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# Designing a living-machine according to Descartes Philosophy

**Resumen**:
René Descartes (1596-1650) fue uno de los pioneros de la filosofía mecánica, cuya influencia se extendió hasta la tercera década del siglo XVIII. En el mundo creado, encontramos dos sustancias diferentes, según Descartes: los cuerpos y las mentes. Los primeros son en esencia tridimensionales y obedecen a las leyes mecánicas de la física. La segunda sustancia, es la sustancia pensante y obedece determinadas leyes o reglas del pensamiento. En este artículo, se analiza de manera breve el primer tipo de sustancias con el objetivo de extraer algunos principios de diseño para diseñar una máquina viviente, siguiente la filosofía mecánica de Descartes. El artículo se divide en cinco breves secciones. En la primera, se introduce la concepción cartesiana de las sustancias. En la segunda, se presenta una contextualización de la filosofía mecánica de Descartes. En la tercera introducimos el concepto de "diseño" tal y como es utilizado en filosofía de la tecnología, como relevante para nuestro análisis. En la cuarta sección introducen cinco principios cartesianos para el diseño de una máquina viviente, y en la quinta sección, se discuten algunas consideraciones generales relativas al enfoque seguido.

**Palabras claves**: Descartes, filosofía mecánica, máquinas vivientes, diseño, substancias.

**Summary**:
Descartes (1596-1650) was one of the most important intellectual figures and pioneers of the mechanical philosophy during the XVII century, whose influence extended until the third decade of the XVIII century. In the created world, two different substances are found: bodies and minds. The first one, its essence is to be three-dimensional and it obeys the mechanical laws. The second one is the thinking substance and obeys determined rules, called the mind´s rules. In this paper, I briefly analyze the first kind of substances aimed at extracting some principles for designing a living-machine, following Descartes´ philosophy. The paper divides into five brief sections. In the first one, Descartes's conception of substances is introduced. In the second, a brief account of the mechanical philosophy is presented. In the third section, a modern concept of design as used in the discussion of the philosophy of technology is introduced. In the fourth section, five Descartes´ mechanical principles relevant to design a living-machine are introduced. In the last section, some general considerations on this account are discussed.

**Key words**: Descartes, mechanical philosophy, living-machines, design, substances.

In *the Treatise of Man* (written in 1632–3), *Description of the Human Body* (written in 1647-8) and the *Passions of Soul* (1646) Descartes presents his ideas on the human body from a mechanical perspective. A perspective that he was the first to systematically introduce in the Western modern culture. *The Treatise of Man* is part of a more general Treatise called *The World*. Descartes announced to Mersenne (Gaukroger, 2004) that he was working on it in 1629. However, he didn´t have any knowledge of anatomy and physiology. So, he decided to study first these subjects and started in 1632. In a letter to Mersenne, he informed that to speak,

> speak more about man than I had intended to before, because I shall try to explain all of his principal functions. I have already written

> about those that pertain to life, such as the digestion of food, the beating of the pulse, the distribution of nutrients etc., and the five senses. Now I am dissecting the heads of different animals in order to explain what imagination, memory etc., consist of. I have seen the book De mote cordis [of Harvey] of which you spoke to me earlier, and find I differ only a little from his view, which I came across only after I had finished writing about this matter. (AT i. 263) (Cited by Gaukroger, 2004).

*The Treatise of Man* collects, then, his results both on psychology (the study of soul) and the anatomy and physiology of human beings. This work is completed and complemented with the *Description of the Human Body* written several years later.

In this paper our interest is to present a brief account of Descartes proposal on living-machines, emphasizing his approach on the above-mentioned writings. So, section 1 and 2 introduce the more general concepts needed to develop, in sections 3 and 4, the concept of design and the process of designing a living-machine.

## 1. Three substances

It is relevant for our approach to living-machines to keep in mind the distinction made by Descartes between res extensa, res cogitans and res Divina. These three substances form the basic Cartesian ontology. Descartes sharply distinguishes between them. Descartes defines substance, in *The Principles of Philosophy*, as "thing that exists in such a way that it doesn't depend on anything else for its existence" (§51). The only substance that strictly meets this condition is the res Divina or God. For any other substance, Descartes offers the following relative definition: Substances are "things that don't depend for their existence on anything except God." (§52). So, in this first approach, there exists a radical difference between God and creatures. Accordingly, "(s)o the term 'substance' doesn't apply in the same sense to God and to other things—meaning that no clearly intelligible sense of the term is common to God and to things he has created." (§51).

Each substance has one principal attribute that defines its essence. For the res Divina or God the principal attribute is that of maximum perfection. In the estimation of the maximum perfection, Descartes considers good, intelligence, justice, knowledge, power, necessity and eternity, so, maximum perfection = {greatest good, intelligence, justice, knowledge, power, necessity and eternity present in one entity}. For the res cogitans or mind, the main attribute is "thinking"; so, the nature of mind is thinking, and for corporeal substance, its extension i.e. its three dimensionally. The last two substances form the world in which we are living. The interaction between divine substance and the two substances is, on the one hand, of causality in the sense that any creature was created by God, but on the other hand of dependency because God provided these creatures with some indications that permanently point to the creator. Additionally, the world needs that God intervenes to keep constant the amount of force needed for the universe to move.

However, we may leave aside any consideration regarding God to emphasize on the other two substances. As known, for Descartes the human being is a mixture of these two substances: corporeal substance and mind or soul. The principal attribute of the soul is its capability to think or thinking. In several writings Descartes tries to give a more precise clarification of this capability. In *the Description of The Human Body*, he says:

> When we make the attempt to understand our nature more distinctly, however, we can see that our soul, in so far as it is a substance distinct from body, is known to us solely from the fact that it thinks, that is to say, understands, wills, imagines,

> remembers, and senses, because all these functions are kinds of thoughts (§226).

"Thinking", includes then, "understands, wills, imagines, remembers and senses" as proper thinking. However, in the *Principles of Philosophy,* Descartes presents a more complete characterization of the res cogitans:

> The kinds of thinking that we experience within ourselves can be classified under two general headings: perception, or the operation of the intellect, including sensory perception, imagination and pure understanding, and volition, including desire, aversion, assertion, denial and doubt (Book 1-32).

Not always can we find in Descartes a clear definition of these attributes. In *Metaphysical Meditation* Descartes tries to distinguish between understanding and imagination in terms of the consequences each conveys. For him, imagination is a negative function of the mind, it "is extravagant enough to invent something so novel that nothing similar has ever before been seen, and that then their work represents a thing purely fictitious and absolutely false, it is certain all the same that the colors of which this is composed are necessarily real." (1-7).

Imagination is, then, the source of ungrounded speculations and fantasies. This use of imagination as something "absolutely false", contrasts with a more constructive and creative faculty of the moderns. However, there are other conceptualizations of the concept of "imagination" in Descartes writings that I will not discuss here. Dennis Sepper (2016) has reassessed the role of imagination in Descartes, not only in the field of physics and mathematics, but also in music and related subjects.

Understanding, on the other hand, is the capacity of distinguishing the truth from wrongness, fiction from reality and existence. It is a faculty of discernibility. Memory, intuition or to perceive clear and distinct are also elements of this faculty.

Finally, in the *Metaphysical Meditations*, Descartes introduces the faculty of will in the following way:

> […] for the faculty of will consists alone in our having the power of choosing to do a thing or choosing not to do it (that is, to affirm or deny, to pursue or to shun it), or rather it consists alone in the fact that in order to affirm or deny, pursue or shun those things placed before us by the understanding (Meditation 1-21).

I may schematize this faculty of thinking, as an input-output system, in which, sensory perception and imagination are the two basic inputs of the system, memory is the storage component of the system; intuition the capacity to distinguish between whole and part, complex and simple, clear and distinct, true and false; the inferential capability (analysis), that is, of forming long chains of reasoning ending in simple, clear and distinct ideas, but also the inverse process belong to the inference capability: the synthetic process; both form the processing component of the system. Finally, the output component is formed by the different products of the analysis and synthesis processes filtered by the will.

As recalled, Descartes considers res cogitans as exclusive to human beings. A human being, as indicated, is formed and complemented by another substance: corporeal substance. In *The Description of the Human Body*, Descartes made a careful and detailed characterization of human corporeal substances, as distinct from the soul. He claims:

> Also, since the other functions that are attributed to it [human being], such as the movement of the heart and the arteries, the digestion of food in the stomach, and such like, which contain in themselves no thought, are only corporeal movements, and since it is more

> common for one body to be moved by another body rather than by the soul, we have less reason to attribute them to the soul than to the body (§226).

Corporeal substances are not limited to human beings, but it includes animals, plants and rocks. As indicated, these substances have the principal property of being extended, that is, three dimensional bodies. Then these last substances are subject to mechanical processes. For Descartes, there exist some interactions between the soul and the res Divina in the sense that God put in every soul eternal idea, innate ideas. These ideas are basic for the proof of God´s existence provided by Descartes. But on the other hand, there exist interactions between the body and the soul; the soul used sensory organs to perceive the external world but also to feel the different states the body itself.

## 2. Mechanical approach

During the late 1618 and early 1919, Descartes was exposed to the atomistic theory of matter by Issac Beeckman; it will have a deep and long lasting influence on Descartes and marked his philosophy (see Shields, 2007). According to this theory of matter in nature there exist atoms (corpuscles), vacuum, and account of phenomena shall be done only in terms of size, form and motion. So during the year of 1619, Descartes worked out different problems in which this atomistic perspective was used. Nevertheless, he soon abandoned the concepts of atom and vacuum (empty) in favor of the infinite divisibility of matter (derive from geometrical considerations) and a world full of matter, complemented with form, size and motion. However, Descartes recognized the importance of postulating some relative level of atomic or corpuscular as relevant for explaining different physical and mechanical phenomena. Of course, in *The Treaty of Light*, section 5, "On the number of elements and their qualities", Descartes introduced three different kinds of corpuscles, taken from Empedocles, to explain the different mechanical and dynamical behavior of phenomena: a) The element of fire "as the most subtle and penetrating fluid in the world.", b) the element of the air, a kind of fluid that "I conceive this too to be a very subtle fluid in comparison with the third, but compared with the first we need to attribute some size and shape to each of its parts and to imagine them as more or less round and joined together like grains of sand or dust." And c) the element of the earth, "I judge its parts to be proportionately larger than and more slowly moving than those of the second, as those of the second are in comparison to those of the first. And indeed, I think it is enough to conceive of it as one or more large masses, whose parts have very little or no motion that might cause them to change position with respect to one another."

Then, the form that takes the first two corpuscles is liquid. So, Descartes claims in the *Principles of Philosophy* that the heavens are fluids (§3-24). As discussed in the paragraph 3 of *The Theory of Light*, hardness and liquidity are relative states. He claims:

> Now I detect no difference at all between hard bodies and fluid bodies except that the parts of the one can be separated from the whole much more easily than those of the other. Thus, to make the hardest body imaginable, I think it would be enough for all the parts to touch each other, with no space remaining between any two and none of them in the process of moving. For what glue or cement can one imagine beyond this with which to hold the one to the other? (§13).

Cartesian position of the relatively of hardness and liquidity is an important antecedent of the development, in the hand of Leibniz, Bernoulli and Euler, of hydrodynamics or fluid dynamics during the XVIII Century, and currently one theory very important in the understanding and modeling of different physical phenomena, including, the atmosphere.

Nevertheless, these different types of corpuscles are the results of the application of a set of laws to a primitive and unique form of matter. So, ultimately, these can be reduced to one form of matter and to infinite divisibility of matter. Descartes doesn´t speculate on the form of this primitive matter, because what is relevant to him is the derivation of the current forms of matter from the application of some nature laws. This means that the actual form of the universe could change in future if new corpuscles of matter is obtained by the continue application of the physical laws.

In the *Principles of Philosophy* and in *The World,* he introduces three Laws and some rules to explain both, the current mechanical behavior of bodies in nature and the way in which this came about from previous states by applications of these three laws. In *Principles of Philosophy*, Descartes introduces them in the following way:

> The first of these laws is that each simple and undivided thing when left to itself always remains in the same state, never changing except from external causes (§2-37).
> The second law is that every piece of matter ... tends to continue moving in a straight line. This is true despite the fact that particles are often deflected by collisions with other bodies, and the fact that when anything moves it does so as part of a closed loop of matter all moving together (§2-39).
> The third law of nature is this: (a) when moving body x collides with body y, if x's power of continuing in a straight line is less than y's resistance, x is deflected so that it moves in a new direction but with the same quantity of motion; but (b) if x's power of continuing is greater than y's resistance, x carries y along with it, and loses as much motion as it gives to y (§2-40).

As you clearly conclude from the above three laws, the key element in the formulation of them is motion, size and form. As indicated, from the atomistic theory of matter, Descartes adopted only these three concepts. It corresponded to Newton (De Gravitatione Et Aequipondio Fluidorum, written around 1664) and Leibniz (in many of his physical works) to exploit the inconsistencies of these mechanical laws.

Motion in Descartes is a very complex issue and not always it clear in his philosophy. For him, the easiest state in nature is motion. In his discussion on hardness and fluidity, he says:

> And note that if two of these minute parts are touching one another and are not in the process of moving away from each other, then a force, no matter how small, is needed to separate them; for once they are so positioned, they would never be inclined to dispose themselves differently. Note also that twice as much force is needed to separate two of them than is needed for one and a thousand times as much to separate a thousand of them. Consequently, if one had to separate several million of them at once, as is perhaps necessary in breaking a single hair, it is not surprising that a significant force is required.
> By contrast, if two or more of these minute parts only touch in passing and while they are in the process of moving one in one direction and one in the other, it is certain that it will require less force to separate them than if they were completely stationary, and indeed none at all if the motion with which they are able to separate themselves is equal to or greater than that with which one wishes to separate them (§ 13).

So, it is more simple to suppose that the universe is in motion that to assume that it is at

rest. And motion is the fundamental concept to understand living-machines as it will be pointed out below. However, in the *Principles of Philosophy* he corrects this perspective and introduces a very challenging perspective on motion and rest. He establishes that the same amount of force is needed to stop a body that to put it in motion. This is an anticipation of the law of action and reaction proposed by Newton in his celestial mechanics. In book 2, paragraph 27 of the *Principles* […], he claims that motion and rest are merely two different modes of the body. That is so, because for Descartes the motion of a body is no more than a transfer from a place to another. Bodies are inert matter, and then only due to an external force, let say, one body can change of condition. Rest is that state of the body in which there no a transference of force that changes its condition. However, he supposes that the universe is in motion, and objects are moved from one place to the other by something like inertia. So, rest and motion from the perspective of an observer are relative or mere states. As indicated, simplicity is the criterion followed by Descartes to adopt motion instead of rest as applied to bodies.

So, Descartes recognizes two different kinds of motion: a) motion in the ordinary sense, b) motion in the strict sense. He defines the first in the following way: "Motion, in the ordinary sense of that word, is simply the action by which a body travels from one place to another [...]". But ordinary motion is in itself contradictory, because it yields the consequence that from observational perspective a body is in motion and rest at the same time. Descartes illustrates this contradiction with the following example:

> […] a man sitting on a ship that is leaving port thinks he is moving relative to the shore which he regards as fixed; but he doesn't think of himself as moving relative to the ship, because his relations to its parts remain unchanged. We ordinarily think of motion as involving action, and of rest as the stopping of action, and by that standard the man sitting on deck is more properly said to be at rest than in motion because he isn't aware of any action in himself." (*Principles*, book 2, § 24).

He considers more appropriate his concept of motion in strict sense, defined as "change of position" by replacement of those objects with which the body of reference is in contact. Giving that the world is full of matter, to push forward an object, means that the other objects around it are moved back to fill the place that the object previously occupied. Motion, then, takes place only by contact between objects. Descartes says: "Transfer, after all, is a reciprocal process: for a body x to be transferred from contact with a body y is for y to be transferred from immediate contact with x. Exactly the same force and action is needed on both sides." (*Principles*, book 2, § 29).

Circular or elliptic motions are composite motion. The basic motion is rectilinear. If we observed an object moving in a circular motion, we have to think that it tends to move in rectilinear form, but many other motions from other objects surrounding it modify its trajectory and give the corresponding circular or elliptical motion observed. Circular motions are explained, then, by application of the laws of motion introduced above.

Then, these laws made that the universe exhibits the features that it now has. All matter moves in great and embedded circles around its centre, called vortices. The universe is formed by many of these vortices, some of them with inter-connections, as those of comets. Descartes relates vortex and matter in the following way:

> I have established that all the bodies in the universe are composed of a single mass of matter that is divisible into indefinitely many parts, and is in fact divided into very many parts that move in different directions and have a sort of circular motion; and that the same quantity of motion is always preserved in the

> universe. […] Allow me then to suppose that God originally divided the matter of which the visible world is composed into particles of about the same size, a moderate size, between the biggest and smallest that now make up the heavens and stars. I'll also suppose that their total amount of motion was the same as what is now found in the universe; and that their motions were of two kinds, of equal force. (1) They moved individually and separately about their own centres, so as to form a fluid body such as we take the heavens to be. (2) They moved together in groups around certain other equidistant points corresponding to the present centres of the fixed stars, and around other more numerous points equaling the number of the planets, [...] so as to make up as many different vortices as there are now heavenly bodies in the universe (Principles, book 3, § 46).

This brief account of Descartes´ mechanical philosophy is enough for our purposes in this paper. After introducing the concept of design that we are interested in, I will resume this issue to make it appropriate for our discussion of designing living machines in Descartes.

## 3. The concept of design

Currently, design is a central concept to understand, among others, the development of technology, as we will briefly see. Mechanical philosophy of XVII and XVIII centuries provided an important framework for pushing the development of technologies (machines). However, during these two centuries design was closely related to teleology (on teleology, see Colin, 2009). As it is widely known, Aristotle made of teleology a central concept of his natural philosophy. Aristotle introduces four causes (material, formal, efficient and final) as criteria for the explanation of natural and living phenomena (see Andrea, 2015, Shields 2016). The best explanation is one that appropriately involves the four causes. As pointed out by Christopher Shields (2007), "is an adequate explanation iff E correctly cites each of the four causes: the material, the formal, the efficient, and the final" (44).

In this line of thinking it was Leibniz who explicitly introduced four principles of design as criteria, not only for explaining different phenomena, but also for assessing the theories that were proposed for accounting natural and social order, and these are teleological in nature. In the *Principles of Nature and Grace*, paragraph 10, Leibniz claims:

> God is supremely perfect, from which it follows that in producing the universe he chose the best possible design—a design in which there was
>
> - the greatest variety along with the greatest order,
> - the best arranged time and place,
> - the maximum effect produced by the simplest means,
> - in created things the highest levels of power, knowledge, happiness and goodness that the universe could allow.

Descartes shouldn´t accept this kind of finalism, at least at the cosmological and terrestrial level, because it is strongly inconsistent with mechanical philosophy and mechanical explanations. There is no finalism in nature, in the two mentioned domains. As indicated, the cosmos as we know it is the result of the application of mechanical laws to some stuff with some form and size. It is a mechanical product. In several writings and chapters, Descartes refers to the way in which God created the world. For example, in defending his approach of the universe as consisting of motion, vortices and matter, as was introduced briefly above, Descartes claims: "There are countless configurations that God might have chosen, and experience will have to tell us which

ones he actually chose." (Principles, book 3, § 46). Of course, he is defending his own position. As mentioned above, the key elements in Descartes philosophy are the primitive matter and the laws of motion, and so, one of these configurations, his owns is introduced as superior.

However, mechanical animals are the result of a special creation of God, because they utilize the current existent elements in their functioning and shapes. In the paragraph 120 of the *Treatise of Man*, Descartes claims:

> I suppose the body to be just a statue or a machine made of earth, which God forms with the explicit intention of making it as much as possible like us. Thus He not only gives its exterior the colors and shapes of all the parts of our body, but also places inside it all the parts needed to make it walk, eat, breathe, and imitate all those functions we have which can be imagined to proceed from matter and to depend solely on the disposition of our organs.

So, I think he describes a weak concept of design (without mentioning it), a weaker concept compared with Leibniz´ one. Designing and constructing a living being from mechanical principles requires some kind of simulating the way that God followed when created the physical world (mechanical thesis), and second, to show that there is no difference between the "real living being" and the constructed one (mechanism correspondence). So, this process of simulation is confirmatory in nature. That is, it aims to confirm the validity of the mechanical principles and corresponding mechanical philosophy.

However, Descartes used the concept of design in connection with the constructions of artifacts. In the *Principles of Philosophy*, two times Descartes introduces this concept. In book 1, paragraph 39, Descartes contrasts our "highest perfection" to act freely or voluntarily, with that of an automaton in which determination is found. We read,

> We don't praise automata for moving in exactly the way they were **designed** to move, because it's necessary for them to do that. We do praise the **designer** for doing a good job, because in building the automata he was acting freely, not out of necessity. By the same principle, when we embrace something true, that's much more to our credit if we do it voluntarily than it would be if we couldn't help embracing it (emphasis added).

The second reference to design is introduced by Descartes in the book 4, in his discussion on the perceiving of unobserved or imperceptible particles. He emphasizes here that the conclusion on the existence of these particles are inferential. He mentions the role of geometry, laws and principles in making these inferences. He recurs to machines as an illustration of this inferential process:

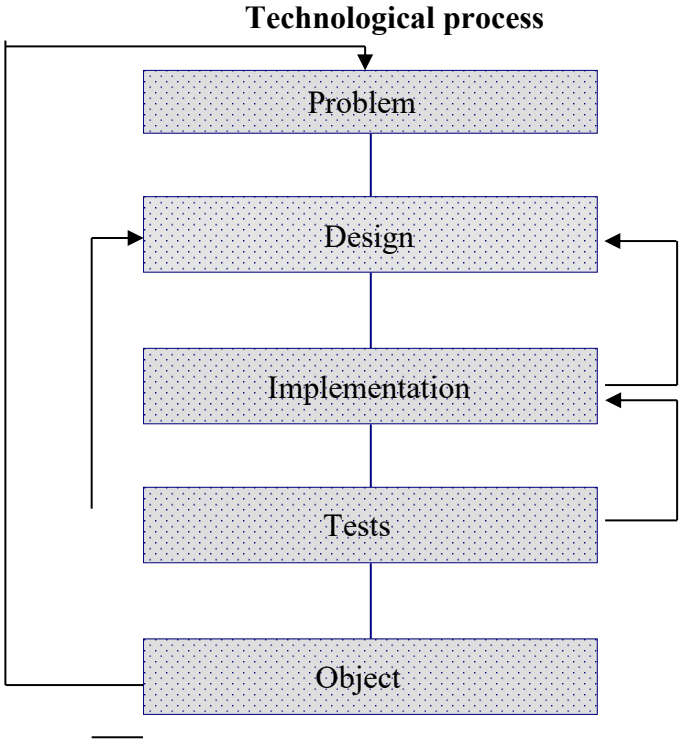
> Men who've had experience dealing with machinery can take a particular machine whose function they know and by looking at some of its parts easily guess at the design of the other parts, the ones they can't see. That's the kind of thing I have been doing—noting the observable effects and parts of natural bodies and trying to work out their causes at the level of imperceptible particles.

It is this concept of design, related to artifacts, the one we are interested in. Currently "design" is understood as the specification of the main components (structures and functionalities) that a machine, device, software or modified organism will exhibit. Design is an intentional process, in the sense that the object, well-constructed, will have the properties that the designer put in, as Descartes says.

As mentioned at the beginning of this section, design is the heart of the technological development. In order to a better understanding, some basic elements of technology and its process are relevant (to complement the perspective discussed here see Franssen, Lokhorst, and van de Poel, 2015).

We may say that technology is a process that transforms a problem into a "product", that is, proposed as a solution to it. It is an intentional process that is closed under the problem under analysis. In formal terms, R(P) = O, where R is a function, P the problem to be solved and O the product. It takes a problem; apply some transformation (R) to produce an object (O) (as solution). Given that R is a complex process (with several stages) it is expressed as $\hat{R}(P) = 0$, to indicate that it is a (partial) recursive process. Technological transformation process transforms the problem into a design (a specification of the object), the design into an implementation; this implementation needs to be tested, and the final result is the object produced. Currently, what is considered a technological object includes: machines, devices, parts, tools, software and biotechnological products.

It is schematized in the following flow process. As observed, there are several feedbacks (loops) in this process that makes that the object produced transforms itself into a new problem, the implementation feeds the design, and tests feed implementation and design.



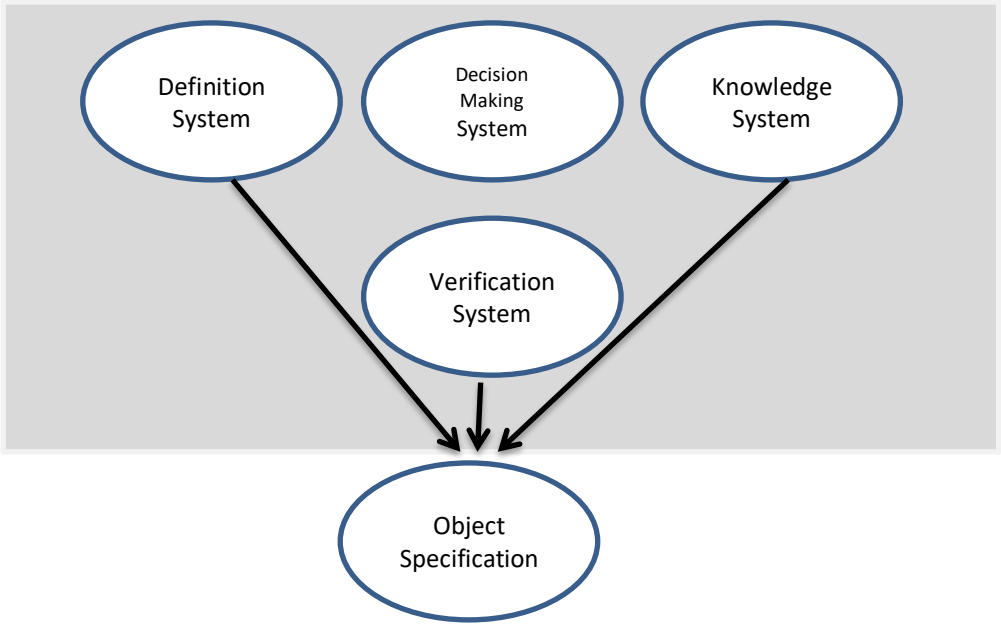

I will emphasize in the following three features are related to the component of design.

Technology as a design centered process. What has been observed is that design is key in the current development of technology. Several reasons support it. First, technology tends to be a very highly standardized activity. The better way to meet these standards is taking them into account from the visualization of the product to achieve, and this is the goal of design. Second, technology production is strongly influenced by the incorporation of scientific research results, mathematical developments, and other technological achievements including ethical issues. Third, recently we have observed a strong tendency toward considering the technology process as part of a technological system, that is, to take into account that a

specific technological product is a part of the solution of a more complex problem. It is important to understand what the role of this specific technological product is in a more complex process. The way in which this is achieved is by introducing standards and protocols among others to facilitate this visualization.

Given the importance of design, it is common to separate it into four main sub-systems, as presented in the following scheme.

**Design Structure scheme**




Three sub-systems are particularly relevant to visualize the object: the definition systems that includes among others, the problem transformed into requirements (what the object will show to solve the problem), structural specification (what is the structure of the object); functional specifications (how the object will work). The knowledge system includes: technological alternatives, availability of scientific knowledge, mathematical and scientific principles relevant to the application, computer tools and ethical issues. Verification system includes different tests that will be applied to the product during the different stages of developments, including ethical tests to determine the appropriateness of the object to the ethical requirements previously defined. Finally, the decision making system is very important because it specifies the human resource involved, the stages in which product will be developed, the way in which recommendations will be decided; who decides which alternative, in case that there are different and incompatible alternatives, will be taken; and finally, it is also responsible for the integrity of the design.

## 4. The design of a living-machine

In this theoretical exercise, our interest centralizes on the process of design, particularly on some aspects of the sub-systems of Knowledge and Definition, as introduced in the previous section. It is proposed only to illustrate some Descartes´ consideration on animals understood as machines. I will enlist five principles of design. From the context it will be easy to see which component is related to knowledge or definition.

1. All bodies are the result of applying the same physical and mechanical principles. So, specificities should take into account only in those cases in which there exists evidence that these

specificities cannot be reduced to these general principles. In this enterprise of differentiating which belongs to the body and which not, the most relevant heuristics is the human being. It is a mixture of body and soul, so careful attention should be paid to differentiate, as clear as possible, what actions or functions correspond to the body and which to the soul. For example, it is an error to attribute motion or movement only to the soul and not the bodies. According to Descartes,

> When we make the attempt to understand our nature more distinctly, however, we can see that our soul, in so far as it is a substance distinct from body, is known to us solely from the fact that it thinks, that is to say, understands, wills, imagines, remembers, and senses, because all these functions are kinds of thoughts. Also, since the other functions that are attributed to it, such as the movement of the heart and the arteries, the digestion of food in the stomach, and such like, which contain in themselves no thought, are only corporeal movements, and since it is more common for one body to be moved by another body rather than by the soul, we have less reason to attribute them to the soul than to the body.
>
> We can also see that when parts of our body are harmed – when a nerve is pricked, for example – the upshot of this is that not only do they stop obeying our will (which is what they normally do) but often even have convulsive movements, which are quite opposed to it. This shows that the soul can cause no movement in the body unless all the corporeal organs required for that movement are properly disposed. And when the body has all the organs disposed for this movement, it does not need the soul to produce it. Consequently, all those movements that we do not experience as depending on our thought must not be attributed to the soul but only to the disposition of our organs; and even those movements that are called 'voluntary' proceed principally from this disposition of the organs, for they cannot have been produced without it, no matter how much we will it, and even though it is the soul that determines them" (*Description of the Human Body*, § 225).

Key in this quotation is that the body system should be tuned to work properly. But when it is defective you can infer more clearly the contribution of soul to the functionality of bodies aimed at making an appropriate separation between what should be attributed to the body and what to the soul. This is a very important heuristic. But motion or movement is only one of these functionalities that should be attributed to body and in some respect to the soul.

As pointed out by Hatfield (2007) you also have to attribute to bodies some "sensory, motor, and low-level cognitive functions", such as some level of memory, "habituation and association". Descartes, as it is known introduced the mechanism of animal spirits to explain these body phenomena. These are produced when the blood is heated, higher to some threshold. At that time, it was a good heuristic to model these body

functionalities. So, the first element in modeling living beings is to consider motion as affecting any inert stuff (living and non-living). As mentioned above, this is a key concept in this mechanical philosophy.

2. In addition to motion, the three different kinds of elements (corpuscles) introduced above are relevant for designing (simulating) the working to the current world, but also relevant to understanding the anatomy and physiology of living-bodies. Concerning the first, recall that Descartes divided matter into: a) elements of fire, in fluid form; b) the elements of the air, and c) the elements of the earth. In applying these elements for understanding the animal body, Descartes says in connection with heat:

> It is beyond doubt that there is heat in the heart, for one can even feel it with one's hand when one opens up the body of a living animal. And we should not imagine that this heat is of a different nature from that which is caused by the addition of some fluid, or yeast, which causes the body with which it is mixed to expand" (*Description of the Human Body*, § 228).

But in modeling organs you should consider also harder elements that avoid softer elements to go out, all of them obtained from elements found in nature. In animals these harder elements are present in different forms and in different degrees of harness too. For example, intestines are formed from softer earth elements than bones and teeth. So, I detail study of the components of body is of great relevance to understand first the role of these elements in these kinds of machines, and after that to design then.

Motion, or better, particles in motion is fundamental to understanding and modeling living beings, as mentioned above. A living machine could be understood as a system of particles in motion contained by a relative harder structure; the system admits the entering and exit of some other elements, fluids and particles, which make that the system maintains in motion and generating the capabilities that allow parts to act as a whole. In describing the circular system, Descartes says:

> And as the agitated matter of the first two elements encounters that of these humours and spirits, running along the filaments that make up the solid parts, they continually make the filaments move forward slightly, albeit very slowly; so that as a result every part of the filaments runs from where it has its roots to the surface of the limb where they terminate, and when it reaches there it comes into contact with the air or other bodies touching the surface of the skin, and separates from it (*Description of the Human Body*, § 248).

But in the paragraph 239, he claims that:

> And thus the same blood goes backwards and forwards several times, from the vena cava into the right ventricle of the heart, then from there via the pulmonary artery into the pulmonary vein, and from the pulmonary vein into the left ventricle, and from there via the aorta into the vena cava, this making a perpetual circular motion which would be enough to sustain the life of animals, without their needing to drink or eat, if none of the parts of the blood left the arteries or veins while it flowed in this fashion.

> But many parts continually leave it, and these are supplied by the juice of foods, which come from the stomach and intestines, as I shall explain below. (*Description of the Human Body*, § 239).

3. The third important principle of design can be formulated as: All phenomena involved in the design of a living machine, should be modeled in terms of form, size and motion. Motion was already introduced as the most important principle of design. However, this third principle has another important formulation. In achieving this goal of modeling in terms of form, size and motion, designer should draw upon on known cases in which mechanical explanations are clear to understand the new situation under modeling. These known cases include: analogies, theoretical deduction and confirmed cases in which the use of some material or process provides a mechanical idea of what is happening in a system. Once again, Descartes recurs to these "known" cases as input for describing and explaining the behavior of these living-machines. For example, in the *Treatise of Man*, he claims, in his explanation of digestion:

> First, food is digested in the stomach of this machine by the force of certain fluids which, gliding among its parts, separate, shake, and heat them, just as ordinary water does those of quicklime, or aqua fortis those of metals. Furthermore, these fluids, since they are brought from the heart through the arteries very quickly, must be very hot, as I shall explain below. And the food is usually of such a nature that it can be broken down and heated up of itself, just as occurs with new hay if it is shut up in the barn before it is dry. (*Treatise of Man* § 121).

Another quotation taking from the *Treatise of Man*, exemplifies the way in which the sensation of joy is produced when the blood is purer and thin, and the sensation of sadness in the opposite state, i.e., when the blood is less pure and thick. He made the following comparison:

> "If you have ever had the curiosity to look closely at the organs in our churches, you will know how the bellows push the air into certain receptacles, which for this reason are named wind chests; and also how this air passes from there into one or another of the pipes, according to the different ways in which the organist moves his fingers on the keyboard. You can think of our machine's heart and arteries, which push the animal spirits into the cavities of the brain, as being like the bellows of an organ, which push air into the wind chests; and of external objects, which displace certain nerves, causing spirits from the brain cavities to enter certain pores, as being like the fingers of the organist, which press certain keys and cause the wind to pass from the wind chests into certain pipes. And just as the harmony of organs depends not on the externally visible arrangement of pipes or on the shape of the wind chests or other parts but solely on three factors, namely the air that comes from the bellows, the pipes that make the sound, and the distribution of air in the pipes; so too, I would point out, the functions that we are concerned with here do not depend at all on the external shape of the visible

> parts which the anatomists distinguish in the substance of the brain and in its cavities, but solely on three factors, namely, the spirits that come from the heart, the pores of the brain through which they pass, and the way in which the spirits are distributed in these pores. Thus, my sole task here will be to explain to you, in a systematic way, what is most important in these three." (*Treatise of Man* § 165).

Form, size and motion are fundamental principles of mechanical philosophy. So, in some cases it shouldn´t be expected to find a mechanical explanation in a single step or considering a single factor. Instead, sometimes it is necessary to consider intermediate results to yield the phenomenon under study; or it is necessary to synchronize processes to achieve the result. For example, understanding mechanically the color and form of blood it is necessary to consider the role of the liver and of the heart, according to Descartes. So, both should be taken into account for a correct explanation of this phenomenon. Descartes claims,

Similarly, it should be noted here that the pores of the liver are arranged in such a way that this fluid, on entering, is refined and transformed, taking on the color and form of blood, just as the white juice of black grapes is converted into light-red wine when it is allowed to ferment on the vine stock.

> […] Similarly, it can be demonstrated experimentally that the blood or milk of some animal will be dilated if you pour it a drop at a time into a very hot flask. And the fire in the heart of this machine that I am describing to you has as its sole purpose to expand, warm, and refine the blood that falls continually a drop at a time through the passage from the vena cava into the cavity on its right side, from where it is exhaled into the lung, and from the vein of the lung which anatomists have called the 'venous artery' into its other cavity, from where it is distributed throughout the body." (*Treatise of Man* § 123).

Then, many (mechanical) resources are available for the designer and she/he can exploit them in an appropriate way to obtain the correct mechanical results.

4. A sufficient understanding of anatomy and physiology of organs of living beings is necessary before engaging in the job of mechanically model a living-organism. In this task you should pay attention to the shared anatomy and physiology among organisms, but at the same time, to those specificities that make an organism different from others. So, the form, the size and the motion have a direct correspondence with physiology. From here it is concluded that some changes in form and size should have an effect on the physiology of the living-machine. But the identified organ´ specificities should be consistent with the general mechanical perspective expressed in the previous design principles.

As pointed out above, Descartes itself devoted several years (at least four years), from 1629 to 1633, to study anatomy and physiology. He came back to this issue several times after. As pointed out by Gaukroger (2004),

> By the time of his move to the Netherlands, however, we begin to find a more systematic interest in anatomy and

> physiology. He tells Mersenne in a letter of 18 December 1629 (AT i. 102) that he has taken up the study of anatomy, and during his first winter in Amsterdam he would visit the butcher daily to watch the slaughtering of cattle, and would take parts he intended to dissect back to his lodgings. He seems to have kept up an interest in these topics throughout the period of composition of the first part of *The World*, and he continued work on the *Treatise on Man*, possibly making revisions to the manuscript, into the mid-1640s." (Gaukroger, 2004, p. ix).

Then, an attentive mind shall be needed to observe, record and model details and small differences aimed at making a better mechanical design of a living being.

5. In the process of designing a living machine, adopt the principle of compositionality, that is, the whole is equal to the sum of its parts and the way in which they are arranged. You should divide a whole into as many parts as needed, in order to have a more precise concept of the anatomy of the living-machine, but at the same time you should keep in mind that these parts are, at the same time, components of a mechanical system that manifest one or more functions (physiology of the systems). Maybe I cannot find this principle formulated in this precise way in Descartes publications. However, a similar principle is followed by Descartes in the *The Rules for the Direction of the Mind* (1628), *The Treatise of Man* (1633), the *Discourse on Method* (1637) and the *Principles of Philosophy* (1644, 1647), in which Descartes followed an analytic method for analyzing complex problems. I consider the principle of compositionality very consistent with the mechanistic approach to nature and to living-machines. Following this method, as pointed out by Gaukroger, (2004), Descartes was succeeded in explaining different phenomena without reference to soul:

> […] various functions had traditionally been ascribed to qualitatively different 'souls': digestion, movement of the blood, nutrition, growth, reproduction and respiration to the 'vegetative soul'; perception, appetites and animal motion to the 'sensitive soul'. Descartes sets out to show how we need postulate no souls at all for these organic processes, that all that is needed is the right kind of mechanical explanation." (Gaukroger, 2004, xxiv).

After separating the whole in different parts, these should be orderly assembled in sub-systems, assuring that the functions associated with the extant living-machine are appropriately expressed in the proposed model, and test them as many times as needed. Finally, these sub-systems should be integrated in only one system. In doing so, you will successfully construct a living-machine.

## 5. Brief discussion

This brief analysis is based mainly on two writings of Descartes: *The Treatise of Man* and *The Description of Human Body*. These works applied the mechanical principles of the mechanical philosophy to understand the body and, therefore, to all the living beings. The use of microscopes in this important area of biology was not available during Descartes academic career. As known, it started with Hooke in 1665

and was deepened by Leeuwenhoek (1632-1723), Swammerdam (1637-1680) and Malpighi (1628-1694). Microscopic observations completely changed this mechanical picture. The introduction of microscopic dimensions in the mechanical explanation was necessary and was made by Leibniz and his followers. However, a change in perspective was introduced. For Leibniz living machines are machines in all of their parts, no matter how small they are. And this makes a great difference between human designed-machines and divine ones. They are naturally different. However, for Leibniz matter is not inert; there exist force present in any part of nature, and this force expresses in different way in the complex scale of nature, starting from body collisions, chemistry, plant, animals and human being. Leibniz extends life to all forms in the universe. As pointed out in the Monadology,

> Thus, every organized body of a living thing is a kind of divine machine or natural automaton. It infinitely surpasses any artificial automaton, because a man-made machine isn't a machine in every one of its parts. For example, a cog on brass wheel has parts or fragments which to us are no longer anything artificial and bear no signs of their relation to the intended use of the wheel, signs that would mark them out as parts of a machine. But Nature's machines—living bodies, that is—are machines even in their smallest parts, right down to infinity. That is what makes the difference between nature and artifice, that is, between divine artifice and our artifice." (*Monadology*, § 64).

However, Descartes approach was a very interesting antecedent of the materialistic approach that aims to provide mechanical construction and explanations of living-beings.

**Bibliograpfy**


Allen, Colin; (2009) Teleological Notions in Biology, *The Stanford Encyclopedia of Philosophy* (Winter 2009 Edition), Edward N. Zalta (ed.), URL = <https://plato.stanford.edu/archives/win2009/entries/teleology-biology/>.

Allen, W. B. Sir Isaac Newton's De Gravitatione Et Aequipondio Fluidorum. URL = < http://williambarclayallen.com/translations/De_Gravitatione_et_Aequipondio_Fluidorum_translation.pdf>

Descartes, René; (1646-7) *Description of the Human Body*. In: Gaukroger, Stephen (2004), *René Descartes: The World and other Writings*. Cambridge University Press:170-205

Descartes, René; (1644) *Principles of Philosophy*. Translation of Jonathan Bennett (2010-2015). URL= < https://www.earlymoderntexts.com/assets/pdfs/descartes1644part1.pdf>

Descartes, René; (1632-3) *The Treatise of Man*. In: Gaukroger, Stephen (2004), *René Descartes: The World and other Writings*. Cambridge University Press: 99-169.

Falcon, Andrea; (2015) Aristotle on Causality, in *The Stanford Encyclopedia of Philosophy* (Spring 2015 Edition), Edward N. Zalta (ed.), URL = <https://plato.stanford.edu/archives/spr2015/entries/aristotle-causality/>.

Franssen, Maarten, Lokhorst, Gert-Jan and van de Poel, Ibo, (2015) Philosophy of Technology, *The Stanford Encyclopedia of Philosophy* (Fall 2015 Edition), Edward N. Zalta (ed.), URL = <https://plato.stanford.edu/archives/fall2015/entries/technology/>.

Gaukroger, Stephen; (2004) *René Descartes: The World and other Writings*. Cambridge University Press.

Hatfield, Garry; (2007) The Passions of the soul and Descartes's machine psychology. In *Studies in History and Philosophy of Science* 38 (2007): 1–35.

Leibniz, G. W.; (1714) *Principles of Nature and Grace Based on Reason*. Translation of

Jonathan Bennett (2010-2015). URL= <https://www.earlymoderntexts.com/assets/pdfs/leibniz1714a.pdf>

Leibniz, G. W.; (1714) *Monadology*. Translation of Jonathan Bennett (2010-2015). URL= https://www.earlymoderntexts.com/assets/pdfs/leibniz1714b.pd

Sepper, D. L.; (2016) "Descartes" in The Routledge Handbook of Philosophy of Imagination. Routledge Publisher, London: 27-39.

Shields, Christopher; (2016) "Aristotle", *The Stanford Encyclopedia of Philosophy* (Winter 2016 Edition), Edward N. Zalta (ed.), URL = <https://plato.stanford.edu/archives/win2016/entries/aristotle/>.

Shields, Christopher; (2007) *Aristotle*. Routledge Taylor and Francis Group, London and New York translated by W. B. Allen Sir Isaac Newton's De Gravitatione Et Aequipondio Fluidorum.

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