Holland, Springer, Elsevier, IEEE Computer Society, and so on).

He presented invited lectures in universities and research institutions, and plenary papers at scientific conferences in Brazil, Chile, China, France, Germany, Lithuania, Poland, Portugal, Republic of Moldova, Romania, Spain, Sweden, Tunisia, and the UK. He gave lectures in *applied informatics*, *computer supported decision making, expert systems* at *"Politehnica"* University. Bucharest university and "Valahia" State university of Târgoviste. He supervised Ph.D. theses at Politehnica and the Romanian Academy doctoral school and was an adjunct professor at the University of Chinese Academy of Sciences-UCAS (2013–2016). He served as an expert and project evaluator to the European Commission (from 1992 to 2017) and the *European Council of Academies of Applied Sciences, Technologies, and Engineering—Euro-CASE* (from 1997 to 2006). As a member of the *Romanian National Advisory Council*, he introduced the competitive system for funding public research in Informatics in Romania in 1993.

He is the founder of the International Journal Studies in Informatics and Control-SIC (in 1992), and the co-founder of the International Journal of Computers, Communications, and Control-IJCCCC (in 2006). He has been elected as a Dr. Honoris Causa of ten universities in Romania and France. He received the National Order "For Faithful Services" at the rank of "Grand Cross" from the President of Romania in 2000 and the "Marin Drimov Medal with Golden Ribbon" from the Bulgarian Academy of Sciences (in 2007).

For more details, cf.: https://acad.ro/cv/FilipF/FGF-CV-en.pdf

Contents

Systems and Networks

21st Century Artificial Intelligence Tackling Climate Instability. Cybernetic Modelling of Living Systems

Boldur E. Bărbat

Humans are so dumb they cannot even prophesy.
SILICON VOICE FROM CARBON VALLEY.

Abstract *Aim*: to defend – with 21st Century Artificial Intelligence means – cybernetic modelling of living systems, as word-oriented technique, to mitigate the deathly effects of climate instability. *Rationale*: Convincing factual evidence shows that the deaths due to extreme weather phenomena increase, whereas scientists predict temperature rising by 2100. Science failed to mitigate the crisis, approaching the issue with wrong premises and ineffective modelling tools. It is shown that the relation between man-made pollution and climate (in) stability is based on factual truths. Among those: Living systems need cybernetic modelling. The armoury for shifting from *numbers* to *words*: Artificial intelligence in paleolinguistics = nuanced reasoning + Computing With (old) Words. Learning issues are outlined as falsifiable criteria: *there is no algorithmic method for learning the mother tongue ably*. The '*Proof of Concept*' validations culminate with modelling homeostasis as macrochronic stability of Barkhausen circuits with natural-language capability. *Assessment*: The algorithmic paradigm is unable to solve emergencies. Ecology requires living system modelling and factual validation, involving: word-oriented artificial intelligence methods; '*Proof-of-Concept*' validation by falsifiability; humanlike communication.

Keywords Artificial Intelligence (*21CAI*) · Climate Instability (*ClIns*) · Cybernetic modelling (*CyMo*) · Computing with Words (*CWW*) · Cognition in living systems

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1 Introduction. Hurricanes Kill Now, Scientists Predict for 2050

Factual evidence shows that the deaths due to extreme weather phenomena increase: "Tornadoes ripped through several US states killing at least seven people in total" [BBC 04/01/2023]. "Scientists have increased prediction for 2023 hurricane season from a near-normal level of activity to an above-normal level of activity" [23].

No mathematical model could help. Therefore (Sect. 2), highlights the worrying relationship between human-made pollution and climate (in)stability. Any living system requires cybernetic modelling (Sect. 3). The armoury used to shift the emphasis from *numbers* to *words* is shown modelling homeostasis in benthic communities (Sect. 4) and describing *Computing with words* applied in paleolinguistics (Sect. 5).The paper culminates *Proof of Concept* (POC) validating the homeostasis model (Sect. 6). *Assessment*: the algorithmic paradigm is unfit for climate urgencies because predictive models cannot tackle extreme weather (Sect. 7).

2 Anthropogenic Pollution is a Main Cause of Climate Instability

The paradigm followed by the scientific elite struggles to manage the challenges for which it was unprepared. The relation between anthropogenic pollution and climate (in)stability is based on facts, used as working assumptions (*WA*): The first, states alternative thinking. The next eight refer to failures or foreshadow the frailty regarding chronic issues. The other *WA* outline a word-oriented paradigm *in embryo.*

WA1: There is a deep mental Rubicon separating the opinions of Kelvin *Number*-oriented scientists (claiming crisp, apodictic truth) and those of Zadeh *Word*-oriented ones (favouring fuzzy, nuanced truth). The gap is shown by two catchphrases: '*Life = DNA software + membrane hardware*' [9] versus '*Computing With Words*' [8]. *WA2*: Statistic predictions are avoided because *humans are not probabilistic beings*. *WA3*: Predictive models predict *synchronically* not *diachronically* (are useful to *diagnose* not to *prognose*). *WA4*: Lacking the idea of *(in)stability*, the algorithmic paradigm is useless: it is a *wrong answer* to a *wrong problem*. *WA5*: Mathematical models cannot allow *managing* emergencies; they *postulate* evolution of events. *WA6*: Lacking the concept of *validation*, the algorithmic paradigm is unsuited for risk management. *WA7*: Humans distrust robotic advice since the system makes them talk in an alien language. *WA8*: Humans (living) and artefacts (inanimate), as *dissimilar* cognitive beings, cannot be modelled *similarly*. *WA9*: A conceptual divorce between *program*-oriented *robotics* and *process*-oriented *21CAI* is necessary. *WA10*: Human–robot interaction → human language → interpretable model → *CWW* → less mathematics. *WA11*: *LS2* require Wienerian time. *WA12*: *Computing With Words* bridges the hiatus between living beings and artefacts. *WA13*: Since the *axis mundi* of cybernetics is the concept of communication, *21CAI* systems require a cybernetic perspective.

Engineers addresses the complex links between anthropogenic pollution and climate instability in an effective manner, even within the algorithmic framework: e.g., addressing "emerging challenges in significantly reducing the energy consumption of communication systems" [17]. Likewise, in water quality monitoring systems "energy management and movable sensors have been used to increase the battery life as well as sensors life" [18]. "Decision support systems become an important and widespread element of different fields of contemporary life in the age of explainable artificial intelligence (XAI). They elaborate on the procedures of data science transforming the data and/or signals into information, knowledge, and wisdom at last. However, most of the current DSS are limited to a mere finding of the situation, i.e., a kind of diagnostics, and do not have a unified mechanism to offer adequate solutions" [10].

3 *Gaia* the Earth–As *Living* Being–Needs Cybernetic Modelling

"Living systems from cell, to human, to society, to *Gaia* are *given as such* (modelers do not have the 'demiurgic privilege' of robot creators to *assign* features). *LS2 are complex*, *indeterministic*, *open* and *evolve in irreversible time.* 'Irreversible' has here the old, simple Augustinian meaning: even for God *Undo* is excluded" [8].

As regards the approach, things are even worse: "Carrel was a forerunner of the–albeit yet fuzzy depicted–'*KS Zeitgeist'*: In man, the things that are not measurable are more important than those that are measurable. Science has to be understood in broad sense, as a method for comprehending all observable reality, and not as an instrument for acquiring specialized knowledge" [20]. Still, even at Harvards' level, such warnings are ignored: "various potential life forms, which vary in the extent to which they challenge standard conceptions of life, including organic life forms on earth, matter, *AI*, and extra-terrestrial life" [16]. Descartes' dualism of mind and body still haunts science. Carrel attacks this parochial approach that sticks at the *Renaissance error*: "Misunderstanding a great Galilean idea. There is a strange disparity between the sciences of inert matter and those of life. Astronomy, mechanics, and physics are based on concepts which can be expressed, tersely and elegantly, in mathematical language. They search for reality beyond the realm of common thought up to unutterable abstractions consisting only of equations of symbols. Such is not the position of biological sciences. Those who investigate the phenomena of life are crushed under a mass of facts, which they can describe but are incapable of defining in algebraic equations. (*Man, The Unknown*, Harper and Brothers, 1935, cited in [20]).

4 Modelling Homeostasis (with Delay) in Benthic Communities

The paradoxical motto underlines the difference between the *silicon (robot)* world and the *carbon (living systems)* one: Humans accept the *unknowable* (first, as future contingency). The climate changes are a set of complex phenomena, caused by century-long, anthropogenic pollution. Worse: such phenomena, boosted by global warming, cause irreversible damage, whilst *pollution* and *warming* were not separated categorically (no relationship could be established). The roots of this conceptual syncretism are due to a *Zeitgeist* where research looks rather for *finding causes*, than for *controlling effects*: a. Human-induced nature of extreme weather is inferred from its evolution, isomorphic with that of industrial revolution effects from city pollution to ozone hole. b. Examples of correlation between extreme weather and global warming: algal symbiont reduction in the Great Coral Reef; Arctica heat in June 2020 [BBC].) c. Phenomena simplicity and huge historic data available, eases modelling of warming, whereas modelling stability of complex systems involves deforming simplifications:

Biologic stability was explored a century ago: "The best material model for a cat is another cat, or preferably the same cat" [*wiki*/Arturo_Rosenblueth]. For modelling homeostasis, a microchronic approach is mandatory since cybernetics was built on the concept of negative feedback. At a first glance, it is weird to consider a process consisting in taking a system's output, processing it, and feeding it back into the system together with the initial input so that the output value should diminish. The reason emerges in radio engineering: to reduce the fading effect in wave propagation. (Although hard to accept cognitively, in electronics feedback mechanisms can mostly sidestep temporal dimensions. Yet such circumvention is impossible when modelling processes in *LS2*.) In biology, homeostasis is keyway to ensure preservation. The homeostatic state results from *adaptation* processes triggered by *perturbations*. Nature achieves homeostasis via hysteretic delay, lagging in response. Without exogenous perturbation, there may be *system stability* but there is no *homeostasis* (Fig. 1).

"**β** was set at the *golden ratio* (**13/21**), because centuries-old anecdotal evidence shows that Australian rabbit reproduction is related to Fibonacci series)" [7].

The flagrant failure of modelling climate changes exposed paradigmatic blindness – as shown by the unshaken belief in mathematics: "The dependence on the initial condition suggests that, for future studies, it is of great interest to initialize the numerical model with conditions taken by field measurements" [22]. So, the real world is seen as a *database*: it contains *data*, not *knowledge*, since all information about process evolution is taken from *references*, not from (field) *measurements*. Corollary*:* models are not meant to *manage* situations, but to *postulate* their evolution. Thus, two processes having totally different speed – *climate instability* and *global warming* – are perceived as being in an odd cause-effect relationship: sudden, *unforeseeable*, extreme weather is caused by *predictable*, slow-paced warming. Worse, the research is focused on a related, secondary process (*accelerating warming* in the future) whilst

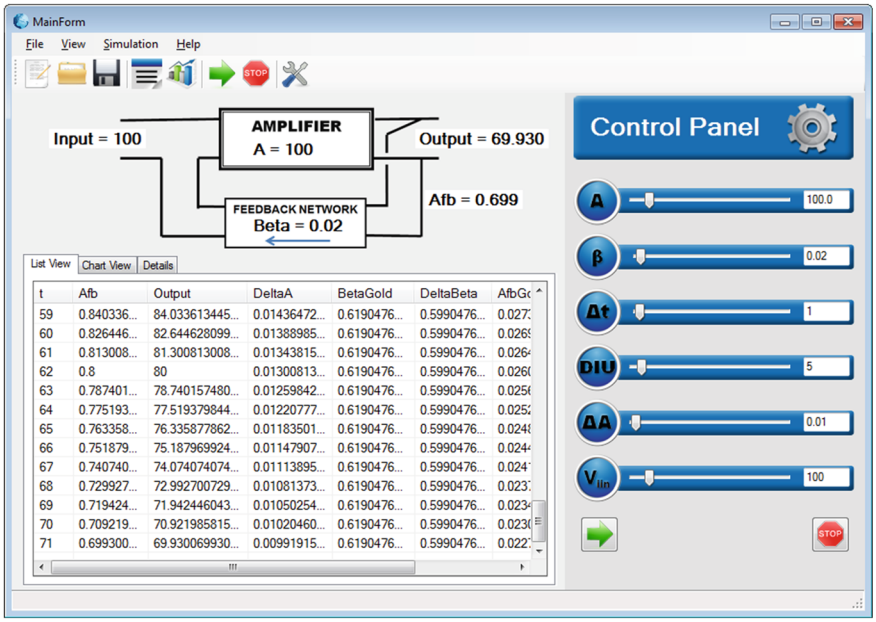

Fig. 1 Interface of an appliance for fieldwork scenarios (courtesy of R. Fabian)

nobody models instability. (“"*Modelling climate instability*"– did not match any articles” [Google Scholar]. How is it possible to disregard such a problem? A plausible answer: the very concept of *instability* as such, cannot be grasped without a cybernetic perspective. What is harder to explain, is the tenacity to model global warming. Seemingly, counting on the huge amount of data attesting that warming is increased due to anthropogenic (human-*induced*) pollution, modellers fall in the pitfall of post hoc *ergo propter hoc*, postulating that pollution *is causing* global warming. Alarming is the inference: fighting warming would mitigate extreme phenomena. Here, beyond the formal logical fallacy (invalid, abduction-based inference), there is also the nonsense of dissimilar processes believed to be closely related: Extreme weather accelerates at a scale of *decennia* (the fact of climatic changes was realised less than a century ago) whilst the Earth is warming at a scale of *millennia* (after the last glaciation, moderately: the worst scenario predict a warming of 3 °C until 2100). However, extreme weather phenomena kill right now because *Gaia lost its homeostatic state.*

Since instantaneity is unacceptable, the problem of what time should be used (i.e., setting up a model of time itself) is consequential for modelling (the stability of) *LS2*.

Research on benthos: fish species populations management [2]; species populations management support system [3]; support for species management DSS [4].

Indeterministic humans prevail over algorithmic robots. Examples of Lewis Carroll and Kleene show that *AND* is sensed as noncommutative operator, suggesting

arrow time. Models are either atemporal or have reversible time. (Effectiveness of such time in robotics has no probative force since robots do not have *NL*-capability [5].)

Wienerian time $\mathfrak{w}$ is defined in [6] as complex-valued extension of physical time $\mathbf{t = 1 / \omega}$ (as measured by any clock): $\mathfrak{w} =_{\mathbf{def}} \mathbf{1/p}$ (the operator in the Laplace transform $\mathbf{e^{pt}}$, i.e., the complex frequency $\mathbf{p = \sigma + j\omega}$. Thus, if writing $\mathfrak{w} = \mathfrak{b} + \mathbf{j\omega t}$, $\mathbf{Re}(\mathfrak{w}) = \mathfrak{b}$ can stand for *Bergsonian time* since $\mathfrak{b}$ exists *iff* σ, symbolling *irreversibility* (e.g., biologic decay) exists. If $\boldsymbol{\sigma = 0}$ (no decay), $\boldsymbol{\mathfrak{b} = 0}$ while the Laplace and Fourier transforms are equivalent (undamped oscillation, $\mathbf{e^{j\omega t}}$). Since in physical reality, $\boldsymbol{\sigma << \omega}$ (at least in important situations–e.g., oscillations), its numerical value is proportional to the numerical value of *irreversible* decay. $\mathbf{Im}\ (\mathfrak{w}) = \mathbf{t}$, called *Eulerian time*, describes *reversible* processes, expressed by *Newtonian time* $\mathbf{t}$ (e.g., movement in mechanics) or by a time (sub)species physically compatible with $\mathbf{t}$ (e.g., discrete time movement).

5 *Computing with Words* Applied in (Romanian) Paleolinguistics

Artificial intelligence in paleolinguistics = *nuanced reasoning* + *Computing With* (old) *Words*. Assessing the summands: '*AI in paleolinguistics*' is a project in the making; '*Nuanced reasoning*' is meant as defined by Moisil in the 70's. *Words* are supple while *Numbers* are rigid. The predominance of suppleness was set up as communication paradigm between living beings and artificial ones, a century ago, accepting the *Unknown* (as future contingent) and *non-apodictic truth* (as nuanced reasoning)" [5].

"Basically, a natural language is a system for describing perceptions. Perceptions are intrinsically imprecise, reflecting the bounded ability of human sensory organs, and ultimately the brain, to resolve detail and store information. Imprecision of perception is passed on to natural languages" [Zadeh quoted in [5]].

In [19] a ten-year long research line on anticipation is elaborated upon, by putting *AI* under scrutiny: "The current state and the future of AI–symbolic, neural, or combined–cannot be meaningfully assessed in the absence of adequate evaluation means and methods. Adequacy itself is reflective of the understanding of the subject of evaluation. It is expressed in the specific metric, the benchmark, to be applied when evaluation of performance is undertaken. The novelty of machine learning is that input is now understood as training, and output as operations (inferences, in the first place) performed on request (interactively) on training data (the more, the merrier the outcome). But there is no knowledge to account for" [19].

On the other hand, in semiotic-oriented meaning, *CWW* is "tried in *CyMo*, a new modelling species aimed at enhancing *LS2* model *efficiency* (software engineering stance) and user *acceptance* (service-oriented engineering stance). Starting from the premises that model tractability is crucial for both efficiency and acceptance, and that

NL-capability is a sufficient condition for tractability, *CyMo* avoids anything with low or without *NL*-capability (precision, bivalence, difficult numerical mathematics). Intractable differential equations are evaded via discrete-time modelling" [8].

In linguistics, Cantemir eclipsed his successors, accepting both Latin nature and '*Unknown*' substratum in Romanian: "From amongst his philosophical writings, his treatise *Divanul*" [*wiki*] is the first attempt to accept the '*Unknown*' in Romanian. He is –in many ways – van Helmont's follower [Cantemir D., *Descrierea Moldovei*, Bucureşti, 1967]: a. Reinstating the holistic approach – lost through the cartesian separation into *res cogitans* and *res extensa.* b. Being the forerunner of linguistics as (European) science: *Descriptio Moldaviae* was written in 1717, whereas *Sanskrit Language* (Jones' book – the beginning of compared philology) in 1782. c. As brain-father of (Romanian) etymology, he had the rare intuition to guess '*six out of seven*' words with unknown etymology in the Moldavian language: "*stezar* quercus, *padure* sylva, *halesteu* stagnum, *carare* semita, *graesk* loquor, *privesk* aspicio, *nemeresk* aliquo pervenio" [*Descriptio Moldaviae,* ed. 1875.] Except for the word *halesteu*, all words are entries in *Cuvântar* (a collection of Romanian words with unknown or contested origin). This database of facts is put to work below.

6 Falsifiability, Fallibility, Risk, Decision-Making by Humans

"Decision support systems (DSS) are becoming an important and widespread element of different fields of contemporary life in the age of explainable artificial intelligence (XAI). All somehow elaborate on the well-known procedures of data science transforming the data into information and wisdom at last. However, most of the current DSS are limited to a mere finding of the situation, i.e., a kind of diagnostics, and do not have an integrated mechanism to offer adequate solutions. The main goal of this work and its novelty is to combine system analysis with proposing solutions using the latest XAI techniques based on the usage of the generalized approach and the newly developed fuzzy SWOT maps method, and on the elements of computing with words according to the certain vocabulary and the lists of rules" [21].

"There is an overt mistrust of computers as advisors to human decision makers. Such scepticism is paradoxical: humans consider computers reliable when decision is (a *synchronous*) part of *problem-solving* mechanisms (as in automatic control) but consider them far too unconvincing when decision is (an *asynchronous*) part of *situation-managing* processes (as in risk management). This paradox suggests deep epistemic limits, since it is strongly related to *NL*-capability, showing that for decision makers trust is *doxastic*, while distrust is *credal*" [8]. (Credal regards opinion acquired through *knowledge*, doxastic regards *belief*). Decisions being not falsifiable, the only way to validate them, is through factual truth. (Or to delegate them to robots.) As regards the complex relations between falsifiability, fallibility, decision making, and machine learning there are incompatible stances: "If a machine is expected to be

infallible it cannot also be intelligent" [Alan Turing]. Another *IT* giant claimed: "I am a monomaniac. What I am a monomaniac about is decision making" [Herbert Simon]. Both address the human manner of learning, but in different contexts: Algorithmic infallibility is unnatural since nature – humans included –is fallible (Turing). Why should machines – robots included – learn anyway when human decision making is yet paradoxical? (Simon). Factual truths: The host of words[1] in *Cuvântar* are the raw material for producing falsifiable assertions. The archetype is *ALMA*: *there is no ALgorithmic Method for learning the mother tongue Ably*. This phrase asserts the nonalgorithmic nature of high-level information processing by humans. That means *learning*, in the ancient meaning of the word, undistorted by the paradoxical issue of *machine learning*. Francis Bacon spread the idea that science is based on induction: repeated observations are, generalized to theories. Popper claimed that the development of scientific knowledge is based on the same principles as biological evolution [Popper, K.R., *Conjectures and refutations; the growth of scientific knowledge*. Basic Books, New York, 1962]. "Machine learning is also taught as rooted in induction from big data. Most *AI* algorithms in use can be understood within a universal Darwinian framework involving a process of variation and selection that searches for a local or global maxima solution. […] There is yet no agreed upon theoretical foundation for understanding how *AI* systems are trained / created" [*wiki*].

The fact that *WA* are falsifiable shows both the necessity and the power of Popper's falsification principle: it is about *truth*. (In epistemic logics, *Lp* means 'it is *known* that *p* is true'; in doxastic ones *Lp* means 'it is *believed* that *p* is true'. Doxastic logics lack the *knowledge axiom*–**T**: $Lp \rightarrow p$.) Popper's ideas exerted influence on mathematics: "It was clear to Hilbert, that mathematical thinking does not proceed in the regimented ways imposed by an austere theory. Though formal rigor is crucial, it is not sufficient to shape proofs intelligibly or to discover them efficiently, even in pure logic. Recalling the principle that mathematics should solve problems 'by a minimum of blind calculation and a maximum of guiding thought', we have to investigate the interaction between understanding and reasoning, between introducing concepts and proving theorems" [Thornton, S., 'Karl Popper', *The Stanford Encyclopedia of Philosophy* (Fall 2021), E.N. Zalta (ed.)]. Indirectly, Popper exposed in philosophy itself, a double standard regarding scientific authority. A famous case: Maurice Blondel was refused a teaching post because his philosophy was deemed to be too Christian and discrediting philosophical reason. The double standard: *Quod licet Jovi* (= the encyclopaedic Gods who decree which thought schools might have philosophical status) *non licet bovi* (= any individual at academic level, who triggers the vaguest remembrance with *l'ancien Régime* – first, the metaphysical status of religious thought). As doxastic species, Blondel's ideas are not falsifiable. But Darwinian theory about '*Survival of the fittest*' is also not falsifiable. Hence, it should be treated likewise in curricula. (Ideally, since education is rooted in credal species, all doxastic species should be in a single textbook: '*Opinions about the Unknown, from Religion to Philosophy*'.)

[1] In December 2023, there were over 8,000 entries.

Admitting that engineers are an occupational family most anchored on situation management, [1] expresses a more tolerant stance towards the strict mathematical perspective. A similar stance is in [11–15] towards computer-supported DSS.

Closing. The limits of POC real-world validation within the (reigning) algorithmic paradigm surface: applying *CWW* in (paleo)linguistics presumes the existence of a comprehensive word base (the *Cuvântar* mentioned above).

7 Predictive Models Cannot Tackle Extreme Weather Phenomena

Drawing any conclusions would be inappropriate since the system defended here is not validated in vivo. However, the POC example for modelling *LS2* (in)stability allows relevant inferences about (recent) extreme weather: a. Century-long factual evidence proves that the frequency and power of extreme weather is strongly linked to human-made pollution. b. Establishing a cause-effect relationship between phenomena with vastly different process dynamics–weather *instability* and global *warming*–fails because it is illogical to assume that extreme weather (*unforeseeable*, instable, sudden) could be caused by Earth warming (predictable, stable, slow-paced). c. The wrong approach is favoured by lacking a cybernetic perspective towards (in)stability per se–as physical phenomenon. d. *Gaia* (as the living Earth) *lost its stable (homeostatic) state* – at least partially – due to *human-caused* perturbations. e. To be effective, *LS2* models should be cybernetic. f. Cybernetic modelling cannot be achieved by deterministic, predictive, modelling. g. In the light of *21CAI*, *CWW* is a valuable tool for bridging the communication gap between humans and robots. h. Modelling *LS2* stability requires *CyMo* and new time species. j. The algorithmic paradigm shows its inability to tackle emergencies – first the climate emergency planet Earth is facing.

In nuce: science failed to formulate the problem of climate instability, being unable to realise conceptual separations between: *living* and *inert* matter (Sect. 3); *data* (in numbers) and *information* (in *words*) (Sect. 5); *postulating* results *mathematically* and *validating* them *physically* (Sect. 4); *intelligent robotics* and *21CAI* (Sect. 2).

Future work. The comprehensive research setting up a physical-semiotic paradigm should be preceded by punctual researches [A] [B], within the old paradigm:

(A) Updating '*Intelligent Robotics and Data Science: Two Salient Fields. So, why Computing With Words?*' *Aim*: showing *CWW* as workable substitute for '*big data*'. *Rationale*: *21CAI* requires nonalgorithmic software since common software lacks *NL*- capability, whilst model interpretability implies it. *Approach*: focus on paradoxes and vicious circles. On this basis, nonalgorithmic software is compared with conventional one, from three stances: conceptual consistency; effectiveness; affordability – mainly, expressing nonalgorithms through usual programming syntax. *Assessment*: the high slope of '*big data*' growth shows that replacement by *CWW* becomes urgent.

(B) Finishing the prolegomena of *EUROLIED* (*EUskara-ROmâna-Lietuvių*, combined with *LIED*), an intended European project. *Trigger*: (re)discovering a family of 15 Basque words, based on *doinu*: "**doinu** *n. (mus.)* tune, melody **doinulari** *n.* musician" [Aulestia, G., White, L., *Euskara-ingelesa, ingelesa-euskara hiztegia*, 1992].

(C) Fleshing out, beyond the table of contents, *Maxwell's Daemon, Resurrected by 21st Century Artificial Intelligence. A physical-semiotic paradigm for complex systems* (humans, cells, robots, cyborgs …) *Rationale*: Maxwell called the *demon* a 'finite being' while the *Daemon* name was given by Lord Kelvin. It is a thought experiment that violates the second law of thermodynamics. (Laplace's demon was an articulation of causal determinism: if someone knows the precise location and momentum of every atom in the universe, their past and future values are entailed.).The *daemon*: Assesses (based on falsifiable factual evidence) the failure of the deterministic-algorithmic paradigm, to control real-world situations involving complex beings. Claims that the failure is systemic (Laplace's demon is defined as '*intelligence'*.) Outlines the paradigm *in embryo*, able to meet the postindustrial era requirements. Proves it *in ovo* in various fields: extreme weather, biocenosis homeostasis, paleolinguistics, pre-Indo-European long-distance links, *UNESCO* patrimony, ….

In nuce: the foundational elements of a new paradigm, aiming to tackle the climate crisis –building with bricks of raw materials available in [5–8]–are: a. An *armamentarium* dedicated to carry out and validate the POC instances: cybernetic modelling (Sect. 3); macrochronic stability of Barkhausen systems (Sect. 4); *CWW* (Sect. 5). b. Adapting older techniques: *What-if* scenarios (Sect. 4); *CWW* interfaces (Sect. 5); fact based research (Sect. 6). c. Wienerian time, as most important feature of the physical-semiotic paradigm, can be studied only in UK or US universities, because it requires huge fundamental research power as well as a few years until it could be patented.

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Sky Computing: Opportunities and Challenges

Ion Stoica

Abstract In this chapter, we explore the potential evolution of the cloud computing ecosystem, emphasizing the similarities and difference to the developmental trajectories of telephony, the Internet, and PCs. So far the cloud computing market has been dominated by proprietary interfaces from its early entrants, like Amazon Web Services, Windows Azure, and Google Compute Engine. However, in recent years has been an increasing drive from organizations towards enhanced compatibility so they can manage their workloads across various clouds. Unfortunately, unlike the emergence of universal technology standards in previous tech domains, we argue that a comprehensive compatibility standard for the cloud is neither imminent nor necessary for facilitating workload mobility across clouds and could potentially hinder innovation. Instead, we advocate for the adoption of "intercloud brokers"–systems that optimize workload placement based on various customer criteria, such as price and performance, thereby eliminating the need for customers to navigate through cloud selection. This approach, which we term "Sky Computing," is anticipated to lower entry barriers to cloud usage, spur technical innovation through specialized clouds, facilitate comprehensive integration of computational options, and enhance compliance, security, and resilience via cross-cloud deployments. We hope the opportunities and challenges we describe in this chapter will help trigger a broader collaboration effort between researchers and practitioners to develop Sky Computing, steering the future of cloud computing towards this vision.

Keywords Sky computing · Cloud computing · Distributed Systems

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