From homo mechanicus to superman: a morphological reflection

"Did I request thee, Maker, from my clay / To mould me man? Did I solicit thee / From darkness to promote me?"
(J. Milton, *Paradise Lost*)

The myth of Prometheus[1] and therefore of the artificial construction of humankind through actions of design, fantasy, or technical sophistication, represents the emotional sense of this essay. Uncanniness on the one hand, and seduction on the other, are the feelings that have always been manifested when dealing with "unnatural" human forms: robots, humanoids, automatons, androids, avatars – more or less similar, but in contemporary reality affirming themselves with very significant formal models, and models for relating with people.
This essay intends to propose a reconstruction of a phenomenon, which is that of the anthropomorphic product by definition – the robot (in one of its multiple semantic modes to which to make reference) – by reflecting on the relationship between the artificial and natural form of the human body. The investigation in the first instance aims to be descriptive of a historical path implemented with the filter of observation, also of a morphological nature, of the various products and of the value of "autonomous" function, a truly important characteristic. The subsequent part of the essay is an analysis of the evolutionary dynamics in progress, with the aim of highlighting the change in the concept of "anthropomorphism" towards a broader definition including an approach more oriented towards the role of autonomy also in terms of "self-sufficiency" and of fusion between human form and machine.
The essay offers a summary that underscores a significant morphological change in the human/machine relationship, taking account of the fact that humans have thus far made only a marginal and in many cases negative contribution to designing nature; in designing the artificial, due to the complexity of the scenario and the dizzying development of technology, the transformation is such as to consider a future of successive and increasingly evident human/machine hybrids possible.

[robot, super-human, uncanny valley, automaton, anthropomorphous]

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If you're similar me, I'll speak, play, and work with you. But if you're equal to me, I'll notice every small difference between your and my equality, and I'll be afraid of any difference of yours.
In 1970, in the journal *Energy*[2], robotics engineer Masahiro Mori published a research work proposing a theory named the "uncanny valley", in which he maintained that the excessive similarities of a robot's features to those of a real person highlighted every small flaw that might be associated with the non-similarity. The emotional reaction of the potential human being who might be interacting with this automaton would thus undergo an emotional "collapse" at a certain point, provoking in him or her a profound sense of unease, revulsion, and fear, due precisely to this "non-complete" equality.
The theory was set out during a period when science began to travel down the road of robotics supported by computer science, proposing, as in the past, its formal, anthropomorphic vision, albeit in the continuous search for a technology that might augment the level of these products' independence and autonomy.
A human being's encounter with a being similar to him or her, but the result of "mechanical" ingenuity, is a relationship ancestral in character. In this relationship, the morphological nature imitative of humans has the aim of recognizing the need for an aid that can be "subjugated" or made use of, with no fear in terms of morality or of emotional involvement. This "similar" being is considered as lacking a subconscious and subjectivity, and thus as "mentally insufficient",[3] and then the real, human party, not without emotional subjectivity towards this insufficient machine, is deemed to become resonant, undergoing an unconscious refusal due to the perceived although unrationalized emotional deficiency.
With this interpretation key, the path of these creations show that the future dynamics, increasingly directed towards hybridization between humans and artifice, require a reconnaissance done with a precise thematic filter – that of analyzing the anthropomorphic "design" of the artifice.

The beginning

Classic historiography on the evolution of the first automata tends to trace these concepts to Classical Greece, where the automaton considered the oldest known (third century BC), and that has come down to our own days, was made: Philon's[4] [automatic servant], designed by an inventor from Byzantium.
The automaton's shape probably alluded to a work of statuary (if the reconstruction that was done is reliable), and its function was to pour wine or water alternatively, depending on the hand where the cup rested.
Of the prominent figures in Ancient Greece dealing with the world of automata we may cite *Hérōn ho Alexandréus*, (Hero of Alexandria, 285-222 BC), a scientist, mathematician, inventor, and expert in mechanics, who also built the precursor of the steam-powered device called the aeolipile.

Among his various writings in a number of fields, he left a significant record in automatic mechanics with his *Automata*[5], identifying what we would now call the scientific landscape of automata.
The ancient Western world was not alone in its contribution to the mechanics of automata. The East dominated by the various Chinese dynasties also shows traces (scantly supported, actually) dating to a millennium before the Common Era, in which certain accounts[6] in a text from the fourth century BC (*Liezi*) describe an extraordinary automaton able to move and sing in the presence of King Mu (5th king of the Zhou dynasty, 1045-256 BC). Built by an inventor/engineer named Yan Shi, the automaton, according to the description in the text, had sophisticated mechanisms perfectly consistent with the human body, like the heart, liver, and other vital parts.
Although not scientifically reliable, the account is considered a significant trace of these products in ancient history, and of the consequent attention given to them by Eastern culture. In the twentieth century, this was to assert itself and become predominant, in parallel with technological evolution.
Centuries after Yan Shi, in the Middle East of the thirteenth century, the engineer Ismail al-Jazari (1136–1206), defined as the "father" of robotics and originally from Mesopotamia, designed and described, in a manuscript, dozens of ingenious machines full of mechanical automatisms. The designs led to the possibility of structuring a "programming" of movements with complicated, manoeuvrable devices, like the design for a small band that could play different sounds depending on the movement of small pistons.
The various designs by this Islamic "genius" depict a Middle Eastern culture of representation, in which sign and colour are elements essential for describing the object of the invention.
Analyzing his production, we may, in 1207, glimpse countless design parallels with the later "Leonardesque" machines, particularly in terms of the attention given to describing the particular component. Of importance is his drawing depicting the internal workings of an automaton for pouring liquids, which may be clearly defined in a parallel with the more well known (to us Westerners) Leonardo's Robot from nearly 300 years later, called the "mechanical knight" and reported in the Codex Atlanticus.
In the case of the mechanical knight, the drawing's attention is devoted exclusively to the internal mechanism, taken apart and subdivided in different folios, emphasizing the culture of the "detail" over the overall image. It was only in 1950 that Carlo Pedretti "discovered" the whole and built an operational prototype, including the armour.
The result is a soldier with armour, that can stand and move its limbs and head.
But even centuries later, certainly as regards the former, we can glimpse the first morphological elements that later built the "sense" of the anthropomorphic automaton, which is to say the theme of single-axis asymmetry, the relationship between high and low, and therefore the role of the mechanical extremities (arms like human arms) and legs, of the interior as a "human machine", and of the exterior as "human form".
While not intending to provide a perfect chronological reconstruction, this essay aims to highlight the most significant passages, linking them above all to certain inspiring principles that promoted this study.
The passage is made in the twentieth century, but the sixteenth through the nineteenth centuries saw an evolution in automata, in terms of the spread of and interest in these products able to greet, play music, smoke, open and close doors, sing, and do arithmetic.
In 1744, Jacques de Vaucanson, a famed inventor of that time, exhibited, at Palais Royale in Paris, a *metallic Duck* "apparently" able to eat, digest, and defecate; in addition to the interior system, the automaton could move its wings, and thus perform certain movement similar to those of the actual animal. The same inventor also built a robot flute player capable of moving its fingers and blowing into the flute, producing sound.
From 1800 to the turn of the twentieth century, France and Paris became the centre for the crafting of these items, which were what we might call today the sexy, hi-tech product.
During this period, the various "automata" were highly detailed, often highlighting the complexity of the mechanism as formally reported, such as skeleton clocks. The product was enriched with highly refined artisanal handiworks, some of which miniaturized and treated like jewels, while others could in form be associated with the shape of dolls[7]. They became cult objects for the upper bourgeoisie that acquired them in richly illustrated catalogues, and were "flaunted" at various social events, as home technology devices are today.

The twentieth century

The last century, starting above all in its second half, substantially changed the role of the "artificial man". Since the late nineteenth century, the cultural attitude often showed itself to be frightened or hostile whenever "artificial" equals turned up in various novels and later films, but in actuality the substitutional role of the "robot" was affirming itself. Throughout the twentieth century, it was represented by a popular assertion of the culture of the automaton, but in fact, during this period, popular imagination was far from the technological evolution of these products.
In the film *Metropolis*, Fritz Lang's dystopian vision from 1927, the role of the designed Robot – affirmed as an element to replace "fatigue and therefore the human oppression of working" –, although conserving all the social values the film contains, was no less significant.
The world of science worked in parallel with this cultural evolution, adopting several morphological registers; consider the hyperrealistic robots (also specifically called humanoids) by the Japanese scientist already cited at the start of the essay,[8] countering the nascent robotized industry of the 1970s and 1980s.
The dominant traits of last century's evolution in formal terms find an articulate combination as regards the human form – the android, for example, in its initial configuration, to be an aid, must wholly resemble the human body. The relationships

between the parts, symmetrical arms, head and eyes, legs (two of them) and a proportioned body, are substantial.
This arrangement came into being due to various factors. The first is that in order to be an aid to people, and considering that the space for action is manmade in nature, the imitative solution is consequently the one most easily adaptable to space.
The second factor is that the (now well-known) culture of biomimesis finds perhaps one of its most significant examples in the imitation of the human body.
The third factor is certainly more psychological and linked to the need for an interaction among like beings, for real exchange and assistance.
The "humanoid" robot, then, also develops in relation to its capacity to relate with people. Human features are necessary for building a friendly relationship, even if its intrinsic characteristics, with the development of technology, might not also use anthropomorphic configurations in order to operate.
In parallel, in the late twentieth century, information sciences began developing virtual "living" beings to support humans, also because they brought human necessities with them, albeit in a highly virtual and "alien" form – consider the famous game *Tamagotchi*.[9]
Another line of evolution, again starting from the mid twentieth century, proposes a greater formal characterization of the Robot as an aid to human beings, capable of a possible autonomy yet seen as an anthropomorphically divided mechanical system – an evolution that conceptually produces a "formal dismembering" of the mechanical man on the one hand, and a dematerialization of intangible but human characteristics, like intelligence, on the other.
Technology transforms the robot from an imitative aid – nearly "useless" because it never sufficiently substituted people – into a "superhuman" product with non-human capacities for response, analysis and calculation.
This condition apparently constitutes a loss of the anthropomorphic value of the "android" product, but in actuality disproportionately enlarges the value of the human form, no longer just as a tangible characteristic but above all as an intangible one.
The "electronic brain" perhaps marks the first time that this term (now in disuse) indicates a condition in progress, which is to say the possibility of exploiting – in a manner raised to the n^{th} power – the logical, mnemonic and processing capacities of a part of the human body: the brain.
The brain and (mechanical) arms are parts that are conceptually anthropomorphic, but in their form are light years away from resembling a body. The whole industrial revolution produces a profound transformation, and the "human" worker is replaced in the necessary parts – head and arms – by electronic brains moving mechanical arms.
This phenomenon is, in evolutionary terms, in the twentieth century, the one most significant in the analysis of the morphogenesis of the robot.
We might then state that morphologically – even though an evolved and expanding technological science using and producing robots that are still anthropomorphic has remained – the world of humanoids, and of robots, underwent a sea change in the second half of the twentieth century.
To this day, this sea change represents, in summary, three passages:
The humanoid, android robot, wholly conserving the morphological relationships with the human body.
The barely humanoid robot, developing only the morphological characteristics necessary for carrying out highly enhanced human activities.
The robot is no longer a part autonomous of the human body but becomes a part supplementing and replacing it – what we might see as a phenomenon of absolute hybridization between body and machine, and as evolution in progress.

The contemporary age

In the contemporary age, the proposed morphological subdivision of the anthropomorphic product is not hierarchically represented. Technological evolution evolves in parallel in all the scenarios summarized above, and we may therefore trace the elements of this transformation horizontally.
The android, which is to say the entity that has a characterizing anthropomorphic nature for formal relationships, is systematically evolving towards a role totally replacing the human being. Emblematic was the inclusion (August 2019) on the International Space Station (ISS) of the humanoid "FEDOR",[10] 180 cm tall and weighing 160 kg. Morphologically representing a typical "humanoid" robot in terms of relationships between the parts, this hi-tech product was endowed with new-generation IT devices capable of "learning" human abilities and movements in a state of microgravity, thus highlighting the evolutionary dynamics typical of AI.
It will learn and then carry out particularly hazardous routine functions, like Extravehicular activity (EVA). The objective of the experiment (carried out by Russian scientists) is that of proposing robots to replace humans in activities with greatest exposure to cosmic rays, with a view to a possible long trip towards Mars.
The parallel with the impressive armies of humanoids in the *Star Wars* saga (to cite one as an example) lies at the limit of the uncanny. This is especially so in morphology, which, considering the potential capacities for evolution and autonomy determined by the sciences studying artificial intelligence, constitutes a "leap into the void" wholly to be assessed.
This context of the world of humanoids and androids – especially considering the development of artificial intelligence, and with it the greater weight taken on by it in this inescapable ability to give these machines an emotional capacity as well – also includes multiple studies and examples proposing products we may summarize as "social robots", developing sophisticated technologies capable of relating with people. These also show feelings and expressions, in addition to making movements and engaging in dialogue, as in the case of Face[11] – an android with female features that communicates with facial expressions, thus simulating an emotional level of relationship for the hearing impaired.

We may thus include in this category the entire development of products that are most imitative of humans, and that in some cases disproportionately expand human potentials in terms of strength, resistance, and intelligence, thereby becoming substitutes for people themselves, and even interlocutors if anything on an equal footing.
In another context, the world of robotics is marked by a substantial loss of the morphological features of the human body, maintaining only some conceptual/relationship ones, such as remote manoeuvrability, and is represented mainly by industrial and service robotics.
While in industrial robotics, already present in the last century and now the source of the abused term "Industry 4.0", evolution appears well guided on easily identifiable tracks (those of replacing man in increasingly sophisticated production and control activities, and therefore for the production of manufactured articles), service robotics, understood as an amplified and transferable prosthesis of human capacities, is certainly the contemporary scenario of greatest interest.
In this case, the entire world that makes it possible to network information, and in particular the world of IoT, is providing a significant, propulsive thrust.
Morphogenesis places the robot between being a remote prosthesis and being an anthropomorphic tool, a transferred piece of the human body – robots guided remotely to carry out activities in which, however, supervision and inputs to action are always controlled directly by humans. Tools for contact, for interaction, are highly sophisticated interfaces, capable of transmitting, on a millimetric scale and with times accurate to the hundredth of a second, the actions of people themselves. The transfer of sensitivity, especially for "robot surgeons", is one of the main elements of study and development.
The ergonomic relationship between actuator and machine is intimate, because it is activated by the ability the machine has to transfer to the operator a set of information that is often triggered by the human body's sense receptors, like noise and scent, and not sight alone. The evolution of the generation of the "Vinci" robot, now a leader in terms of spread and technology, is just starting out, although it has operated on more than 90,000 patients so far.
The real experimentation lies in the ability to learn with artificial intelligence devices so as to constitute an active support at any moment of the operation.
The last scenario of the contemporary age – which we might summarize as the completion of a relationship between humans and machines such as to bring about in the true hybridization between artifice and nature that has taken place – is the one typical of the sciences of bionics, in which two substantial morphological passages may be recognized: the world of exoskeletons and that of replacing human parts with "hi-tech" parts.
Both scenarios represent a substantial fusion between humans and artifice, with an integration of parts(complete or partial) that are auxiliary, but that still integrate the human body: different, detachable, and also with an autonomy of function.
Likewise in "invasive" bionics, overlooking all the reflections of a technological nature but stressing the formal character, the relationship between the human part and the technological one becomes "intimate", indivisible, belonging to the self, even if still replacing lost normality and abilities.
But with a view to the future, in proximity to the previous morphological scenarios in which robots and androids replace humans by expanding their capacities disproportionately, bionics, although directly linked to the exploitation of natural principles, if not necessary for remedying deficits, will be able to become prostheses expanding already normal human capacities.
Just as augmented reality makes clear the hybrid condition between reality and its technological amplification, in bionics the hybrid relationship between "anthropomorphic" normality and technological artifice constitutes the true "super-human" horizon. The theory of the "*uncanny valley*" will therefore be amplified not to respond to a non-human "flaw", but for a new, amplified "abnormality", in which the role of artificial intelligence, or of physical capacities, will not be substitutive, but an intimate expansion of the person's individual intelligence and physical ability.

[1] Understood in Ovid's vision, which is to say as the creator of men from clay.

[2] Mori, M. (1970). Bukimi no tani - The Uncanny Valley (K.F. MacDorman& T. Minato, Trans.). Energy, 7(4), 33–35. (Original in Japanese, English translation).

[3] Ludovichi, M.L. (2008) "L'automa con quella faccia da straniero" in "Stranieri in famiglia" Percorsi di Psicanalisi VII/2008. Pisa: ed. ETS.

[4] At the Kotsanas Museum of Ancient Greek Technology in Athens.

[5] *Automata* came down to our time in the version (*De gli automati*) translated from the Greek by the abbot Bernardino Baldi in 1589.

[6] Reported in "The Shorter Science and Civilisation in China" by Joseph Needham and Colin A. Ronan

[7] See Jaquet-Droz's automata.

[8] Masahiro Mori's robots.

[9] Electronic game created by AkiMaiata and AkihiroYokoi in 1996.

[10] Final Experimental Demonstration Object Researchç.

[11] Facial Automaton for Conveying Emotions, developed by researchers at the Piaggio centre.

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