System Analysis: A Literature Review

Anouar Hallioui (*), Brahim Herrou (**)
(*) : Industrial Techniques Laboratory, Center for Doctoral Studies in Engineering Sciences and Techniques - Faculty of Sciences and Techniques of Fez,
SIDI MOHAMED BEN ABDELLAH University, Fez
anouar.hallioui@gmail.com
(**) : Superior School of Technology, BP. 2427 Route d'Imouzzer, Fez
brahimherrou@ yahoo.fr

Abstract

Everything that exists in nature competes without ceasing on its part, for a finality that makes its raison to be and ensures its continuity and that of its environment. The dynamic vision attached to the systemic thinking is a modern vision, because it is opposed to the static vision related to the analytical (classical) thinking! According to our research in the literatures on this subject, in 1637, René Descartes launched his ''Discourse on the Method'' which was the model for many research works before systemic and system analysis in particular, and which is now a classic, as soon as the system analysis appeared in the 20th century, filled in the ''New Discourse on the Method'' of the specialist in systemic and constructivist epistemology, Mr. Jean-Luis Le Moigne in his work ''The General System Theory : Modeling Theory''. ''Each discourse has its paradigm'' as Le Moigne (1977) said in his New Discourse on the Method! The precepts of the new discourse on the method, as well as the characteristics of the open system paradigm as a new system paradigm defined by the systemic in general, have given after several historical processes the bankruptcy of the classic discourse of Descartes.

Keywords
Dynamic vision, systemic, system analysis, the precepts of the new discourse on the method, new system paradigm defined by the systemic.

1. Introduction

For any system or phenomenon, whatever its nature and complexity, our way to see it, to perceive it, to explain it, to act and manage it depends on our style of thinking. Our perspective and motivation to reveal the modern and optimal way of understanding and managing production systems in terms of their performance justified us the work on the study of system analysis, on the one hand by considering the system analysis as a means likely to enable us to understand, model and manage the various phenomena, and on the other hand by considering it as an objective or an effect with components to be discovered and defined through this work of research.

In this perimeter, the study of the system analysis is made in four parts, the first makes it possible to put the system analysis under the light to eliminate subsequently all the confusions that may exist between the various concepts related to the systemic, the second part is a serious comparison between the analytical approach and the systemic approach, the third part presents the new paradigm of system according to the systemic and the last part describes all the historical processes that preceded and caused the bankruptcy of the discourse of Descartes for manifesting the precepts of the New Discourse on the Method making the pillars of system analysis as a tool of the systemic.

Given that the systemic thinking knows a great success in all research areas, as well as a perfect adaptation to the time from the years before the 2nd half of the XXth century until today, and thanks to our systemic thinking opposed to the analytical thinking: how can we explain the system analysis? What are the limitations of the Cartesianism and the analytical thinking in general?

Epistemologically speaking, the way of defining and explaining a simple system is absolutely different from the way of defining and/or explaining a complex system. So, by studying the system analysis, we discover the different historical processes that generate the obsolescence of Cartesianism and describe the system analysis as a simple phenomenon thanks to the linear interactions taking place between the different processes (fig.1). Thanks to the diagram below, we present the context of creation and the origin of the system analysis:

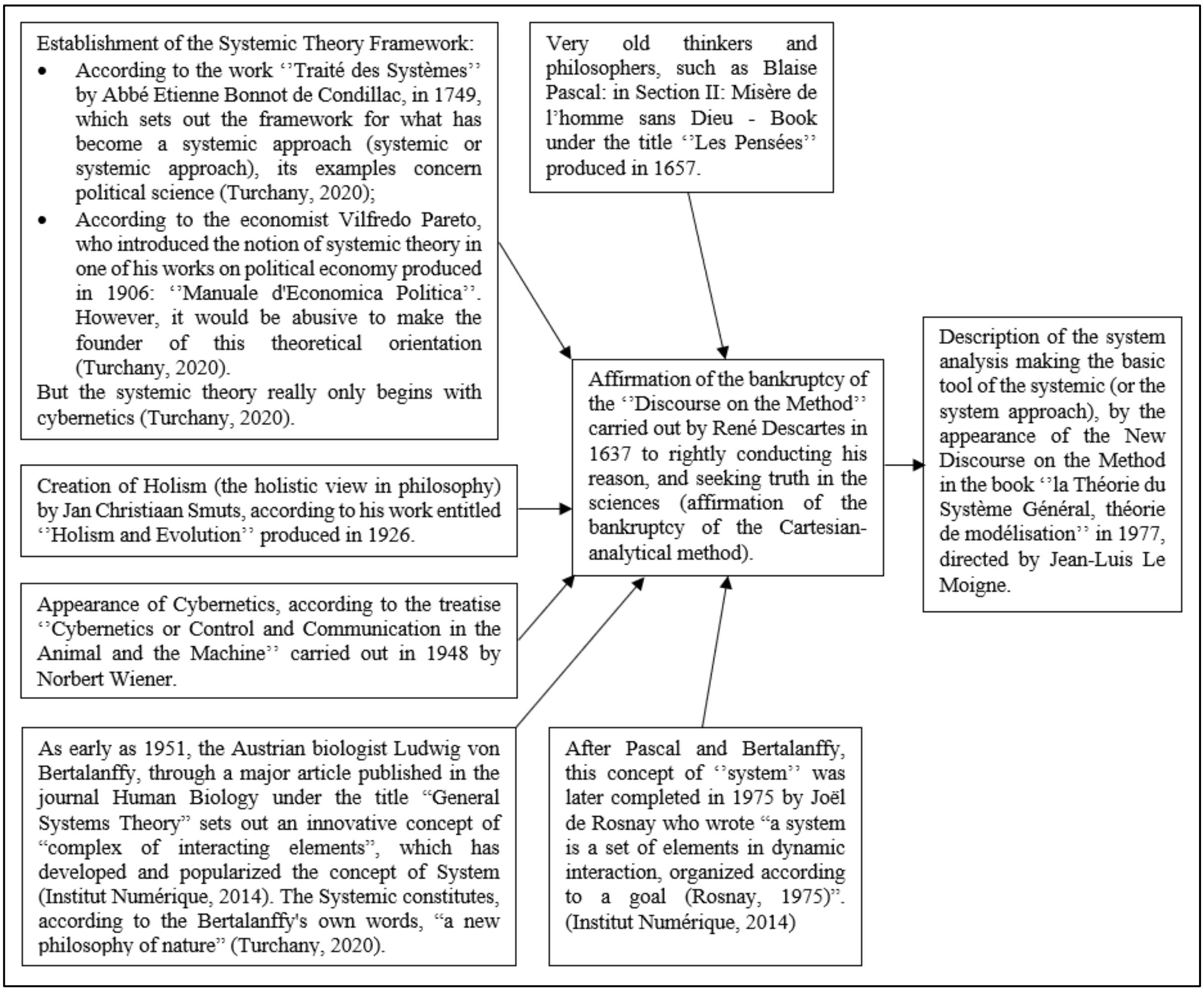

Figure 1. The context of creation and the origin of the system analysis.

2. Light on the system analysis ''tool of the systemic'', elimination of confusion of concepts related to the systemic

The systemic concept (the systemic approach concept or the system approach concept) frames that of system analysis and other important concepts that can be confused in the context of systemic. Many authors have contributed to anchor the concepts related to the systemic in the literature. The systemic, the cybernetics, the general systems theory, the system analysis and the systematic approach are all concepts that are often confused.

The word systemic appeared in the second half of the 20th century and derives from Systems Theory (or Systemic Theory) which is one of the bases of systemic, but not the only one (Turchany, 2020). As early as 1951, the Austrian biologist Ludwig von Bertalanffy, through a major article published in the journal Human Biology under the title ''General Systems Theory'' sets out an innovative concept of a complex of interacting elements (Institut Numérique, 2014). He said "A system can be defined as complex of interracting elements (Bertalanffy, 1968)", which has developed and popularized the concept of System. The Systemic constitutes, according to the Bertalanffy's own words, "a new philosophy of nature" (Turchany, 2020). The systemic is a scientific method that applies the systemic theory. It is based on the logic of system. Thanks to a holistic vision (comes from Holism), it allows us to go beyond the limits of classical Cartesianism to tackle complex subjects that were resistant to this last. It is recent and comes in particular from cybernetics (Turchany, 2020). The system approach is based on cybernetics and systems theory (Rosnay, 1975).

According to Rosnay (1975), we must situate the systemic approach in relation to other approaches with which it is often confused: the systemic approach goes beyond and encompasses the *cybernetics* approach, which has as its main goal the study of regulations in living organisms and machines; the systemic differs from the *General Systems Theory*, the ultimate goal of which is to describe and encompass, in a mathematical formalism, all the systems encountered in nature; it also deviates from the *system analysis*, this method is only one of the tools of the system approach, taken in isolation, it leads to the reduction of a system into its components and elementary interactions.

Finally, the systemic approach has nothing to do with a *systematic approach*, which consists of approaching or carrying out a series of actions in a sequential way (one thing after another), detailed, leaving nothing to chance and not forgetting any element (Rosnay, 1975).

3. Comparison between the analytical approach and the systemic approach

Before starting the comparison and thinking about the differences between the analytical approach and the systemic approach, we quote that the history of scientific research, ways of thinking and styles of management of structures testifies to the complementarity of the both approaches. First, we start the comparison between the analytical thinking and the systemic thinking to go through the comparison between the two approaches, then the comparison between the concepts which are related to them.

The use of systemic thinking facilitates the understanding of complex systems. The most important property of systems is that they are made up of several parts that are not isolated, but closely interlinked, forming a complex structure. A random conglomeration of the elements does not characterize a system. On the contrary, all of its components are subject to a certain order, and each part of a system naturally can be a system (Vester, 1976). This lends a great deal of importance to systemic thinking, in that it helps to describe complex systems and their interrelations (interactions), using approaches that facilitate globalizing thought, avoiding the inconveniences of simplifications (Seiffert and Loch, 2005). So, through our dynamic vision of the system approach attached to systemic thinking: the system includes classes of subsystems, internal and external interactions; each class has subsystems and their dynamic interactions (Hallioui and Herrou, 2020).

Rosnay (1975) said that:

- The systemic approach is *a common approach* making it possible to better understand and better describe the organized complexity, since the notion of ''system'' (living system, economic system, ecosystem, etc.) links all the different basic notions that come up most often in biological model, ecological model, economic model, etc., and which can easily be grouped into a few broad categories: energy and its use, flows, cycles and reservoirs, communication networks, catalysts and agents of transformation, the re-establishment of balances, stability, growth, evolution, etc. ;
- The system approach is a unifying and transdisciplinary approach symbolized by the macroscope. It should not be considered as a science, a theory or a discipline, but as a *new methodology, making it possible to gather and organize knowledge with a view to greater effectiveness of action*;
- The system approach is based on the notion of a system. This notion, often vague and ambiguous, is nevertheless used today in a growing number of disciplines because of its power of unification and integration;
- According to the most common definition, *"a system is a set of interacting elements"*. A city, a cell, an organism are therefore systems. But also, a car, a computer or a washing machine! We can see that such a definition is too general. No definition of the word system can be satisfactory. Only the *notion* of system is fruitful. Provided, of course, to measure its scope and limits;
- At the difference from the analytical approach, the systemic approach encompasses all of the elements of the system studied, as well as their interactions and interdependencies. It must be applied in the case of high complexity systems, made up of a very large diversity of elements linked by strong interactions. To consider a system in its *totality*, its *complexity* and its *own* dynamics. Thanks to simulation, for example, we can animate a system and observe in real time the effects of the different types of interactions between its elements. The study of its behavior in the time leads to the definition of the rules of actions aimed at modifying the system or designing others;
- The analytical approach seeks to reduce a system to its simplest components, in order to study them in detail and to understand the types of interactions that exist between them. It must be applied in the case of homogeneous systems, that is to say systems comprising similar elements and representing weak interactions between them;
- The analytical approach and the systemic approach are more complementary than opposed. But yet they are irreducible to each other.

The following table (tab. 1) recapitulates the summary of a comparative study between the analytical approach as a classical approach (of which the Cartesian-analytical method or the Discourse on the Method of Descartes is part) and the systemic approach as a modern approach (based on the system analysis contained in the New Discourse on the Method):

Table 1. Comparative study between the analytical approach and the systemic approach (Rosnay, 1975).

Analytical approach	**Systemic approach**
Isolates: focuses on the elements.	Connects: focuses on the interactions between the elements.
Consider the nature of the interactions.	Consider the effects between interactions.
Relies on the precision of detail.	Relies on the global perception.
Modify one variable at a time.	Modify groups of variables simultaneously.
Independent of duration: the phenomena considered are reversible.	Integrates duration and irreversibility.
The validation of facts is achieved by experimental proof within the framework of a theory.	The validation of the facts is carried out by comparing the functioning of the model with reality.
Precise and detailed models, but difficult to use in action (example: econometric models).	Models insufficiently rigorous to serve as a basis for knowledge, but usable in decision-making and action (example: Club of Rome models).
Effective approach when interactions are linear and weak.	Effective approach when interactions are non-linear and strong.
Leads to teaching by discipline (juxta-disciplinary).	Leads to multidisciplinary teaching.
Leads to a planned action in detail.	Leads to an action per objective.
Knowledge of details, ill-defined goals.	Knowledge of goals, unclear details.

In his contribution to the comparative study between the analytical approach and the systemic approach, Rosnay (1975) said that "In addition to the opposition between analytical and systemic, there is the opposition between static vision and dynamic vision". The table below presents the concepts related to the classical thinking and those related to the systemic thinking, in fact, the static vision characterizes the analytical approach attached to the classical thinking, and the dynamic vision characterizes the systemic approach attached to the systemic thinking (tab.2). It is necessary to know the differences between the two approaches, taking into account the objective and type of target system for each one, in order to use these approaches correctly. It is true that the analytical approach has become a classic in the field of applications of scientific approaches and methodologies after the 2nd half of the 20th century, but we must never forget that nothing is perfect, indeed, the correct use of an approach requires the adequacy between its objective and that of the observer, moreover, it is only a question of *relevance* which is one of the basic precepts of the system analysis. In this context, we well remember the discourse of Pareto and Bonnet (1909) on the subject of theories, who stated that ''It must be added that theories are only means of knowing and studying phenomena. One theory may be good for achieving a certain objective; another may be to achieve another objective''. Then, on the basis of Table 1 and Table 2, we can only say that the analytical approach is favorable for simple systems and the systemic approach is favorable for uses where complex systems are involved:

Table 2. Important concepts related to the classical thinking and those related to the systemic thinking (Rosnay, 1975).

Static vision *(simple systems)*	**Dynamic vision** *(complex systems)*
Solid	Fluid
Force	Flow
Closed system	Open system
The only form of explanation of phenomena is the Linear Causality (i.e. the mode of explanation based on a logical chain of causes and effects): ✓ Stability; ✓ Rigidity; ✓ Solidity. Cause $\longrightarrow$ Effect Before $\longrightarrow$ After	The mode of explanation of phenomena based on a circular causality open on the finality: ✓ Dynamic stability; ✓ Steady state; ✓ Continuous renewal (turnover).
$\longrightarrow\!\!\longleftarrow$ Balance of forces	$\rightleftarrows$ Flow balance

Example: Crystal	Example: Cell
Systems behavior: ✓ Predictable; ✓ Reproducible; ✓ Reversible.	Systems behavior: ✓ Unpredictable; ✓ Irreproducible; ✓ Irreversible.

4. The system paradigm defined by the systemic

The systemic fixed the principles characterizing the natural character that ensures the equilibrium for any system, whatever its nature and structure. It has given to the concept of system its deserved value, by taking it out of the cage from the closure designed by the reductionists (the Cartesians) towards the opening on its environment.

According to Brandenburg and Wojtyna (2006), the systemic thanks to its system analysis tool, defines the system by:

- *Borders (what is inside and what is outside):* It is the observer who determines where the system starts and stops, depending on the purpose of the analysis. What is system in one case of analysis can become subsystem or environment in another case. Any system has its limits with an another or more;
- *Exchanges with its environment (what happens at its borders)*:
    - ✓ Inputs that are a source from the environment;
    - ✓ The outputs which are the action of the system on its environment;
    - ✓ The transformation described by the difference in the state between the inputs and the outputs.
- *An interior with a set of elements linked together (the interacting subsystems)*;
- *A certain stability (the system is maintained even in a changing environment):* This last characteristic leads to the notion of feedback or cybernetics; it is also called the feedback loop. It is an adaptation mechanism that ensures constant outputs and makes its good response even if the inputs or the environment fluctuate. The quality wheel (Deming wheel) or PDCA cycle is a derivative of this principle of feedback.

It is normal that this system paradigm is recent, arising from the systemic, after the analytical approach and Cartesianism defining the system as a closed set. But in reality, this system paradigm defined by the systemic in the 20th century can be defined as an ancient modern paradigm! Since very old thinkers and philosophers provided a framework for all that is currently known by the systemic, the system analysis and the new paradigm of system.

5. Chronological affirmation of the bankruptcy of Discourse on the Method of Descartes

5.1. Review of the Discourse on the Method of Descartes

To rightly conducting his reason, and seeking truth in the sciences, René Descartes founded the ‘’Discourse on the Method’’ in 1637, which was the paradigm for much research before the system approach, allowing former researchers to study the phenomena and the problems. This is known by the Cartesianism, since it is attributed to the philosophy and reasoning of Descartes.

The four precepts of the Discourse on the Method of René Descartes are as follows:

- The first was never to accept anything for true which I did not clearly know to be such; that is to say, carefully to avoid precipitancy and prejudice, and to comprise nothing more in my judgement than what was presented to my mind so clearly and distinctly as to exclude all ground of doubt (Descartes and Veitch, 2012);
- The second, to divide each of the difficulties under examination into as many parts as possible, and as might be necessary for its adequate solution (Descartes and Veitch, 2012);
- The third, to conduct my thoughts in such order that, by commencing with objects the simplest and easiest to know, I might ascend by little and little, and, as it were, step by step, to the knowledge of the more complex; assigning in thought a certain order even to those objects which in their own nature do not stand in a relation of antecedence and sequence (Descartes and Veitch, 2012);
- And the last, in every case to make enumerations so complete, and reviews so general, that I might be assured that nothing was omitted (Descartes and Veitch, 2012).

To fully understand the principles of the Cartesian Discourse, according to the Descartes's own words “The long chains of simple and easy reasonings by means of which geometers are accustomed to reach the conclusions of their most difficult demonstrations, had led me to imagine that all things, to the knowledge of which man is competent, are mutually connected in the same way, and that there is nothing so far removed from us as to be beyond our reach, or so hidden that we cannot discover it, provided only we abstain from accepting the false for the true, and always preserve in our thoughts the order necessary for the deduction of one truth from another (Descartes and Veitch, 2012)".

The four long chains of reasons, as they were called by Descartes in his Discourse on the Method can be summarized according to Brandenburg and Wojtyna (2006) in the following lines:

- *The precept of evidence:* Accept what is obvious for real;
- *The reductionist precept:* Divide the difficulties to solve them one by one;
- *The precept of causality:* Starting from the simplest to the most complex, from cause to effect;
- *The precept of exhaustiveness:* Measure everything exhaustively, to be sure not to forget anything.

5.2. The constructivist idea of ''system of parts and interactions'' (Blaise Pascal in 1657)

In the XVIIth century and precisely in 1657 (Institut Numérique, 2014), Blaise Pascal intended fragments of manuscripts to his apology for the Christian religion. With a view to describing the misery of man without God, in a heavy and direct letter which is opposed to Cartesian reductionism contained in the Discourse on the Method, Blaise Pascal said: "I cannot forgive Descartes: he would have well wished, in all his philosophy, to be able to do without God; but he couldn't help but flick her to set the world in motion; after that, he has nothing to do with God. Descartes useless and uncertain. Descartes. - We must say roughly: *It is done by figure and movement,* because it is true. But to say what and to compose the machine, that is ridiculous. Because it is unnecessary and uncertain and painful. And when that would be true, we don't consider all philosophy to be worth an hour of labor. (Pascal and Brunschvicg, 2010)". This is because Blaise Pascal was against the idea of the Whole is equal to the sum of its parts, and the Whole must be divided into independent parts, which is known by the Cartesian analytical tradition.

To understand the whole, it is necessary to know the parts in addition to never neglecting the movements, that is to say the exchanges, the links or the interactions between the parts within their whole. The reason for which Blaise Pascal proposed in the book ''Les Pensées'': "So all things being caused and causing, aided and aiding, mediate and immediate, and all maintained by a natural and insensible link which binds the most distant and the most different, I hold it impossible to know the parts without knowing the whole, no more than knowing the whole without knowing the parts in particular. (Pascal and Brunschvicg, 2010)".

5.3. Establishment of the framework of the systemic theory since 1749

The systemic theory is one of the foundations of systemic (or system approach), but not the only one. It brings together all the theoretical principles that explain the systemic. This theory only really began with cybernetics in the second half of the XXth century (see the introduction of this article), although its framework had been drawn up since the IIXXth century, by the philosopher, the writer, the French academician and economist Abbé Etienne Bonnot de Condillac in his work ''Traité des Systèmes'' produced in 1749, then by the Italian sociologist and economist Vilfredo Pareto in his work on political economy ''Manuale d'Economica Politica'' published in Italian in 1906. Vilfredo Pareto would however be abusive to make the founder of this theoretical orientation. It is Norbert Wiener, teacher at MIT who, in 1948 in his treatise ''Cybernetics or Control and Communication in the Animal and the Machine'', proposed for the first time to raise the idea of the black box to the rank of instrumental concept of the scientific modeling. To understand the interest of this evolution we must remember that since René Descartes the scientific research has been based on *the postulate of causality*: the phenomena of the world can be explained by a chain of causalities. If a phenomenon initially appears to be too complex, it suffices to break it down into several chains of causalities. This approach is what can be called an analytical approach. With the systemic theory, the approach is totally different. *The teleology* is accepted as an operational postulate. We are therefore going to represent what we do not understand in a phenomenon that we are trying to study under the aspect of a black box. This black box is considered as an active phenomenon whose behavior we know but not how it works. Insofar as we can know the information entering this black box and that we know its reactions, we can deduce from it an "informational feedback" which will gradually make it possible to describe the control system of the black box (Turchany, 2020).

Before Cybernetics and its innovative principle *teleology* (or finality) stated in the 1940s by Norbert Wiener in his work ''Cybernetics or Control and Communication in the Animal and the Machine'', the framework of teleology is drawn up by Mr. Abbé Etienne Bonnot de Condillac since the year 1749. This last quoted at the end of the page 175 and the beginning of the page 176 of the work ''Traité des Systèmes'' a so clear idea on the system, the teleology and even the system approach, saying that "An organized body is one whose parts have a harmony between them which makes them all work towards the same end in an order in which they appear to act only in dependence on one another (De Condillac, 2010)".

Abbé Etienne Bonnot de Condillac is the first designer of the perimeter of what became systemic theory, cybernetics and system approach in the XXth century. He began his Book ''Traité des Systèmes'' with an exhaustive definition of the concept of system, saying that "A system is nothing other than the arrangement of the different parts of an art or a science in an order where they all support each other, & where the last are explained by the first. (De Condillac, 2010)". In this definition of system, De Condillac mentioned the following concepts:

- *System:* Can be anything in nature, but with distinguished parts in an order organizing them according to a finality. This was not confirmed until 1975 by Joël de Rosnay (after Pascal in 1637 and Bertalanffy in 1951) who wrote that ''a system is a set of elements in dynamic interaction, organized according to a goal. (Rosnay, 1975)";
- *Art or science:* It is the system, the whole or the phenomenon to be studied, understood, explained or managed;
- *Distinguished parts:* These are the different components of the set;
- *Order:* It is the organization of the disposition of the different parts, making it possible to achieve an objective (an end or finality);
- *Mutual supports:* These are the interactions, harmonies or mutual influences between the different parts of the set (the Whole), within the framework of their organization (order) according to the objective to be achieved;
- *The last are explained by the first:* Which means that we can explain and understand the parts of the set in relation to each other since they influence each other through their interactions. In this expression the content is so far and contradictory to the precept of causality of Descartes in his discourse on the method, and this is well confirmed by Abbé Etienne Bonnot de Condillac in the page 212 of his work ''Traité des Systèmes'', of which he said in opposition to a causalist philosopher that "The Author extends & turns this reasoning around in a thousand different ways; & he applies to it yet another principle, that a cause must contain its effect. But a mind which does not have knowledge does not contain it; therefore, he will not give it to himself. If, for example, he has only one knowledge, he will never be alone a judgment, nor a reasoning; because for a judgment two knowledge is needed, and three for a reasoning. But one does not contain two, it does not contain three. A mind that has only one knowledge will therefore not give itself a second or a third. (De Condillac, 2010)". Hence the need for interactions between the parts of a system, so that they can be explained in terms of each other.

In a second time of establishing the framework of the systemic theory, Vilfredo Pareto did not contribute thanks to his work ''Manual of Political Economy'' until 1906, to a theory of general equilibrium, on the basis of its sociological reflection combined with economics in the stage of the political economy. In order to focus on the general equilibrium theory (or general theory of economic equilibrium).

In the context of discussing theories in the first pages of the ''Manual of Political Economy'', Vilfredo Pareto says that "It should be added that theories are only means of knowing and studying phenomena. A theory can be good for achieving a certain goal; another may be to achieve another goal. But anyway, they have to agree with the facts, because otherwise they would be of no use. (Pareto and Bonnet, 1909)", which we can explain by the non-existence of an ideal theory, or of a theory better than the other, then everything depends on the predetermined objective and the coherence with the reality imposed by the concrete phenomenon to know or study.

Vilfredo Pareto was right, we ourselves treat the system analysis which is a tool of the systemic approach and opposed to the principles of the classical discourse of René Descartes, in particular his causalist precept, but to develop this article and study the system analysis , we proceeded the causality (linear causality) starting from the causes towards the effects, in fact in the introduction of this article, we explained the context of creation of the system analysis, starting from the origins and ideas triggering this tool from the systemic until its manifestation, and just based on the elements (neglected interactions) because they are linked by weak interactions (see the diagram of the context of creation and origins of the analysis system, see the Introduction). Our reason is not that we prefer causalism to present the context of creation of the system analysis in this article, but just: In view that the chronology and the causalism (linear causalism) as elements of the ordinary logic (or the static vision linked to the analytical approach attached to the classical thought), they may have been useful to us in describing the context of creation of system analysis as a simple phenomenon (cause-effect relationship or simple system); To show the concrete limitation of cartesianism (or cartesian-analytical modeling) in general and of causalism in particular in this context. This put us in the concave and quite agree with the expression of Vilfredo Pareto in the page 247 of the "Manual of Political Economy" which says that "It is the mutual dependence of the economic phenomena which makes essential the use of mathematics to study these phenomena; the ordinary logic can be used well enough to study the cause and effect relationships, but soon becomes powerless when it comes to relationships of mutual dependence. (Pareto and Bonnet, 1909)". Indeed, the complex systems of which it is a question of strong interactions and a great diversity of the elements make a real limitation for the classical thought in general.

Vilfredo Pareto continued on the impulse to establish the framework of the systemic theory resulting from the dynamic vision of a systemic thought based on a circular causality and open on the finality, opposite with the causalism or the linear causality of René Descartes in his classical discourse, saying in the page 307 of his book ''Manual of Political Economy'' that "The theory of economic equilibrium will teach us how these prices are determined. We must therefore be careful not to make the mistake of saying that the cause of the difference in these prices is in the difference in the times at which these goods are available. Because there is no cause for this difference; there are a very large number of them; and these are all the circumstances, without excepting one, which determines the economic equilibrium. (Pareto and Bonnet, 1909)", which can be translated by the fact that the completion and the explanation of the ''economic equilibrium'' as a system is achieved by a ''theory of economic equilibrium'' making it possible to consider the set of circumstances (the interactions between the different prices) is responsible for the price difference determining the end (finality) of the economic equilibrium as a complex system. It is the dynamic vision of the systemic thinking tracing the framework for the systemic theory.

To anchor and strongly outline the framework of the systemic theory which is based on the teleology (the finality), Vilfredo Pareto said in the page 659 of the recently cited work that "To know the equilibrium position of a system such than the system (148), we need to know how the movements of which this system is susceptible are effected. (Pareto and Bonnet, 1909)". As an indication, to know the movements of which the system is susceptible, as Vilfredo Pareto said, it is essential for us to know and explain the system by its behavior contained in the behavior of its different parts influencing each other, and it is what is known by the finality or the teleology of the system in globality. This is the systemic theory that only really emerged and popularized after cybernetics at the turn of the first half of the XXth century.

5.4. Creation of the Holism in 1926

Holism (from Whole) is the term here coined for this fundamental feature of wholeness in the world (Smuts, 1936). The fundamental characteristic of wholeness in the world is the concern of understanding the concept of Holism!

Let us remember, from part of the definition given to the systemic by Dr. Guy Turchany in his article ''The Systems Theory and Systemic'': "The systemic is a scientific method which applies the systemic theory. It is based on the system logic. Thanks to a holistic vision, she makes it possible to go beyond the limits of the classical cartesianism to tackle complex subjects that were refractory to it. (Turchany, 2020)".

According to this definition, the holistic vision or Holism is one of the pillars of the systemic, making it possible to go beyond the limits of cartesianism (the Cartesian-analytical method or the Discourse on the method which is called the Classical Discourse on the method), but at what level is this systemic overcoming of cartesianism in terms of the Holism component?

The definition of Dr. Guy Turchany can be put under the light of a concrete example presented by Jan Christiaan Smuts, in his work entitled ''Holism and Evolution'' produced in 1926, to answer our question and give us a real image on the holistic philosophical vision (Holism or the holistic character of sets in the nature).

The example of Christiaan Smuts is contained in the part where he said "Taking a plant or an animal as a type of a whole, we notice the fundamental holistic characters as a unity of parts which is so close and intense as to be more than the sum of its parts; which not only gives a particular conformation or structure to the parts, but so relates and determines them in their synthesis that their functions are altered; the synthesis affects and determines the parts, so that they function towards the *whole*; and the whole and the parts therefore reciprocally influence and determine each other, and appear more or less to merge their individual characters: the whole is in the parts and the parts are in the whole, and this synthesis of whole and parts is reflected in the holistic character of the functions of the parts as well as of the whole. (Smuts, 1936)". This can give us a solid basis, in order to say that the overcoming of cartesianism by the systemic in terms of its component Holism, is done in opposition to cartesian reductionism (or reductionist precept of Descartes) according to which the system is equal to the sum of its parts and we must divide the difficulties to solve them one by one or divide a phenomenon to understand or explain it, without taking into account the interactions and their effects! The holistic vision is the tendency of nature to generate sets greater than the sum of their parts (Wikipedia contributors, 2020), therefore it is a vision in the light of which the phenomenon to be understood is indivisible and to be considered as the set of its parts in their synthesis, and this is the reason for its opposition to the cartesian reductionism by the generation of *the precept of globalism* to be studied in the New Discourse on the Method determining the system analysis tool of the systemic.

After the example that Jan Christiaan Smuts gave in the page 85 of his work ''Holism and Evolution'', he came to press on the page 86 of the same work, what we said in the previous paragraph, saying that "Natural wholes are always composed of parts; in fact the whole is not some entity additional to the parts, but is just *the parts in their synthesis*. (Smuts, 1936)" and "As Holism is a process of creative synthesis, the resulting wholes are not static but dynamic, evolutionary, creative. (Smuts, 1936)". As remark, if we take the first example of Jan Christiaan Smuts, we underline "the whole is in the parts and the parts are in the whole, and this synthesis of whole and parts is reflected in the holistic character of the functions of the parts as well as of the whole. (Smuts, 1936)", it is said in 1926 and it is not an idea ex-nihilo, it is only an extract of explanation of the constructivist idea of the system of parts (process) and interactions (see the part 5.2 of this article) by Blaise Pascal in 1657 in his book ''Les Pensées'' saying "So all things being caused and causing, aided and aiding, mediate and immediate, and all maintained by a natural and insensible link which binds the most distant and the most different, I hold it impossible to know the parts without knowing the whole, no more than knowing the whole without knowing the parts in particular. (Pascal and Brunschvicg, 2010)".

5.5. Appearance of the Cybernetics in 1948

The modern cybernetics designate since the work ''Cybernetics: or Control and Communication in the Animal and the Machine'' of the mathematician Norbert Wiener, the general science of regulation and communications in natural and artificial systems. The cybernetician's task consists to (Turchany, 2020): recognize the structure and internal state of the machine or the animal; describe the relationship that it has with its environment; predict its behavior and evolution over time.

Historical: Since 1919, Norbert Wiener has taught mathematics at MIT. Shortly after joining the institute, he met neurophysiologist Arturo Rosenblueth, a former collaborator of Walter B. Cannon and working at Harvard Medical School. From this brand-new friendship should be born, twenty years later, Cybernetics. Rosenblueth sets up small interdisciplinary teams with Wiener to explore the no man's lands between the established sciences. In 1940, Wiener worked with a young engineer, Julian H. Bigelow, on the development of automatic aiming devices for anti-aircraft guns. Such servomechanisms must predict the trajectory of an aircraft taking into account elements of past trajectories. In the course of their work, Wiener and Bigelow are struck by two surprising facts: the apparently ''intelligent'' behavior of this type of machine and the ''diseases'' that can strike them. Behavior ''intelligent" because it relies on ''the experience'' (the recording of past facts) and forecasting the future. But also, a strange malfunction: if you try to reduce friction, the system goes into a series of uncontrollable oscillations. Impressed by this ''disease'' of the machine, Wiener asks Rosenblueth if such behavior exists in humans. The answer is affirmative: in some lesions of the cerebellum, the patient cannot put a glass of water in his mouth; the movements are amplified until the contents of the glass spill over the floor. Wiener deduces from this that, in order to control a finalized action (that is to say directed towards a goal), the circulation of the information necessary for this control must form *a closed loop making it possible to evaluate the effects of its actions and adapt to future driving based on past performance* (see fig. 2). This is characteristic of DCA's pointing device, but it is also characteristic of the nervous system when it commands the muscles to move, the effects of which are detected by the senses and sent back to the brain (Rosnay, 1975).

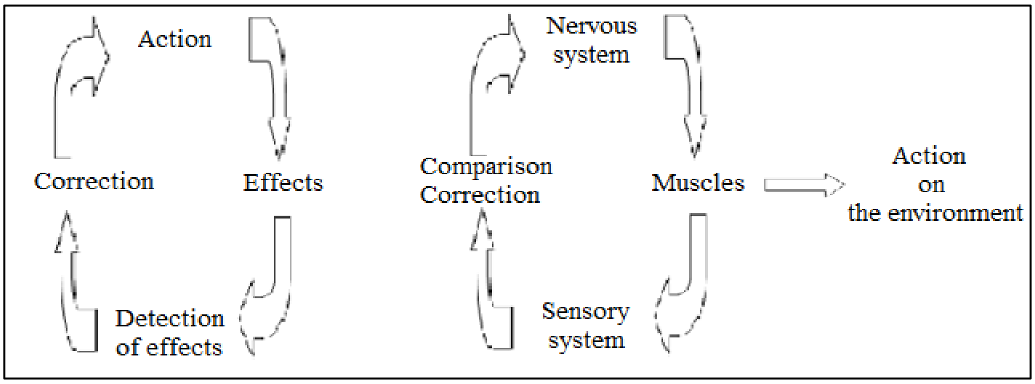

Figure 2. The closed loops that are formed by the circulation of the information necessary to control a finalized action, for the machine and the human. (Rosnay, 1975)

Wiener and Bigelow thus discover the circular loop of information, necessary to correct any action, *the negative feedback loop (la boucle de rétroaction négative in French)*, and generally this discovery to the living organism (Rosnay, 1975). This is also called *the negative reaction (la contre réaction in French)*. Meanwhile, Rosenblueth's multidisciplinary groups are forming. Their goal: to approach the study of living organisms from the perspective of the builder of servomechanisms and, conversely, to consider servomechanisms with the experience of the physiologist. A first seminar was held at the Institute for Advanced Studies at Princeton in 1942. It brought together mathematicians, physiologists, mechanical and electronic engineers. Following its success, a series of ten seminars is organized at the Josiah Macy Foundation. A man is working with Rosenblueth to set up these seminars: neurophysiologist Warren McCulloh. He had to play a considerable role in the development of the young cybernetics. In 1948, two fundamental publications mark an era already so fertile of new ideas: the book of Norbert Wiener *Cybernetics or Control and Communication in the Animal and the Machine*; and *the Mathematical Theory of Communication*, of Claude Shannon and Warren Weaver, which is the basis of the theory of information (Rosnay, 1975). The cybernetics is a modeling of the exchange, by the study of information and principles of interaction. It can thus be defined as the science of self-regulated systems, which is not interested in components, but in their interactions, where only their overall behavior is taken into account. Today, cybernetics is defined as *the science constituted by the set of theories on the processes of command and communication and their regulation in living beings, in machines and in sociological and economic systems*. *Its main purpose is the study of the interactions between ''governing systems'' (or control systems) and ''governed systems'' (or operational systems), governed by feedback processes (or feedback)* (Turchany, 2020). In his book ''Cybernetics: or Control and Communication in the Animal and the Machine'', Norbert Wiener gave a concrete example of interactions between the governing system and the governed system, governed by feedback processes:

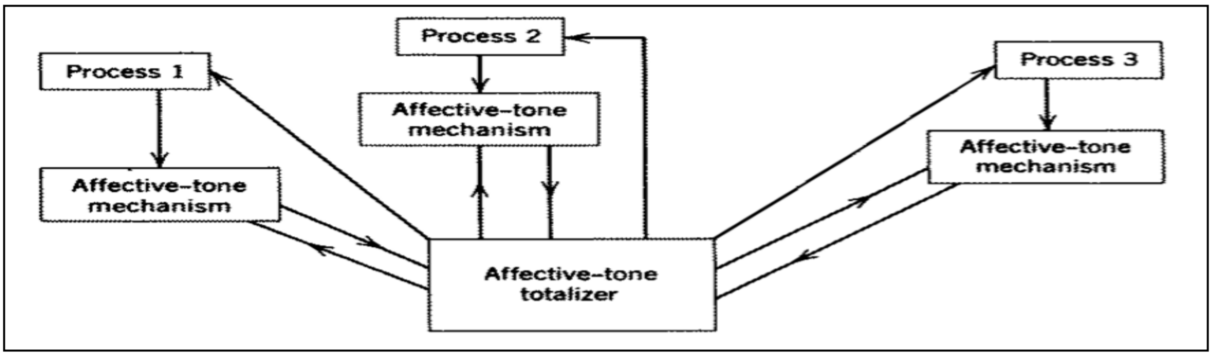

Figure 3. Interactions between Affective-tone Totalizer and action execution Processes in the living being. (Wiener, 1962)

In this example (fig. 3), the totalizer for affective tone combines the affective tones given by the separate affective-tone mechanisms over a short interval in the past, according to some rule which we need not specify now. The leads back to the individual affective-tone mechanisms serve to modify the intrinsic affective tone of each process in the direction of the output of the totalizer, and this modification stands until it is modified by later message from the totalizer. The leads back from the totalizer to the process mechanisms serve to lower thresholds if the total affective tone is increasing, and to raise them if the total affective tone is decreasing (Wiener, 1962). The concrete example of interactions between the governing system and the governed system governed by feedback processes or feedback for a living being, can then be put in the context of the characteristic Stability of the new paradigm of the system defined by the systemic and its system analysis tool, after the appearance of cybernetics by the mathematician Norbert Wiener in 1948. We have cited this characteristic (stability) in the part 4 of this article, and we would like to add that cybernetics as it was first defined by Turchany (2020) “as the science of self-regulated systems, which is not interested in components, but in their interactions, where only their overall behavior is taken into account”, then in a second time as “a modeling of the exchange, by the study of information and principles of interaction”. It is strongly present in the field of automation for the control of technical systems (Machines), of which we model the self-regulated systems by block diagrams with transfer functions describing the system, the feed-back process linking its response to all the inputs from the environment. In view that the stability is a finality (studied and to be reached) for a system by cybernetics, we present an example of model of stable system in a changing environment (fig.4), that is to say having a feedback process which is the adaptation mechanism which makes it possible to ensure constant outputs and making its correct response even if the inputs (or the environment) fluctuate:

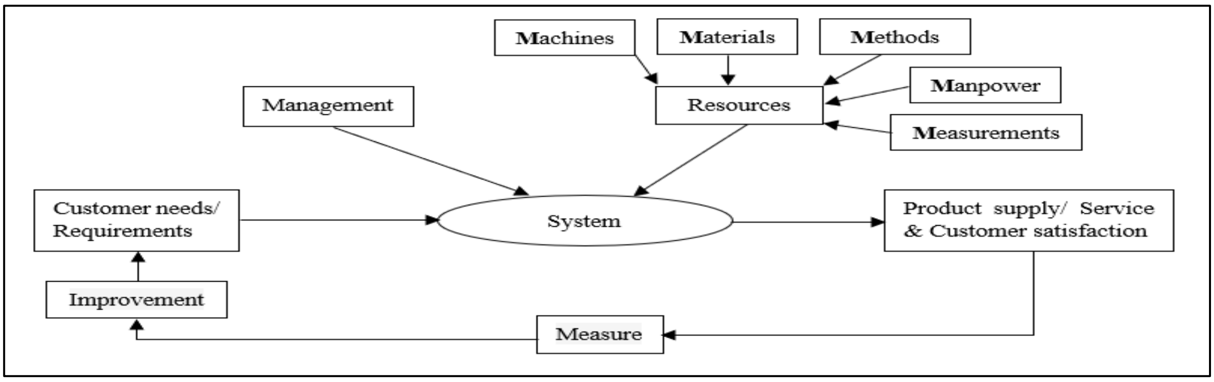

Figure 4. Block diagram modeling the stability of the closed loop system (negative feedback loop) in a changing environment. (Hallioui and Herrou, 2020)

5.6. Appearance of the New Discourse on the Method in 1977

Two questions allowed to lead the gap between the classic cartesian Discourse on the Method and the system analysis (or the New Discourse on the Method), according to Le Moigne (1977) ‘’the gap between the two discourses of the method (the cartesian and the new) is the change drained to strike and hide the cartesian method making it possible to understand, manage, study or explain the problems or the phenomena according to René Descartes *to rightly conducting his reason, and seeking truth in the sciences*’’.

To show that rationality is not only cartesianism, Le Moigne (1977) asked two questions leading the way towards the New Discourse on the Method: *The imprecision of the method's goals: rightly conducting his reason?; Are there other methods?*

System analysis is based on the four precepts of the New Methodology Discourse which are according to Le Moigne (1977):

- *The precept of relevance (the opposite of the cartesian precept of evidence):* Agreeing that any object we consider is defined in relation to the implicit or explicit intentions of the modeler. Never refrain from questioning this definition, if our intentions change, our perception of this object changes;
- *The precept of globalism (the opposite of the cartesian reductionist precept):* Always consider the object to be known by our intelligence as an immersed and active part within a larger whole. To perceive it first globally, in its functional relationship with its environment without unduly sourcing to establish a faithful image of its internal structure, whose existence and uniqueness will never be taken for granted;
- *The precept of teleology or finality (the opposite of the cartesian precept of causality):* Interpreting the object not in itself, but by its behavior, without seeking to explain this behavior a priori by some law implied in a new structure. On the other hand, understand this behavior and the resources it mobilizes in relation to the projects that, freely, the modeler attributes to the object. Take the identification of these hypothetical projects for a rational act of intelligence and agree that their demonstration will very rarely be possible;
- *The precept of aggregation (the opposite of the cartesian precept of exhaustiveness):* Agree that any representation is partisan, not by forgetting the modeler, but deliberately. Consequently, look for a few likely to guide the selection of aggregates considered to be relevant and exclude illusory objectivity from an exhaustive inventory of the elements to be considered.

As a recapitulation of the four precepts of the New Discourse on the Method representing the system analysis, according to Jean-Luis Le Moigne, we write:

- *The precept of relevance*: Define any object in relation to the explicit or implicit intentions of the observer; Never refrain from questioning this definition if our intentions change or if our perception of the object changes (Brandenburg and Wojtyna, 2006).
- *The precept of globalism*: Consider any object as an immersed and active part within a larger whole; First of all, perceive it in its functional relationship with its environment; Not to be interested a priori in its internal structure, whose existence and uniqueness will never be taken for granted (Brandenburg and Wojtyna, 2006).
- *The precept of finality:* Interpreting the object by its behavior (and not in itself) without trying to explain this behavior by a law internal to its structure, but understanding its behavior and the resources it mobilizes in relation to purposes that the observer attributes to it (Brandenburg and Wojtyna, 2006).
- *The precept of relevance (or aggregation):* Agree, deliberately, that any representation is simplifying and choose to consider only the elements considered relevant by the observer (Brandenburg and Wojtyna, 2006).

6. Conclusion

The constructivist idea of the system of parts and interactions, the establishment of the framework of the systemic theory in addition to the innovative concept of the theory of equilibrium, the forging of holism, the appearance of cybernetics, the development and popularization of the innovative concept of system as a complex of interacting elements and of the systemic as a new philosophy of the nature, the impulsion of Joël de Rosnay describing the systemic by the symbolic instrument *macroscope* allowing a global way of seeing, understanding and acting on any organism in the universe, as well as the scientific knowledge of the latter; they have all made us processes coinciding with historical processes contributing in concert to the bankruptcy of the Discourse on the Method of Descartes, to put together the New Discourse on the Method anchoring the precepts of the system analysis tool of the systemic. All this by studying system analysis as a simple phenomenon or simple system.

We treated the system analysis which is a tool of the systemic, whose we are opposed with the principles of the classic discourse of René Descartes, in particular his precept of causality, but to establish this article and study the system analysis, we have proceeded with the causality (linear causality) starting from the causes to the effects!

In fact, in the introduction of this article, we explained the context of the creation of the system analysis, starting from the origins and the ideas triggering this tool from the systemic until its manifestation, by relying just on the elements (neglected interactions) because they are linked by weak interactions (see the Introduction part). Our reason is not that we prefer the causalism to present the context of creation of the system analysis in this article, but just: In view that the chronology and the causalism (linear causalism) as elements of the ordinary logic, they may have been useful to us in describing the context of creation of system analysis as a simple phenomenon (cause-effect relationship or simple system); To show the concrete limitation of cartesianism (or cartesian-analytical modeling) in general and of causalism in particular in this context. This put us in the concave and quite agree with the expression of Vilfredo Pareto in the page 247 of the "Manual of Political Economy" which says that "It is the mutual dependence of the economic phenomena which makes essential the use of mathematics to study these phenomena; the ordinary logic can be used well enough to study the cause and effect relationships, but soon becomes powerless when it comes to relationships of mutual dependence. (Pareto and Bonnet, 1909)". Indeed, the complex systems of which it is a question of strong interactions and a great diversity of the elements make a real limitation for the classical thought in general.

References

Bertalanffy, L., *General System Theory: Foundations, Development, Applications*, Revised ed. New York, NY, USA: Braziller, 1968.

Brandenburg, H., and Wojtyna, J. P., *L'approche processus, mode d'emploi*, 2nd Edition, Groupe Eyrolles, Paris, 2006.

De Condillac, A. E. B., *Traité des systèmes : où l'on en démêle les inconvénients et les avantages*, Internet Archive, https://archive.org/details/traitdessyst00cond, 2010.

Descartes, R., and Veitch, J., *Discours de la Méthode [French English Bilingual Edition] - Sentence by Sentence Translation (French Edition)*, Wolf Pup Books, 2012.

Hallioui, A., Herrou, B., System approach for improving the dependability of production systems, state of the art, *Proceedings of the 5th NA International Conference on Industrial Engineering and Operations Management*, USA, Detroit, Michigan, August 10 – 14, 2020.

Institut Numérique, 2 Petite histoire de l'approche processus, https://www.institut-numerique.org/2-petite-histoire-de-lapproche-processus, February 15, 2014.

Le Moigne, J. L., *La Théorie du Système Général : théorie de la modélisation*, Collection Les CLASSIQUES DU RESEAU INTELLIGENCE DE LA COMPLEXITE, 1ère édition, 1977.

Pareto, V., Bonnet, A., *Manuel d'économie politique*, Translated from the Italian edition by Alfred Bonnet (reviewed by the author), Paris 5ème, V. GIARD & E. BRIERE, Libraires-Editeurs, 1909.

Pascal, B., Brunschvicg, L., *Les Pensées*, http://www.samizdat.qc.ca/arts/lit/Pascal/Pensees_brunschvicg.pdf, Edition 1897 à Paris, Ebook par Samizdat, 2010.

Rosnay, J., *Le macroscope : vers une vision globale*, Edition du Seuil, ISBN: 2-02004567-2, 1975.

Seiffert, M. E. B., & Loch, C.,Systemic thinking in environmental management : support for sustainable development. *Journal of Cleaner Production*, *13*(12), https://doi.org/10.1016/j.jclepro.2004.07.004, pp. 1197-1202, 2005.

Smuts, J.C., *Holism and Evolution*, 3th Edition, Macmillan and Co., Limited, London, 1936.

Turchany, G., La théorie des systèmes et systémique, https://inventin.lautre.net/livres/Turchany-Theorie-des-systemes.pdf, Accessed Day: May 5, 2020.

Vester, F., Ballungsgebiete in gives krise, Deutsche Verlags-Anstalt, p. 83, 1976.

Wiener, N., *Cybernetics: or Control and Communication in the Animal and the Machine*. 2nd Edition, The MIT Press, Cambridge, Massachussetts, 1962.

Wikipedia contributors, *Holisme*, https://fr.wikipedia.org/wiki/Holisme, June 22, 2020.

Biographies

Anouar HALLIOUI is a PhD student in the Department of Industrial Engineering, at Faculty of Sciences and Techniques of Fez, Sidi Mohamed Ben Abdellah University, Fez, Morocco. He is Engineer, he received her Dipl-Ing degree in Mechatronics Engineering from Faculty of Sciences and Techniques of Fez, Morocco, in 2017. He has more than one year of industrial experience working as Production Manager and Site Process & HSE Manager for industrial companies. Her areas of interest include engineering management, system approach, industry and manufacturing, production systems dependability, reliability, optimization of systems maintenance and productivity in the different industries, etc.

Brahim HERROU is a Doctor Engineer in Industrial and Mechanical Engineering, Professor at Sidi Mohamed Ben Abdellah University, Fez, Morocco.