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SIXTY YEARS OF CYBERNETICS
The Philosophical Foundations of Cybernetics

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1. PHILOSOPHICAL STARTING POINTS

The well-established traditions of leading US universities have always included the practice to host multidisciplinary workshops and discussions attended by specialists from different scientific domains to hammer out issues of common interest, questions and findings concerning a number of scientific – and partly also technical – disciplines. As a rule, main attention of such gatherings is focused primarily on methodological problems, issues relating to learning and especially on the modelling of processes related to the animate as well as inanimate nature, and usually also to man, his action and products. Such workshops and meetings were generally initiated and organized by the Association for the Philosophy of Science. Their most significant outcomes would then be published in the prominent journal "Philosophy of Science", the mouthpiece of the Association. Such opportunities were also later taken up by N. Wiener, the founder of cybernetics, to formulate the concepts and principles that eventually anticipated some major starting points for his own notion of a science on communication and management, which he called "cybernetics". These were primarily two major works from the late 1940's, co-authored with other participants in the workshops, namely A. Rosenblueth and J. Bigelow who, for their part, proceeded from the concepts and knowledge of physiology and medicine. The first of the two studies [3] offers an interpretation of the terms "goal" or "goal-seeking" behaviour, concepts freed from their metaphysical connotations and serving analyses and explications of the behaviour of not only living organisms, but also of some human artefacts and thus machines. It is this joint work in particular that has formulated the underlying principles of cybernetics on the basis of specific integration of the knowledge of different domains in an effort to create a common conceptual framework. The other study [4], written jointly with physiologist A. Rosenblueth, explains the function of models, proceeding from the principle "pars pro toto", hence from the positions of isomorphism and homomorphism.

Of great substance for the prevailing atmosphere in which the basic ideas of cybernetics emerged proved to be some new initiatives and accents then asserting themselves particularly strongly in the United States. Indeed, the period before and during World War II is known as an era when the world's leading thinkers in science and culture were becoming well aware of the dangers posed by the totalitarian systems and their monopoly and fundamentalist ideologies. And America became a safe haven for thousands of scientists and scholars active in different cultural branches. Some of them were arriving with new initiatives that later found positive response and reception in the free-thinking climate of the US universities and America's academe. Norbert Wiener himself had a great deal of sympathy for such a reception, because he himself had also come to America with his family from Europe – the czarist Russia where he was born in today's Polish town of Bialystok. His father, a former journalist well versed in several Slavonic languages, was appointed Professor of Slavonic studies at the famous Harvard University. Seen in this light, it was no accident that Norbert Wiener's father, Professor Leo Wiener provided hospitality to Czech Professor T. G. Masaryk during the latter's visits to that university, while Masaryk was staying in the United States. When – after World War I – N. Wiener continued studies at several European universities, after finishing his university education in the United States, he also visited Prague, during his fellowship in Göttingen, and as a guest of the Masaryk family stayed at Lány Chateau.

The above interdisciplinary workshops, focused on methodological and philosophical aspects, have helped – and still undoubtedly are helping – in forging links among different members of the academic community or research teams, which are today described as "intellectual networks" or "invisible colleges". Their focus of interest is known to transcend the boundaries of the traditionally divided scientific disciplines or research areas. That is also why the network that was instrumental in shaping the genesis of cybernetics includes, to this day, the names of C. Shannon, the pioneer of the mathematical theory of information, J. von Neumann, the founder of the theory of games and decision-making, linguist R. Jakobson, the above-mentioned specialists in the medicine- and biology-oriented branches, and many other scholars. Similar conceptions and aspirations connected therewith also proved to be conducive to the emergence and expansion of the works and studies devoted to the role of the sign, its creation, significance and function in communication, i. e. semantics and semiotics. Efforts were made to uncover more profound links and subsequently to outline paths leading to a unification of different scientific domains, particularly by integrating the language of science. There was a mounting interest in methodological and epistemological problems and – generally speaking – in finding ways and means of attaining more profound and thorough learning. All these and similar tendencies had and still have one common trait: they kept enhancing respect, weight and significance attached to mathematics, to mathematical methods of expressing and depicting problems, and to mathematical thinking in general. The integrating tendencies encompassing the actual contexts, mutual links and stimulation of different scientific branches and their thematic domains cover a number of issues and other schools of thought, out of which especially the following are to be regarded as particularly important for the emergence of the general science on control and communication:

— It has been shown that the disciplines that focused on relating to various other thematic domains and thus to different semantic areas can be considerably useful to one another, that they can serve better in efforts at terminologically grasping and expressing a theme in hand. As a result, there is an *expansion of the field of semantic coverage* of concepts a given discipline adapts from another domain, usually considerably different in terminological terms.

— Extensive sets of terms were created in each individual branch, giving rise to systems of concepts and *conceptual frameworks* that are also characterized by specified relationships among concepts. It has been established that some conceptual frameworks could also be used in different other branches. This means that the actual competence of a conceptual framework or rather of the rules connected therewith may well be extended.

— Individual elements of thematic fields, anticipated in different domains, may be integrated, forming new entities, especially those of higher levels. This, in turn, helps in establishing a system of rules on the basis of which concatenation of different elements is possible and permissible in a way to create wholes that are usually described as *structures*. The term "structure" is then grasped as a novel unit that makes it possible to form or apply new properties and functions that do not belong among its elements as long as isolated entities exist.

2. THE PHILOSOPHICAL ACCENTS EMPHASIZED BY CYBERNETICS

The upsurge of cybernetics, the theory of information and other major scientific and technological initiatives connected therewith, especially those generally described as the "artificial intelligence (AI)" and "information technologies (IT)", have upstaged the role played by some of the principles, even though these had already been previously followed or at least taken into consideration. We'll try below to single out at least some of the most distinct ones:

(a) Up to the 19th century, two different types of action processes or sequences of changes and systems associated therewith were distinguished in philosophy and in the fundamental scientific branches:

- mechanical, deterministic, purely material systems for which causality was of utmost importance,
- systems dependent on will power, intention, well-defined goal orientation for which the decision of a specific subject was of great significance, i. e. systems that can also be characterized as teleological ones.

Teleological systems are systems capable of coping with natural processes of the growth of indeterminateness, and thus with tendencies marked by a rising level of entropy. It was deemed a matter of course that this particular capacity – naturally with a different level of accompanying restrictions – belongs to man and living creatures. Consequently, identification of mutual links between the terms "information" and "entropy" was thus in a position to expand and actually specify what was originally quite an intuitively conceived meaning of the terms "goal", "purpose", "intention", "request", as well as other concepts formerly associated with the human subject. However, another step taken thanks to cybernetics, the theory of information, the artificial intelligence, information science and other domains associated with the field of information technologies has shown that decision-making concerning goals, purposes and other forms of what were originally solely human intentions can be not only modelled, explicated but also realized by means of a technical device. This just serves to corroborate human ability to create systems capable of displaying forms of behaviour and reactions to external stimuli, which man had originally claimed only for himself, or rather for his own potential of intellect, thoughts and creativity. The programmes launched by cybernetics, the theory of information and – in parallel – also by the realm of the artificial intelligence, the study of cognitive and decision-making processes have justified the accents placed on what some philosophers called "intentionality", "teleological worlds", "worlds of the artificial", and "sciences of the artificial". (Speaking about those contexts, we should not forget the seminal role played in this field by initiatives authored by H. Simon [5].) When evaluating the stimulating significance of those programmes, it is impossible to omit yet another insight into these issues and their contemporary importance. Judging the substances and causes of the problems besetting contemporary civilization, including those confronting the world at the beginning of the present century, we will come to realize that the fountain-head of a substantial portion of today's problems and conflicts lies not only in the different levels of civilization, technical equipment, in an abundance or lack of prerequisites for one's healthy life, but rather in differences in the very concept of what is desirable, what is to be preferred, what is appreciated as a goal orientation. There are also profound differences in the comprehension, concept and content of what is spelt out by such terms as "teleological world", "intentionality", social and life "objectives".

(b) Norbert Wiener, notably in his works, but also in discussions and speeches, ascribed special importance to the initiatives launched by the great philosopher G. W. Leibniz. That thinker was not only the founder of mathematical analysis but also a pioneer of logic, reasoning and the rules of reasoning, and a distinguished scholar who, in many respects, anticipated the views and attitudes assumed by contemporary mathematical logicians, linguists, experts on the artificial intelligence and the study of cognitive processes. Out of the bulk of Leibniz's stimulating ideas we pay particular attention to the subject of inference and inferred entities. Man is free to enter the "possible worlds" in Leibniz's concept by inferring on the basis of his knowledge prerequisites and appropriate rules acquired and constructed in the sphere of the actual world, by creating – on the basis of his reasoning – images, patterns and models of entities, states or situations in a possible world. However, he also has at his disposal an opportunity to put some of the contents of his images, patterns and models into effect, providing he is equipped with necessary resources, means and other prerequisites. That is why the modal attribute (or – to put it in terms of logic – modal operator) "possible" does not yet mean "feasible". Therefore, it is important in any reasoning about possible worlds to differentiate the prerequisites of the possible in the modal sense from the prerequisites, conditions, sources and capacities of the feasible.

N. Wiener had applied himself in practical terms to the subjects of inferred entities still before conceiving the notions and principles of cybernetics, while solving the well-known problem of prediction. This involved anti-aircraft fire control and calculation of anticipated trajectory of aircraft and projectile trajectory. This type of calculation was required to set firing parameters in a way to make sure to hit the most likely spot on the aircraft's anticipated trajectory at a time when the plane may be hit by the projectile in question. But the issue of inferred entities must be combined not only with the conditions of feasibility but also with those pertaining to human and responsible acceptability, factors described as the "human dimensions" of a contemplated practical solution, as "human friendliness" etc. In actual fact, this involves sets of conditions, limits and boundaries that should never be crossed by any human action whatsoever, not only due to reasons of health, unacceptable level of other risks, but also due to universally human, ethical and cultural reasons. These particular aspects of cybernetics and the related anticipated advance of computers and other sectors of information technologies are the main topics discussed in another book, whose title quite evidently emphasizes the aspect of human friendliness [7]. (Interestingly and typically enough, the Soviet and subsequently Polish and Czech titles of that particular book used only the original subtitle of this work, namely stressing the relationship between cybernetics and society [6]. Since cybernetics had been condemned and repudiated in the Soviet Union as a bourgeois would-be science, the first edition of Wiener's books published in the Soviet bloc countries had to be furnished with critical comments and prefaces penned by various ideological arbitrators. A case in point is the series of critical remarks and often outright abuses of the author's "half-hearted approach", accusations of his being "in two minds", of oft-repeated claims that the author does not understand this or that aspect, which may found in the preface written by A. Kolman to the Czech edition of Wiener's book on the human dimensions of cybernetics [8]).

(c) The founder of cybernetics himself described the discipline he was trying for create as a major contribution to the process of fashioning an image of the world as a *realm of randomness, probability, of random processes*, where it is impossible to make do with the laws similar to Newton's law on movement associated with determinism and certainty. Scientific learning concentrated more on efforts to reduce the rate of uncertainty, indeterminateness and disorganization, to engage in a quest which is more or less an uncertain search. Reducing the rate of uncertainty is also a communication process aimed at attaining new findings and knowledge, and also at creating units, constructs or systems of highest level of organization, displaying a lower level of losses, risks or damage. Seen in this light, communication processes and control procedures share common objectives. A shared goal of those activities is an effort to reduce indeterminateness and related losses or risks, to attain more suitable or acceptable results. Discussing those contexts, Wiener used to speak of creating places, islands or constructs with a reduced level of entropy.

Saying that we move, live and create in a world of randomness, probability or accidental processes, we have to realize that probability is just form of a measure which may figure in different values, that it constitutes an operator of statements with a different level or degree of indeterminateness, uncertainty or lack of knowledge, that it might also involve very diverse attitudes to what a measure under consideration is really related to in the given situation [1]. These forms also correspond with various linguistic expressions in natural languages. For its part, Latin distinguished the meanings "probabilis" and "verisimilis" (in English "probable" and "likely"). Different forms of certainty or uncertainty can be introduced by using such terms as "we expect", "we suppose", "probably", "with a small or great degree of probability", "almost certainly" and naturally with a number of other means available in natural languages. The actual rates of certainty or uncertainty can also be indicated by means of accompanying non-verbal components of given communication. If a rate of certainty or uncertainty is used in communication, it is always crucial for the recipient of a statement spelt out by the operators with a corresponding degree of uncertainty to take into account what may be described as "competence", "specialization", "credibility" of the speaker vis-à-vis the context in which the pertinent statement is made and within the context of many other circumstances.

(d) The first steps taken by such disciplines as cybernetics, computer science, informatics, the theory of games and the theory of decision-making, start-up and development of the artificial intelligence, the study of cognitive processes, new modes of communication and the structure of language and some other initiatives associated with these trends were focused on and distinctly enriched the attention traditionally devoted to the issues of learning, scholarly research and inquiry as well as ways and means of generating new knowledge. Seen against this backdrop, these are problems which are usually regarded as the subjects of philosophical inquiry. Looking at their sum-total, it is definitely impossible to omit the following issues, particularly when considering the origin and development of cybernetics:

- problems pertaining to ways and methods of learning, and thus epistemological and methodological issues,
- relationships between the old and the new, relations involving what is sometimes called "a priori" and what is described as "a posteriori",
- matters concerning major knowledge-related changes, their motives or sources,
- human and social contexts of momentous changes occurring in our knowledge and in science and technology progress.

The journey leading to the concepts of cybernetics, the theory of information, the artificial intelligence and related domains constitutes an unflagging quest marked by a number of turns, obstacles and potential pitfalls. Such a path is virtually impossible and unthinkable without a patient looking-back over the shoulder to see what has already been performed and formulated. That is also why Wiener linked up to and developed the stimulating impetuses, initiatives and marked shifts in knowledge made by preceding thinkers and philosophers among whom it was primarily Leibniz who enjoyed particularly great respect. As a mathematician, he appreciated his predecessors and teachers as well some outstanding physicists. He acquired and utilized a lot of inspiration and different subjects from his colleagues, co-workers and co-authors active in biological domains. Of great importance is also the finding that Wiener was known to seek anticipations of his own views, thus confirming the fact that we tend to view newly acquired or discovered findings through the prism of our existing knowledge. We do so also because we have at our disposal the hitherto available and thus acceptable and easily interpretable terminological apparatus, conceptual systems and related patterns and rules. To put it in other words, when studying and elucidating new subjects and scrutinizing new-found problems, we never operate with an absolutely blank sheet, an empty mind or without specific prerequisites, expectations and often preliminary hypotheses.

(e) Quite definitely, N. Wiener does not rank among those members of the academic and scientific community who would lavish on new steps in science and technology and on positive shifts in the endeavours to broaden knowledge only words of admiration and praise or even jubilation and show of optimism. He figured among those distinguished representatives of creative efforts in those new fields of human activities who also raised a cautionary voice, pointing to possible risks, to both advantages and disadvantages associated with the new domains of science and technology and their application. Seen in this light, it is by no means accidental that a mere two years after the publication of his main work on cybernetics, Wiener published a book on the human use, human dimensions and relationship between cybernetics, man and society. Wiener himself warned that science and technology progress does not come "free of charge", that its achievement calls for expending great efforts and funds, and also that we have to pay for the creation of what he called islands with an opposite tendency in the development of the level of entropy by an increase in the level of entropy outside these islands. It is vital to recollect that such warnings and apprehensions had been voiced already at a time when nobody else was prepared even to admit concerns over the limits of resources, over the so-called greenhouse effect or at a time when nobody voiced such warnings at all.

Allusion to the "human use", the "human dimensions" of cybernetics was one of the few voices speaking out about limitations and abuses of some results of science and technology. Just as the theory of information and analysis of information transfer were taking their first steps, C. Shannon and others pointed to what was described as a redundancy and later flooding of useless and unnecessary data, to the danger of society being inundated by undesirable messages, which may eventually even overshadow the desirable and necessary ones. In a similar vein, the pioneer of the concepts of the "information society" A. Weinberg cautioned that the widespread conviction according to which is it the general public, society, public opinion that will be able to make the best selection of what is needed may prove to be an illusion since in many situations the society does not actually know what is necessary for itself.

The human and social aspects of cybernetics and informatics do have their philosophical and ethical dimensions. If it is true that cybernetics was born as a product of the synthesis of different, previously and traditionally autonomously cultivated disciplines, then its development and application tend to produce ever new and different requirements laid on the generalizing tendencies in science and research. This applies primarily to the task of harmonizing the technical and human dimensions, time cycles, capacity and human dimensions, time rhythms. (The French researcher A. Lebeau characterized this particular field of problems by the term "engrenage", which originally means engagement of toothed wheels in a gear set [2].) But this does call only for integrating different natural, technical and humanitarian disciplines but also fir amalgamating knowledge and values, notably ethical, cultural and aesthetic ones. That is why questions of the type "cui procest", "cui bono" and similar queries can be excluded neither from science nor – and this is doubly important – from its applications.

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