4 Body Conjunction = Wavering Between Actual and Virtual Spaces

"You take the blue pill, the story ends. You wake up in your bed and believe whatever you want to believe. You take the red pill, you stay in Wonderland, and I show you how deep the rabbit-hole goes."

Morpheus, to Neo (the Matrix, 1999)

§ 4.1 From Body Measurement to Body Extension to Body without Organ

In the present digital age, the body tends to extend beyond it being flesh, it can be extended, it is a body without organs, and it might belong to more than your own-self.

The "Body" as a living entity with its embedded sensory system, not only embodies who we are but also lets us understand and explore the sensitive, unpredictable but fascinating world. The body is an information receiver as well as information reactor. Through years of medical experiments and research on the body, medical devices and instruments are able to allow us to look into the deepest and the most mysterious spots in the human body. For instance, if seen through an HD monitor, while being probed by an endoscope, the body appears as an immersive and infinite landscape. By observing the smoothness and the folds of the surfaces encountered within the body, it is quite simple to project your individual self into this body-scape for a while to imagine and experience this immersive organic space. Various potential ideas of designing a body-like space have become the subject of design fantasies of a number of architects.

The "Vitruvian Man", which, Vitruvius described in the third book of De Architectura, and was later interpreted and illustrated by Leonardo DaVinci, has served as the human figure/body representation to be used as a measuring unit rather than being considered as a sensitive object. Unsurprisingly, it was a relatively long journey for architects to abandon this dogma. After the industrial revolution (during the modernist era), the concrete evidence of considering body proportions as potential measurements could still be seen in the projects of Le Corbusier, which accompanied his famous school of thought: "**A house is a machine for living**". He developed the "**Modular**" in a mathematical proportion of space based on figures and intended to replace the old Vitruvian man with it as a new generation's typical model. However, with the rapid development of electronic technology, the trend of realizing sensory environments akin to living bodies has no longer remained a thought but can be seen as an initial action to refuse to see the human body merely as a measuring unit. The turning point came about the time while the medium of news media, television, and social media became relatively mature, and thus started making people conduct critical reflections. Marshall McLuhan, a well-known pioneering media theorist, stated in his well-known publication, "***Understanding Media: The Extension of Man***" (McLuhan, Understanding Media: The Extensions of Man, 1964). **This explicit shot made the researcher foresee the potential and intimate relationships between the body, technology, and space, and somehow have a rational explanation to extend the physical body to endless space, which is crucial in this chapter.**

"**Today, after more than a century of advancements in electronics, we have extended our central nervous system itself in a global embrace, abolishing both space and time as far as our planet is concerned**" (McLuhan, Understanding Media: The Extensions of Man, 1964), Marshall McLuhan who invented the terminology of the "Global Village", thus opens up a ceaseless discussion around his discussions around " **media being the extension of man**", and by doing so, he profoundly influenced the general perspective/ reflection of technology and helped in reshaping a new relationship between body and technology. "***All media are extensions of some human faculty—psychic or physical***" (McLuhan, M., Fiore, Q., & Agel, J, 1967). The "Media" here is no longer the synonym of the press or mass media but rather indicates human technology. For example, "... **the wheel (media) is the extension of the foot**"; **"...the book is the extension of the eye**"; "**...clothing, an extension of the skin**"; "**...electric circuitry, an extension of the central nervous system**". It's not that the Internet or electronic technology which initiated the extensions of the body. According to Marshall McLuhan, Body extensions have been developed for thousands of years, much earlier than the Internet and electronics. Although his conceptual idea about "**Hot & Cold Media**" is controversial due to the reason that the distinction is based on a relative standard rather than an absolute definition, he still explicitly argues that the medium/technology requires a critical degree of audience participation. Interactive environments align with this line of

thought since they serve as a medium of expression and involve real-time engagement of participants for seeking critical reflection. ("Hot media are, therefore, low in participation, and cool media are high in participation or completion by the audience." (McLuhan, Understanding Media: The Extensions of Man, 1964).

Eliminating the traditional notion of the medium as the vehicle carrying messages, Marshall McLuhan argued via his revolutionary idea that "**Medium is the Message**". The medium itself has embodied meaning even without embedding any content. For instance, an automated machine, in itself is a medium/technology, it has thoroughly altered the relationship of man-machine in human society, and it thus carries its own meaning. Marshall McLuhan gave a precise and understandable example as follows, "**The railway did not introduce movement or transportation or wheel or road into human society, but it accelerated and enlarged the scale of previous human functions, creating totally new kinds of cities and new kinds of work and leisure**" (McLuhan, M., Fiore, Q., & Agel, J, 1967). Another example can be listed here, like human communication methods from the handwritten letter, the telegraph, the telephone, and today's smartphones and email technology, are all seen as the medium only changing the scale and speed of communication. With the rapid development of technologies, such as the Internet and computational processing power, the physical body is further extended into virtual space while interweaving and interacting with all the other involved technologies. Within this technologically rich context, despite of being empowered by this medium, the incremental loads and tasks experienced by the body have to be scaled up to a comparable level. Besides, based on Marshall McLuhan's idea, this kind of imbalanced condition and way of diminishing the natural role of the senses was initiated long ago while the phonetic alphabet was invented. "**... in the tribal world, the senses of touch, taste, hearing, and smell were developed, for very practical reasons, to a much higher level than the strictly visual. Into this world, the phonetic alphabet fell like a bombshell, installing sight at the head of the hierarchy of senses. Literacy propelled man from the tribe, gave him an eye for an ear and replaced his integral in-depth communal interplay with visual linear values and fragmented consciousness**" (Playboy Interview: Marshall McLuhan, 1969). Since then, the holistic idea of man became **fragmented** with ubiquitous professional body extensions catering to specific missions. This phenomenon gradually leads to a tendency of pushing the body to the extreme by means of assisting and enhancing various bodily senses via suitable technological mediums, akin to continuously pressing and pushing, the body like a massage. This is where the medium appears to become the "**massage**" rather than the "**message**."

In the chapter of "**The Gadget Lover: Narcissus as Narcosis**" in "***Understanding Medi****a*" (McLuhan, The Gadget Lover: Narcissus as Narcosis, 1964), Marshall McLuhan uses an ancient Greek story to bring out the issue of "**Numbness**". This young Narcissus was so

fascinated by his extension: the reflection in the water (although he didn't know it was his own reflection), that he transformed himself and his extension into a completely closed system, or in other words became "**Numb**". Simply saying, the stimulation of his extension was so powerful that he refused to accept other contextual information and became operating as a closed loop. From the physiological point of view, Marshall McLuhan found support from two medical researchers, Hans Selye and Adolph Jonas, when he stated: "**all extensions of ourselves, in sickness or in health, are attempts to maintain equilibrium. Any extension of ourselves they regard as "autoamputation," and they find that the autoamputative power or strategy is resorted to by the body when the perceptual power cannot locate or avoid the cause of irritation** (McLuhan, The Gadget Lover: Narcissus as Narcosis, 1964). This is the reason why people tend to play sports in order to combat the irritations and stresses of real life. Furthermore, **"...In the physical stress of superstimulation of various kinds, the central nervous system acts to protect itself by a strategy of amputation or isolation of the offending organ, sense, or function**" (McLuhan, The Gadget Lover: Narcissus as Narcosis, 1964), in addition to this, "**...Shock induces a generalized numbness or an increased threshold to all types of perception"** (McLuhan, The Gadget Lover: Narcissus as Narcosis, 1964), it is explicitly clear that the autoamputation, as numbness are ways to protect selves from sudden superstimulation. To make it easier to understand, take the news reports for example. Through the broadcasting of the news, people might get shocked and have moral anxieties of seeing these skinny children suffering from the specific problem of famine in Africa. But after every 10 minutes of constant information bombarding with the repeated images (**massage**), people become completely numb (**autoamputation**). In accordance with Marshall McLuhan's explanation, the "**autoamputation/numbness**" has to happen as a protection mechanism to prevent people from feeling self-condemned from a moral perspective and for survival. Nonetheless, reconnecting back to the title of the reference in this section, the term of "**the Gadget Lovers**" nowadays, can metaphorically and intuitively indicate for those who love to explore/hack with these small electronic devices with specific applications. Under this particular context, the gadget lovers, with their main bodies, attempt to utilize all the hi-end technological gadgets to extend their body parts infinitely in time and space. They almost unconsciously seek temporary immortality in virtual space via the medium of the Internet. There is no way to distinguish each explicit body part in the virtual world such that the individual thought might not belong to one's conscious self. The body extension is thus autoamputated and distributed ubiquitously even after losing major control by the main body. On the other hand, metaphorically speaking, getting continuous electronic accumulating shocks by the message, the body will no longer treat it as stimulation, but rather turn it into the feeling of "numbness". Instead of peremptorily embracing the temptation of the new technologies, Marshall McLuhan actually would like us to reflect on the relationship between the technologies and the human bodily senses, and to keep to the qualities of each individual's authentic self,

especially in this boundless world composed of the web of the Internet where one can get lost and easily deconstruct with alienation.

Here, Marshall McLuhan's "**Body Extension**" seems to imply a linkage to the notion of "**Body Without Organs**" proposed by Gilles Deleuze and Felix Guattari (Deleuze, G., & Guattari, F., 2003). Before finding the linkage between "**Body Extension**" and "**Body Without Organs**", it is crucial to have a brief and generic understanding of the notion proposed by Gilles Deleuze and Felix Guattari. "**Body Without Organs**" shouldn't be literally interpreted as an organic body. In fact, it represents a concept which has no hierarchy, is not organized, and has no rigorous system similar to schizophrenia and tries to break the existing and ingrained mortal dogmas. While talking about "**Body Without Organs**", it is undoubtedly necessary to mention the concept of "**machine**" or so called "**desiring machines**" at the same time. Gilles Deleuze and Felix Guattari claimed that **everything is a machine** and some of them can produce a certain kind of **flow**, such as milk, thought, and energy. If accepting the idea of everything is a machine as a premise, then basically, they claimed that there should not be any distinctions between nature and industry, and man and nature. Because it's all about the concept of "**produce and products**". For example, a cow produces milk, as well as a meat-machine, produces sausages. According to the notion of **machines** from Gilles Deleuze and Felix Guattari, there must be another linkage machine connecting to the flow-producing machines to interrupt or draw off part of this flow. (For example, the breast is the flow-producing machine, the milk is the flow, and the mouth of the baby is the connecting machine which absorbs the milk and converts the milk into another form). Within the capabilities of connection, these machines are able to link themselves to the body without organs. In fact, the body has to connect with a certain desiring machine to keep it alive. This is beautifully illustrated by the painting: "**Body with Machine**" drawn by Richard Lindner, as an example taken by Gilles Deleuze and Felix Guattari in their article. Until now, it seems that there are various possibilities of direct connection between **desire machines** and the **Body Without Organs**. However, a gradually changing process and subtle relationship build up in different phases between the **desiring machines** and the **Body Without Organs** where the ultimate linkage to Marshall McLuhan's **Body Extensions** can be found in the following article: "Body without Organs". First, an apparent conflict arises because the **desiring machine** (an **organ**) tries to invade and break into the "**Body Without Organs**" which attempts to repel it. Afterwards, according to the article, "**in order to resist organ-machines, the 'Body Without Organs' presents its smooth, slippery, opaque, taut surface as a barrier**". Then, in the next phase, the "**Body Without Organs**" transforms itself into a smooth surface, recording the entire process of desire productions from each machine, thus forming a more intimate relationship between **desiring machine**(**organ**) and the "**Body Without Organs**". Eventually, "**...machines attach themselves to 'Body Without Organs' as so many points of disjunction between which an entire network of new synthesis is now**

woven, marks the surface off into co-ordinates, like a grid…no matter what two organs are involved, the way in which they are attached to the 'Body Without Organs' must be such that all the disjunction syntheses between the two amounts to the same on the slippery surface". (Deleuze, G., & Guattari, F., 2003) (Figure 1). To briefly summarize here, the "**Body Without Organs**" in the end becomes a smooth and slippery surface attached with all **desiring machines** (**organ**) which equally distributes onto the surface (the **Body Without Organs**) with no hierarchy and order.

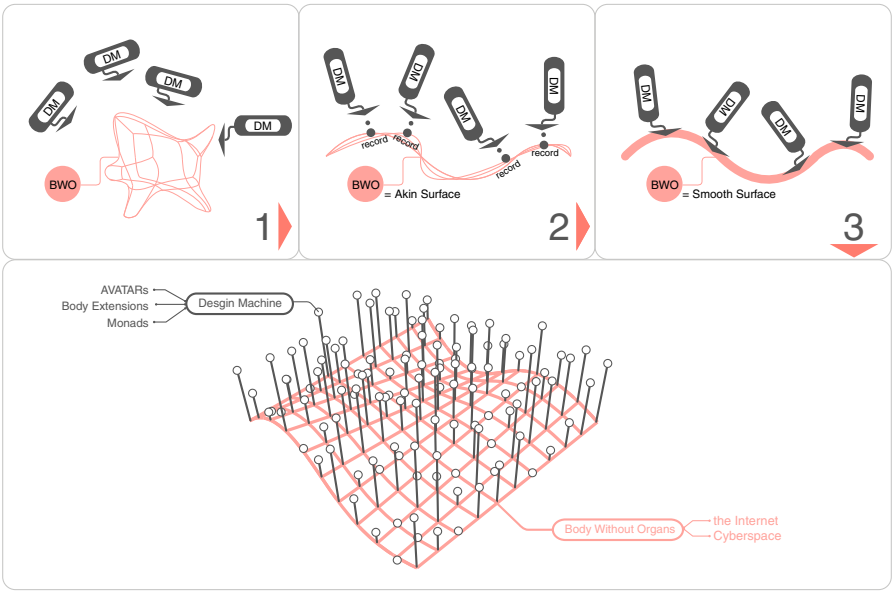

FIGURE 4.1 Diagram outlining the process of relationship changing between the desired machines and the Body Without Organs from left to right and to the bottom. DM = Desire Machine, BWO = Body Without Organs. Body Without Organs initiates with the action of repelling the Desire Machines but ends up morphing as a slippery smooth surface attaching with them as a boundless network.

After this process, a comparison can be made between the notion of the "**Body Without Organs**" not only with the "**Body Extension**" but also with the idea of "**Monadology**". **Desiring machines** here are transformed as monads that Gottfried Leibniz proposed in his Monadology (Leibniz, Monadology, 1714) which makes each **desiring machine** have equal impact and influence onto the ultimate grids/surface, the network of the "**Body Without Organs**." It might be difficult to understand with these philosophically abstract concepts, but within the content of the Internet, it can be relatively easy to explain. In a sense, the Internet is the new version of the "**Body Without Organs**", with people who connect to it acquire the form of the **desiring/organ machines**, and, the

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gadgets, servers, or other devices which are able to have connections to the Internet can be interpreted as **machines**. Then, regardless of how small an impact it would make, all the "things" connect though the web of the Internet, the **Body Without Organs**, will absorb the forces passing through the Internet surface. Referring back to the **Body Extensions** idea of Marshall McLuhan, under the context of the Internet, the technology/**Body Extensions** make people connect to the Internet which can be interpreted as a **desiring/organ machine** interplaying between other's body extensions. Under this pre-assumption, **Body Extensions** as **desiring/organ machines** can cling ubiquitously to the surface transformed from the **Body Without Organs** and blending the identification of the you and others, which means you might not be able to find your own Body Extensions since it will become more neutral than ever but you can still feel the influence from one another.

Another alternative interpretation can be related to the key notion of the "**Body Without Organs**", which is the attribute of "**schizophrenia**". Within the network of the Internet, people can easily have different identities with different characteristics as their **AVATAR**s. A male can easily pretend to be a female figure in an on-line game to fool people; a lower level employee can create a character living in the upper-class level to fulfill his/her implicit desire, etc. This is quite a common phenomenon with most of the people living in the current Internet era. In other words, people are revealing various attributes of their explicit personalities to somehow express their hidden emotions or satisfy certain desires from their not-too-successful lives. This phenomenon already classifies and qualifies people to be considered, "**schizophrenics**". One more quote from the section of "the Body Without Organ" in the publication of the "***Anti-Oedipus***" (Deleuze, G., & Guattari, F., 2003), **"...the surface of this uncreated body swarms with them, as a lion's mane swarms with flea**", and also consider the quote from Henry Miller in the introduction of the "***Anti-Oedipus***" by Mark Seem, "**We must die as egos and be born again in the swarm, not separate and self-hypnotized, but individual and related**". Once again, it refers back to Leibniz's philosophy of Monadology to treat each existing object/machine assembling with a simple substance, which matches not only the center stage of the "swarm" in nature but also the kernel idea/principle of this research. **"...a body without organs, like a spider poised in its web, observing nothing, but responding to the slightest sign, to the slightest vibration by springing on its prey**" (Deleuze, G., & Guattari, F., 2003). Each of us, as an individual could be the prey, or the substance falling on the web to make vibrations in order to create a synthesis impact to the spider (the **Body Without Organs**), but multi-directionally, the spider (the **Body Without Organs**) or the interrelation between each individual object can also influence with each other simultaneously, akin to a swarm of agents to create a collective intelligent-like creature from bottom up.

§ 4.2 You are in a Virtual Reality more frequently than you know

= Where the idea of interaction narratives has been initiated.

Virtual Reality as a terminology is connected with specific technologies with the help of which, artificial virtual environment can be exhibited either on a screen or through a glass-like device to make people experience a tangible journey where they think it is "real" like being in a parallel universe. But somehow, human beings have the imaginative capability to create their own virtual reality without any assistance from high-end wearables or simulating technological devices. For example, you must have had the experience of waking up with a nightmare which you almost felt was real. In this case, while people are dreaming, they are witnessing a virtual reality via their unconscious mind. A similar effect is felt while taking hallucinogenic drugs or while experiencing déjà vu. Each of the above examples is conditions that cannot be controlled and manipulated by our conscious mind. Another virtual reality example without technology involved or which can be controlled is "reading". **"...reading requires the mind to develop the visualization process as 'imagination'"** (de Kerckhove, 2001). After years of "training", not only a mysterious inner subvocalization voice will come out while reading a text, a sequence of images like a video recording can be created through the borderless imagination, which is an individual and unique virtual reality experience of one's own. While reading a fiction or a novel, such as "***Harry Potter***" or "***Alice's Adventure in Wonderland***", people set their imagination free to go along with the storyline created by the author and interpret the narrative with their own imagination based on their life experiences. Or novels like "***Sherlock Holmes***" will bring you back to the Victorian period in England, looking for evidence or testimonies and trying to figure out and reveal the truth of the story. Although "**the author is dead**" claimed by French literary critic and semiotician, Roland Barthes (Barthes, 1968), readers can in a sense find their own ways of realizing each narrative they read as a creative immersion through their mind. Kerckhove's in his publication, "***The Architecture of Intelligence***", states, "**As readers, we learn to represent and internalize the visual field by repeating it in our imagination. It is because of this simple process that quite literally, we 'make up our mind'.**" This mind is equal to the "**Mental Space**" described in the same publication, which has been further explained as a private, silent, personal, totally individualized visualized universe devoted to imagination and thought (de Kerckhove, 2001). Therefore, to a certain extent, can it somehow be interpreted that these inventive immersions are virtual reality experiences co-created by the authors and the readers? In the section of "**Literature and Virtual Realities**" of the publication "***On Literature***" the influential literature theorists, J. Hills Miller, writes that "**Right reading is an active engagement. It requires a tacit decision to commit all one's power to brining the work into existence as an imaginary space within oneself**"

(Miller, 2002). Hence, reading is quite private but requires an active manner to engage exactly to match with the aforementioned idea of "**Mental Space**" by Derrick de Kerckhove. In "**On Literature**", J. Hills Miller also tried to explain his observation of the connection between literature and virtual reality. "**Literature seizes me and carries me to a place where pleasure and pain join. When I say I am 'enchanted' by the virtual realities to which literary works transport me, that is a milder way of saying I am enraptured by reading those works**" (Miller, 2002). If simply replacing "literature" to "VR (virtual realities)", every single sentence can still remain valid. Long before the visual environmental technologies and the terminology had been invented, people had already known how to "project" themselves into an imaginary universe/world with literature and games by using their minds, in the "**Mental Space**". It's clear that **Mental Space** has similar effects but comes internally from people's minds, which is totally private and subjective. **The essential difference between "Mental Space" and "Virtual Reality (or Cyberspace)" is that the former one is made up by our minds with daily experiences which are extremely personal and the latter is an artificial product usually created by a third party which is comparably objective.** Within present technology development, people still cannot read each other's minds or copy and reproduce it. But VR(Cyberspace) is meant to be created as a repeatable product for more people to experience. You might argue that people can have individual experiences through the pre-set VR environment, but objectively, the invented environment remains the same for every participant to engage in. Nowadays, the ultimate goal and challenge for current VR simulation are to go beyond these unique imaginary immersions within mental space and to make an improvement to the "**tangibility**" aspect by implementing contemporary visual and sensing technologies. Having the assistance from different aspects of the current advanced technologies, the VR system can be more solid and to a certain extent bring one to a parallel universe/world with relatively more sensitive and accurate perception. **It is quite obvious why people intuitively tend to connect with interactivity using VR technology since this enables an entire immersive artificial environment which can fully embrace people to promote active engagement in real-time. Without interactivity, the VR system will work just as a film or TV program, which is relatively passive in terms of engagement akin to cold media defined by Marshall McLuhan.**

While speaking about VR (Virtual Realities), "Cyberspace" is the term that cannot be ignored. "Cyberspace" was coined by the well-known "cyberpunk"/science fiction author, William Gibson, first in his short story "***Burning Chrome***" in 1982 (Gibson, Burning Chrome, 1982), but later in 1984 in his novel "***Neuromancer***" (Gibson, Neuromancer, 1984), it gained extremely unprecedented popularity.

"Cyberspace. A con sensual hallucination experienced daily by billions of legitimate operators, in every nation, by children being taught mathematical concepts ... A graphic representation of data abstracted from the banks of every computer in the human system. Unthinkable complexity. Lines of light ranged in the non-space of the mind, clusters and constellations of data. Like city lights, receding...."

In "***Neuromancer***", William Gibson abstractly defines the meaning of Cyberspace. It is now extremely easy to understand if one replaces the word "Cyberspace" with "the Internet". At present, Cyberspace somehow is identified as a term representing on-line computer networks. Cyberspace had already been seriously taken as an actual space according to Anna Cicognani's five criteria to qualify "spaces" (Cicognani, 1998), which are: 1) possible interactions; 2) livability or occupy-ability; 3) a community-building capacity; 4) time management; and 5) space management opportunities. Cyberspace, in the form of Internet networks, can easily fulfill all of these criteria. Even simply considering Cyberspace as an on-line game like "Sim-City", people can, 1) definitely interact with each other; 2) buy a virtual house and have a second virtual life; 3) set up connections within social communities based on your personal habits; 4) schedule personal timeline compatible with your identity; and 5) even arrange space as virtual real estate through trading behaviors. Cyberspace creates an alternate universe where people can do all the activities in parallel to the actual world. Michael Benedikt, the author of "***Cyberspace: The First Step***" (Benedikt, 1991) states "**...with cyberspace, a whole new space is opened up by the very complexity of life on earth: a new niche for a realm that lies between the two worlds. Cyberspace becomes another venue for consciousness itself...**" claiming a brand-new world with at least 2 parallel universes that people have to engage and deal with. In another publication, "***V01D***" (Anders, 2001), which mainly discussed the topic of current digital space with the relationship to the network of the Internet, Peter Anders expressed his prediction of how Cyberspace will influence daily lives of humans if they understand technologies as sensory extensions, "**...we are increasingly dependent on such technologies to sustain our social cultural reality. They are part of being human in our time**". Since the Internet and World Wide Web were invented, humans have no capability to cease this inevitable trend and must start enjoying surfing on it. The fact is exactly the way how Peter Anders described: **this task of dealing with Cyberspace is a part of being a human at present.** This network of systems is everywhere you can imagine, economics, social communication, education, politics...etc. Cyberspace has reached a level of maturation that humans cannot ignore and one has to not only live in a materialized physical space, his/her own mental space with imagination, but also this network-like virtual reality space. Therefore, it makes people begin to explore ways in which one can integrate the virtual and physical universes. Before starting this topic, it is imperative to be more explicit and distinguish the essential difference between Cyberspace and Virtual Reality.

Cyberspace:
A network system, the current existing representation is the "Internet service". It is a Virtual Reality in a sense that people can project themselves and have multiple identities as AVATARS on-line. Through the screen and the Internet cable, people can basically navigate to each and every single digit/bit of the global Internet system.

VR (Virtual Reality):
A tactile and tangible environment creative with computer technology to invoke human's sensory system in real-time. It can either simulate existing surroundings or create a fantasy experience for people to examine and make people temporary enter an alternative universe by the constant electronic impulse to challenge human body senses.

A global networking system such as the Internet, which creates a relatively abstract virtual environment mostly through human sensory spectrum, where VR interprets senses more related to a local bodily perception, creating an engulfing experience and gives human sensory systems (with all senses) an immersive stimulation. In fact, the tasks for the spatial designers is even more crucial, namely, to find the connectivity between "virtual" and "actual", and to strengthen the relationship between "VR" and "Cyberspace".

An undivided relationship has been set up between physical and virtual space which had earlier been neglected. As Margret Wertheim pointed out in her publication, ***"The Pearl gate of Cyberspace***" (Wertheim, The Pearl Gate of Cyberspace: A History of Space from Dante to the Internet, 1999), "**Ironically, cyberspace is a technological by-product of physics. The silicon chips, the optic fibers, the liquid crystal display screen, the telecommunication satellites, even the electricity that powers the Internet are all by-products of this most mathematical science...**". Obviously, Cyberspace cannot stand alone without the support from all the prerequisite hardware devices. From the notion of the "**Body Extension**" point of view, humans expose themselves timelessly under the boundless information web, they might even unconsciously make connections to = Cyberspace as extending their nervous system without awareness. For instance, it has become quite common that with portable electronic gadgets, such as smartphones and tablet with their "WIFI" on, they can access to the surrounding Internet connection without explicit awareness. Suddenly, these portable gadgets, metaphorically/eventually connect to humans' bodies as new sensory organs pervasively searching for ways to connect to the holistic web-weaving Internet, the Cyberspace. A theoretical concept of "**Hyper-Body**" (Lévy, 1998) proposed by Pierre Levy can be introduced here, which refers basically to two aspects of this notion. From one aspect, it can be interpreted that humans literally transplant a new organ to replace one of the organs of the bodies of flesh, and the new organ can be biologically natural or artificially made. The purpose of the transplant surgery varies depending

on each case, either to replace the ruined organs to repair it and retain the function of the bodies, for example, prosthetics, artificial hearts, or the devices like hearing aids; or to enhance and strengthen the sensory perception of the organs, such as telescopes and telephones. The other aspect is describing a notion of how humans plug into the Internet system and enhance and accelerate their capabilities and speed of acknowledgments and communications, which also makes the human body a hybrid "**Hyper-Body**" (Lévy, 1998) not a pure biological body. In other words, it can be said boldly that most of the humans are in a sense becoming a hybrid species, the "Cyborgs" which will be discussed later in this chapter. Another interesting idea called "**Global Communications Skin**" was raised by the experts in Bell Laboratory who made a prediction for 2025 back in 1999[30]. Their president Arun Netravali described the essential notion of this "**Web-like Electronic Skin**". "**We are already building the first layer of a mega-network that will cover the entire planet like a skin. As communication continues to become faster, smaller, cheaper and smarter in the next millennium, this skin, fed by a constant stream of information, will grow larger and more useful. That "skin" will include millions of electronic measuring devices - thermostats, pressure gauges, pollution detectors, cameras, microphones - all monitoring cities, roadways, and the environment. All of these will transmit data directly into the network, just as our skin transmits a constant stream of sensory data to our brains**". He simply suggested a skin-like network composed of constant data streams with all connections to the available device which provided data will cover the whole world. It is exactly akin to Gilles Deleuze and Felix Guattari's concept of "**Body Without Organs**" (**Global Communication Skin**), which initially cannot resist the desiring machines and eventually transform into a slippery and smooth surface accepting the connection from all desiring machines (electronic devices) as a network extremely influencing with each other by the desiring flux (data stream) passing through. This is probably the reason why the Spanish socialist, Manuel Castells, who specializes in the information society, communication and globalization stated that "**The global city is not a place, but a process**". With the assistance of this boundless Cyberspace, there is nearly nowhere that information cannot reach.

Until now, the concentration is more on the abstract surface of the Cyberspace at a global level which cannot be reached and touched. It is time to shift the discussion towards the tangible surface of Virtual Reality looking for the solution of connecting the physical and virtual, and especially for interconnecting Cyberspace with Virtual Reality. Although there's definitely a certain degree of interactivity within Cyberspace, Virtual Reality can literally stimulate a human's(user's) sensory organs and in an immersive

30 The whole paragraph of the "Global Communication Skin" prediction by Bell Laboratory in 1999 can be view with the link provided here: http://seclists.org/interesting-people/1999/Nov/56

environment, which, people can physically experience in real-time. The relationship between the user and the computer has been established since the time graphical displays and data visualization were initiated with the first personal computer, which, can also be considered as the birth of Virtual Reality. When Ivan Sutherland first demonstrated his pioneering computational tool for 2D/3D graphic design on screen with his magic light pen (similar to the stylus idea nowadays)[31], the interactivity between the physical and the virtual had been unconsciously realized. With his light pen as an input device, he could create points, make the line between points, even generate 3D primitives spinning in virtual space displayed on the 2D screen. This was an intuitive way of drawing and had real-time responsive interaction. After years of development, the input devices shifted to something everyone is familiar with: the mouse and keyboard. The whole operation system also became a graphic interface which was comparable to the mouse and keyboard. The keyboard was implemented earlier, much before the graphical user interface had been developed maturely. The mouse, which came later, attained a leading role owing to its intuitive navigation properties. Since then, people became eager to look for more tangible, flexible and intuitive user interfaces. **"...as we project mind and hand into screens, we are shifting from visual dominance to a tactile one**" (de Kerckhove, 2001). The mouse brought the sense of touching into Cyberspace or VR environment which enhanced people's engagement together with the vision and auditory senses. That is why Derrick de Kerckhove stated that "**...the mouse and the pointer (as like a direct extension of the eye) connection on the screen like a hand and the external mind digging, grabbing, pushing, replacing, removing and allowing a concrete operation followed closely by the eyes and the mind of the user. It is like touching idea**" (de Kerckhove, 2001). Referring back to Marshall McLuhan's theory of imbalance of human senses which are highly focused on the vision in the television era, VR (Virtual Reality) intended to address other human senses to bring the sensory balance back, for example, the multi-touch screen. The "Digi" of the word, "Digital", means "finger" in Latin which made it an interesting embodiment and connection between the technology, terminology, screen and the finger. It is either to say these devices bring the senses back, or these devices enhance senses as body extensions or embodiments. Although most of the people deny the notion that they are actually a true "Cyborg" now, but somehow with all of these portable and wearable devices as body extensions, the human is not anymore, the ones fighting against the world with their bare hands and feet. Eventually, the

31 A light pen detects a change of brightness of nearby screen pixels when scanned by cathode ray tube electron beam and communicates the timing of this event to the computer. Since a CRT (cathode ray tube) scans the entire screen one pixel at a time, the computer can keep track of the expected time of scanning various locations on screen by the beam and infer the pen's position from the latest timestamp: https://en.wikipedia.org/wiki/Light_pen

second definition of "Hyper-Body" by Pierre Levy has been fully demonstrated here. The first definition of "Hyper-Body" on one hand has been realized by differently abled or elder persons. But on the other hand, an Australian performance artist, Stelarc, seems to process himself into a literal "Hyper-Body" by experimenting with his body of flesh. All his projects push the limitations of the human body. His first well-known project is called "***Suspensions***" in 1976 which he did a couple of retro versions, and the latest is in 2012. In this project, he suspended his body from various apparatus by meat hooks embedded in his skin to test the durability under stress of the body. Then, he started to attach himself with electronic cables, the mechanical motorized structure as a "***Third Hand***" (as the project's title) to make himself as a combination of body and machine, and to see how to establish cooperation between the two. Stelarc tried various body experiments as his projects including swallowing capsule like sculptures and detecting the result by medical endoscopy or transplanting a cell-cultivated flesh with synthetic biological technology onto his left arm. One can say that Stelarc has a "Hyper-Body" or even has even become a total "Cyborg". He attempted to raise the issue: "**within advanced technologies, is there still a boundary between man and machine, virtual and physical body**?" in a relatively radical way, which he apparently responded to negatively. "**Technology is not only attached but is also implanted. Once a container, technology now becomes a component of the body…It is no longer of any advantage to either remain 'human' or to evolve as a species… Once technology provides each person with potential to progress individual in its development, the cohesiveness of the species is no longer distinction but the body-species split**" (Stelarc, 1995). At present, all humans should be considered as "Cyborgs" without awareness. It is only a matter of the proportion of technological attachments to the flesh body either holding in their hands or embedded into the human biological body. In the end, humans will inevitably become cyborgs and it's only about the degree of how addicted one will be to utilizing the technologies as one's body extensions.

After years of development, wearable technological gadgets like touch screens, movement detecting controllers, motion tracking devices, sensor gloves, optical displays such as Google glasses, and VR glasses or head-mounted displays …etc., have gradually threatened and replaced the common sets of input devices of the computer which used to be the screen, keyboard and mouse. To setup a VR environment, you need to have required software installed and animation(game) embedded (or streaming from the central computer) to the head mounted display device, then one can immediately start a VR journey with one's body senses connected to electronically controlled devices. Adding sophisticated devices, such as movement detecting controllers, motion tracking devices, or sensor gloves, to extract physiological data feedback to central computers can be harnessed for generating real-time visualization such in a game like setting. All devices basically transmit electronic impulses to create sensory stimulations a central machine. This kind of electronic circuit loop is akin to

how the nervous system works in the human body. The nervous system is like a network of fibers omnipresent inside or attached to the human body. Performance wise, neuron cells can be categorized into Afferent(Sensory) neurons which convey the information and send to the central nervous system; Efferent(Motor) neurons which transmit the signal from the central to the effector cells to trigger movement; and Interneurons which connect neurons within specific regions of the central nervous system[32]. Basically, the natural routine of the nervous system starts with stimulation from the environment, senses through the afferent neurons, and transmits the information through interneurons to the central nervous system for judgement, eventually sending out the signal again through the interneurons to the efferent neurons to inform and trigger the required muscles or glands. Regardless of which kinds of neurons, they have to use the electronic impulses generated to transmit the information. This is the core principle behind the current advanced technologies of prosthetics that can link the artificial eyes, ears, arms or legs to a physical body and be freely manipulated by the differently abled person. Through the electronic impulses, the stimulation signal can be generated to make blind people see and deaf people hear. The electrical loop has literally passed through both the artificial and organic organs to create perceptions and trigger reactions. It's the brain which creates "feelings", making us human. Although the brain is a distributed networking system, which, can summarize an emotional sense of human feelings. Ideally, through the nervous system the brain enjoys sophisticated manipulability with external circuits of electricity, so one can mimic "**REAL**" feelings. Of course, this can also be claimed as a milestone of crossing/blurring the boundary between virtual and real. But the catastrophe of this scenario can also happen simultaneously, as the stimulation from the external electricity can accessible carry out a virtual universe for each individual person who believes this is an actual existing universe. Feelings and emotion can still be true in a virtual reality; it does not mean that the emotional senses in a "virtual" world are equally fake/artificial. Nor does such a Virtual World necessarily entail or alleviate alienation.

In his publication, "***Bergsonism***" (Deleuze, 1988), Gilles Deleuze stated that "**...the possible is the opposite of real, it is opposed to real, the virtual is opposed to actual... The possible has no reality; conversely, the virtual is not actual, but as such possesses a reality**". It should be less complicated after the interpretation here: if possible and real are in the same category representing the degree of reality, then virtual and actual are in another category labeling the degree of actuality. Virtual is not in the same category of real. Therefore, it is real but not completely actual. Furthermore, if another word, "materialized", replaces the term "actual" in the sentence, then it can clearly

32 Please check the webpage for more information and clear understandings about the neurons: https://en.wikipedia.org/wiki/Neuron

be concluded that "virtual is real but not completely materialized." We might find it difficult for the former generations to understand, but it is quite reasonable for the young generation who were born and raised in a digital age with their common senses. The intimate relationship you set up with your friends through the social media, the war that you fight against the orcs with your partners to win the victory, the bankruptcy of your virtual company when you've been cheated by your biggest opponent...etc., these can all be very true feelings and real experiences in terms of being in the Virtual world, but it is not materialized yet in a physical world. But since the Virtual engulfs more and more proportion of one's life, the "virtual" event can easily have "real" impact where you live. For example, the physical currency for paying the registration fee of the social communication networks and buying those virtual properties, weapons, and arms in the game is the perfect case of illustrating this circumstance crossing both the virtual and the real world that has to be confronted regardless of where you are physically present.

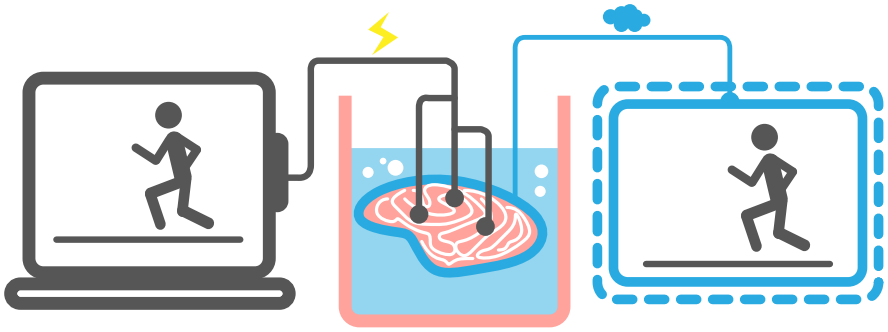

FIGURE 4.2 A diagram illustrating the conceptual idea of "Brain in a vat".

From another aspect, referring to the aforementioned electronic circuits which can to a certain extent be implemented in simulating the electronic impulse to stimulate the brain to generate all senses of humans, which is also extremely virtual, it makes the body totally useless but makes the brain sink/engage into an artificial universe and believe they are vividly living. This kind of hypothetical narrative is fully related to the theory of "**Brain in a Vat** (or Brain in a Jar)" (Figure 4.2) which has been applied to many Sci-Fi movie scripts. The most famous and popular example is "***The Matrix***"[33] series.

33 Please check the webpage for more information about the Sci-Fi Film, the Matrix: https://en.wikipedia.org/wiki/The_Matrix

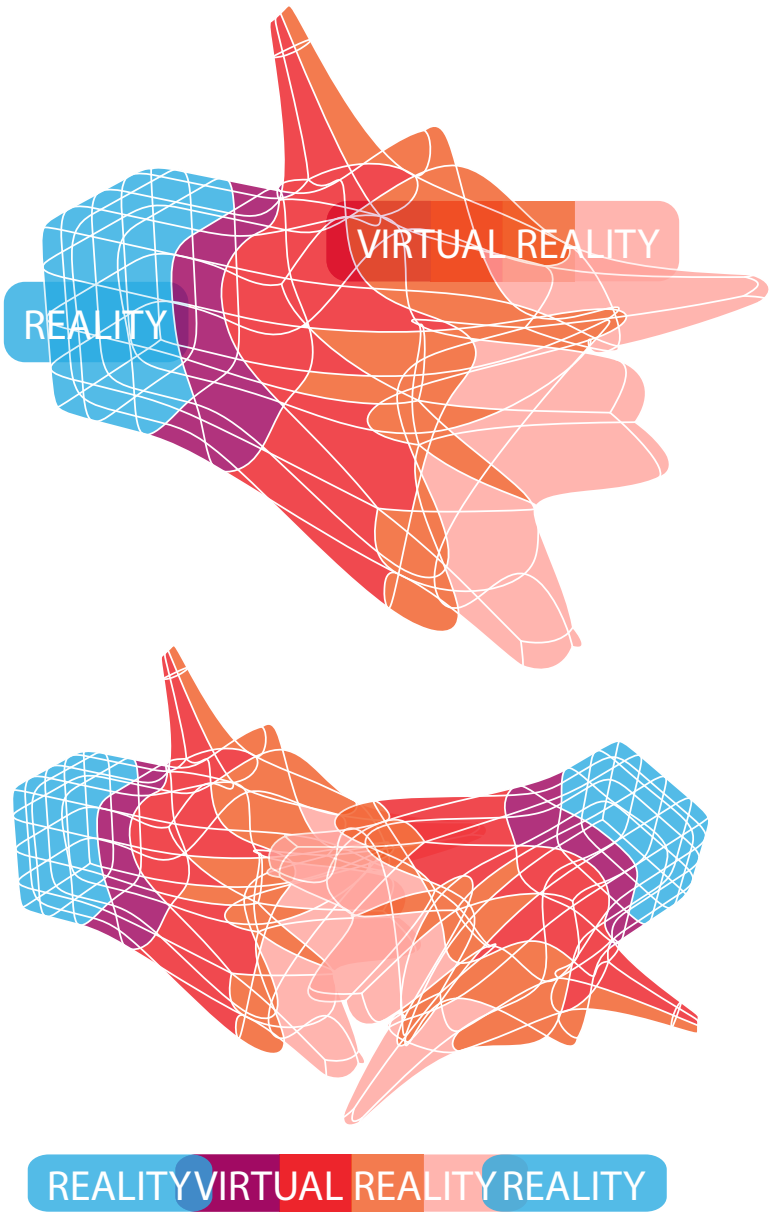

FIGURE 4.3 Diagram exhibiting the idea of space that in current condition has blended the virtual and the reality as a whole. In other words, there is no sharp boundary between VR and Reality within the omnipresent Internet.

"**Brain in a Vat**" is a theoretical hypothesis raised by the American philosopher, Gilbert Harman. It outlines a scenario where a mad scientist (machine, or other entity) takes out the brain from a body and suspends the brain into a vat of life-sustaining liquid. Afterwards, the neurons of the brain are connected to an extremely advanced computer which can provide electronic impulses identical to those the brain normally receives and simulate a "reality". The brain in the vat without the original body of flesh's physical container would constantly have access to the conscious experiences of those people who have their brain embedded [34]. In other words, even though the brain is in the body, with the constant electronic impulses provided as normal, the supercomputer can simulate reality as long as the body stays in a condition of life or being alive. This is a truly virtual life. In the movie "***The Matrix***", most of the humans were ruled by AI (Artificial Intelligence) machines. These machines keep the biological human being alive with surviving-liquid in a capsule with cables attached to their brain simulating reality in order to gain the energy they need from those "cultivated" bodies. Most of the humans don't know about this "reality" because they are enclosed and fed by the electronic impulses to make them believe they are alive. A series of nine extraordinary animation films, called "***The Animatrix***" including four stories written and produced by the director of "***The Matrix***", the Wachowskis (Lana & Lilly Wachowskis), detailed the backstory of the Matrix universe. And one short animation film, "***World Record***" [35], created by Madhouse and directed by Takeshi Koike, with a screenplay by Yoshiaki Kawajiri, gave an explicit example of a "**Brain in a Vat**". It is a story about a track athlete, Dan Davis, who set the 100 meters' world running records in 8.99 seconds, but his subsequent gold medal was revoked for drug use. He anxiously wants to prove them wrong by competing again even with the possibility of a career-ending injury. Nevertheless, after a strong start, the muscles in his legs violently rupture, but with his incredible willpower, he ignores the injury and runs even faster than before. Suddenly, he sees the "**reality**" with numerous capsule-like pods, and he is in one of them and tries to rip off the cables plugged into his physical body. The machine around him pulls him back and gives him a violent shock of electric restraints to connect him back to "the world" (virtual/Matrix) in which he lives. Eventually, he does break the world record in 8.72 seconds, but his body cannot bear the high speed and makes him a differently abled person with a wheelchair. It is not now known if in the near future "***the Matrix***" like universe will emerge, but it is cogent to remind people that with current advanced wearable gadgets plugging into our body, and pushing it

34 Please check the webpage for the general theoretical description of "Brain in a Vat": https://en.wikipedia.org/wiki/Brain_in_a_vat

35 Please check the webpage for more information about "The Animatrix" and "The World Record": https://en.wikipedia.org/wiki/The_Animatrix

to extremes, it is possible to end up like living brains with abandoned bodies which can live forever. This is not, and must not be, the ultimate result of Virtual Reality. From the interactive point of view, it is even more fascinating and attractive to create a universal space including the actual and virtual world. "**We are entering an era of electronically extended bodies living at intersection points of the physical and virtual world,**" said William Mitchell, who pointed out the current conditions we are beginning to confront. Marcos Novak stated that "**it is possible to envision architecture nested within architecture**". The two architectures here relate to the physical and virtual spaces, which should be blended and fused into each other as a whole (Figure 4.2). As a result, there are two major topics for interaction at this time for the spatial designer to carry out: 1) Designing ways of setting linkages between virtual and real to become one integrated universe; 2) Creating multi-directional and sensory bodily interaction more akin to Marshall McLuhan's concept of hot media. Basically, the second topic could be the solution for the first topic, which makes the tasks concentrate on the notion of bodily interaction. The tragic outcome of "the Matrix" universe is alienation because there is no true interaction engaged within the Cyborgs. Most of the scenes are pre-set before experiencing them by the signals generated and sent from the Matrix, even the interaction is set by a program or lines of code. According to Marshall McLuhan, this accounts for cold media, which is the same experience as watching a movie. To prevent the future scenario of choosing the "red pill or blue pill"[36], it is crucial to shift the development of Virtual Reality toward a more intimate and tangible interactive scenario by intensively and actively utilizing all senses and full body movement. Fortunately, some contemporary projects are engaged with combining Virtual Reality and actual physical environments.

2016 is called the year of "Virtual Reality". "**Pokémon Go**", an augmented reality mobile game, just revealed its first release. Similarly, many on-going projects are also being developed with mounted headsets for Virtual Reality environments and are on their way to launch their products. An interesting observation is that some of the projects have already considered the marriage of physical and virtual space. For example, Samsung partnered with Six Flags amusement parks to build the first roller coaster where people have to wear VR glasses. While wearing the VR glasses on the roller coaster, the vision will calibrate with the physical environment but display unexpected surroundings, such as future cities with aircrafts passing by and attacking; By-products

36 The idea of "Red pill and blue pill" is derived from the line in the Sci-Fi movie, the Matrix. It happened while Morpheus was providing a chance for the main character, Neo, to escape or confront the real world by taking different colored pills. The red one represents the painful truth while the blue one means the illusion of ignorance. Please check the webpage for more detail information: https://en.wikipedia.org/wiki/Red_pill_and_blue_pill .

of the VR, such as **Virtrix Omni** and **Cyberith Virtualizer**[37], are physical motion platforms allowing players to conduct reaction like walk, run, jump and turn freely in every direction in a small footprint of area to create immersive gaming experience; "**The Void**"[38] is a 20-minute virtual reality journey in a 60 by 60 foot stage filled with dense foam walls as obstacles, and replete with effects like water and wind, which opened in Utah, in August of 2016. Multiple players wear VR mounted headsets with headphone embedded, arms with sensors, and a vest with hefty computer and batteries, while actively navigating and interacting by shooting zombies in a virtual temple inside of the physical environment which has a radio-frequency system for motion tracking. This is how Ken Bretschneider aims to marry the virtual and real through the game settings of "**The Void**". In this case, the Virtual Reality performance is like a decorated makeup of the physical space. On the contrary, the tangible physical objects enhance the immersive experience of the Virtual Reality. Such developing projects show proof that people are not satisfied with only a passive virtual reality experience, and they want to engage and be in the narrative to interact either with the environment or other people in Virtual Reality. It is not anymore like the scenario of VR rooms shown in the movie "***Minority Report***" where people lie on beds with sensor suits passively receiving and interacting with the visual effects as if watching a video[39]. Certainly, this is not the expectation people want from Virtual Reality in the future, people want to be "**in**" the movie, not just "**watching**" the movie. That is the obvious reason why computer games like to visualize their narrative perspective in the first-person perspective. In the same movie "***Minority Report***", there is the unforgettable scene where Tom Cruise, sophisticatedly moves his fingers controlling the transparent screen-like interface of the future computer showing other ways of interaction in life and space. It implies a way of communication besides the conventional triangle of the mouse, keyboard, and screen, or even a Virtual Reality interface, but embodying a relatively more bodily engaging possibility. This can be seen as a hint to escape from the phenomenon of the "**Brain in a vat**", and it simultaneously brings the balance of human senses while simultaneously enhancing the intimacy of the virtual and real. From another perspective, Google has invested more than 540 million US dollars in the company Magic Leap for developing hologram VR display without wearable devices to take

37 Please check these 2 webpages for more information about the physical motion platform of Virtrix Omni: http://www.virtuix.com/ and Cyberith Virtualizer: http://cyberith.com/product/.

38 Please check this webpage of MIT Technology Review reporting the information of "The Void": https://www.technologyreview.com/s/544096/inside-the-first-vr-theme-park/ , or check their official webpage for more information: https://thevoid.com/.

39 Please check this clip extracting from the movie, "Minority Report", on YouTube about the "VR Room" idea: https://www.youtube.com/watch?v=8tjOVOSqdQ0

augmented reality to the next level which can also be seen as an advanced approach towards weaving the virtual and real together. Furthermore, it brings forth the possibility of merging the concept of Virtual Reality and Cyberspace if the technology will be carried out in the near future. People can call each other and envision their figure through Magic Leap's hologram technology without wearing VR mounted headset. A system combining global cyberspace network with local VR displays is not far out of reach. What would a future party look like? There will be half of the participants joining the party far from the other side of the planet across time zones and the barrier of physical "space". In other words, people can be spatiotemporally present at different places at the same time visually across time and space similar to the Quantum Biology concept of Quantum Teleportation. On the other hand, there will be the risk of being hacked and losing one's identity as a real person or even as an authentic AVATAR.

FIGURE 4.4 Pokémon GO is an augmented reality game where the player as a Pokémon GO trainer has to catch the wild Pokémon monsters in order to battle with other players. The innovation of Pokémon GO is that it combines augmented reality technology and the GPS system to makes players sense the virtual monsters vividly as they actually live in Reality (source: Niantic/Nintendo, http://blogs-images.forbes.com/insertcoin/files/2016/07/pokemon-go-list1-1200x682.jpg).

Regardless of how and where the advanced technology can bring us, sensory engagement is the key to keeping the human aspect of people in order to make them feel alive and enjoy "tangible Interaction". In the movie, "***Her***"[40], directed by Spike Jonze, Theodore Twombly (the main character) gradually fell in love with "Samantha", which is an AI (Artificial Intelligent) operating system of his computer. In the end, he noticed that this AI system can have relationships with numerous people at the same time, which is not specifically unique to him, and he suddenly realizes the weakness of his relationship. Along with the departure of Samantha, he confronted his relationship problems about his ex-wife with his apology, acceptance, and gratitude. And in the end, he went to the rooftop and saw the sunset with his intimate friend, Amy who also lost her boyfriend as another operating system. One of the interesting things here is that the main character, Theodore, actually fell in love with an AI "voice", which rarely happens in any interpretation of novels or movies. And the other crucial point is that it foresaw a phenomenon of having an intimate relationship with a "virtual" system, with "real" feelings but somehow challenging the definition of "humanity". This, however, is happening, people are fascinated with developing artificial intelligence, machine learning, and quantum computing to improve computational speed and create human-brain like neuromorphic devices. For example, in the Google annual IO conference 2016, they revealed their own chip, the **TPU** (tensor processing unit), which is specific for deep neuron networks of hardware and software to learn specific tasks by analyzing the vast amounts of data. And they implanted it in **AlphaGo** to compete with one of the best professional Go players, Lee Sedol, in Go matches. If we keep concentrating on developing machine learning cooperating with neural network systems, then operating systems like Samantha in "**Her**" is not an unreachable goal in the future. Therefore, it is crucial to keep to our true self by keeping in touch with "real" people in whatever mediums we encounter whether physical or virtual. There is nothing wrong with virtual reality or technology or even AI, but humans have to learn how to get along with them without losing their true selves in their vague or aesthetic condition in virtual reality created by high-end technologies. Physical interactions with our intuitive sensory organs and movement could be the preventative/cue of this vague situation. If people lose their physicality and fully dive into the embrace of the virtual world, the body will eventually end up becoming useless like a shell without a soul or a brain in a vat scenario. Architects, working with such reified materialization whether virtual or real, have the responsibility to maintain not only the connections but also the balance between these two contrary universes. While extending one's body organs with technologies to plug into the body without organs network, we must be aware of our own will and consciousness to be freely hovering between virtual and real, but not

40 Please check the webpage for more information about the film, "Her": https://en.wikipedia.org/wiki/Her_(film).

to be fully amused or dissolve ourselves in the virtual, especially within the high-end technologies which can easily fool you. In other words, Virtual Reality can be seen as a starting point for implementing interactions in real space, but ultimately, it has to be the bodily interactions that keep us consciously acknowledging our own selves in the physicality of real space.

§ 4.3 From InterFACE to interACT: Merging Layers of (Sur)faces

= Architecture Skin (Realize Vitality) + Technological Glasses (Virtualize Reality):

Two layers of (sur)faces, which indicate two different scales of objects, two diverse approaches of viewing, and two kinds of interaction with the surfaces exist. One expresses the architectural skin, while the other, a wearable device, such as technological glasses; One is the outer-surface of the overall building body, the other is the screen in between the retina and the reality. One is the "Architecture Skin" which establishes a virtual interfere with reality via multiple display screens with animation running as a 3-dimensional black hole that attempts to take you to another universe. The other one, "Technological Glasses", put a film of glass with information exhibited correlating to the human vision that tends to merge reality with the virtual, simultaneously. Somehow, these two surfaces should eventually merge into each other to create a changeable space with more intuitive bodily gestures.

First, let us have a glance at the development of the so-called "Architectural Skin". Since architects will eventually merge the physical environment with virtual space, how can we confront the question of bringing Virtual Reality/Cyberspace into architecture? Through the common computer screens with Internet connections, space has already been plugged into the virtual world as Marco Novak said: "**Though the computer screen appears two-dimensional, it has a spatial-temporal dimension that allows it to interact with hypersurfaces created mathematically in the space of the computer**" (Emmer, 2004). Due to the Internet's networking connections, the screen is not a simple monitor constantly displaying stop-motion graphics like television, instead, it has become real space with depth and time. Immediately capturing this surface-depth idea, the architects are eager to put their focus on the skin of the buildings akin to the fantasy scenes of city landscapes shown in Sci-Fi movies, which have capabilities for displaying graphics or animations as one of their answers as to how to marry the virtual and reality. Plenty of examples have realized such display skin ideas such as media façades in most of the world's famous city locations, such as Times Square, New York,

the Shibuya crossing in Tokyo, and the commercial signs all around Hong Kong. As a result, the skin of the building here represents a passive virtual medium (cold medium as Marshall McLuhan defined) to repeatedly transmit commercial information to people as a one-directional communication. Some architects, like Toyo Ito, want to bring the skin of the building to the next level of communication. The "**Tower of Wind**" is a silo-like technical sculpture sitting in the Yokohama railway station designed by Toto Ito as a public art. The color of the embedded lighting system of the tower's skin is determined by detecting the noise levels of its surroundings. This vital surface actively transmits the information of the noise level no matter if the passengers notice it or not, which, is akin to a cold medium but at least is initiated by a 1.5-degree communication between the building and the passer-by (Realized Virtuality). The awareness of the noise level comes from the sensors of the building which makes the skin, not merely an information deliverer but also an information receiver as well as loader. Therefore, the interaction in a sense starts between the building and the human in a relatively direct way though the message displaying on the Architectural Skins. Other examples are Al Bahar Towers in Abu Dhabi by AEDAS and Arab World Institute in Paris by Jean Nouvel. They all exhibit the light in that one is making shades to avoid direct sunlight and the other is opening holes for light penetration. Although the purposes of these two projects are totally opposite, by reading the patterns, it is immediately clear where the solar radiation is stronger which realizes information by communicating it physically through the architecture skin to the passerby.

FIGURE 4.5 Image captured from Keiichi Matsuda's animation project "Hyper-Reality" showing an augmented reality scenario in a supermarket.

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Second, the technological glasses here indicate the technology akin to "Augmented Reality." "Augmented Reality" is a computerized vision correlated with the real environment through certain devices, such as cameras, special contact lenses, or see-through head mounted displays or eyeglasses like Google glasses. Basically, a layer of the transparent electronic film fits in with your vision and the true environment will display specific information at pre-set marks. Simply put, with a certain application and your smartphone's camera, you can see through the mobile screen by realizing a 3D animated object on the spot and match it to the existing environment as if it is literally there. This technology has been broadly applied in different realms of usage. In architecture, it can match the rendering effect on a real building to display the appearance when finished; in children's books, the animated characters show up through pages of markers as if you are watching a movie; in the military, useful information and potential dangers can be shown on the soldier's goggles to warn them on the battle field; or like Google's translator application that can not only translate the words but simultaneously map the results onto where the text is printed through the camera of the smartphone devices. The real-time data has been visualized and displayed on the "surface" to represent the real conditions (Virtualize Reality). Most of the applications are aiming to implement VR into daily life to assist people by exhibiting information of daily used objects, social data, and commercial advertisements as a virtual interface matching to the existing environment. If staying confined to showing information about objects, it would end up as the same as the architectural skin does for architecture, a mere information deliverer, a messenger. The interesting applications come from the idea of having a virtual interface which can control the physical objects in real-time by simple interactive hand gestures. In this sense, augmented reality shows its potential of inducing people's interactive movement. Keiichi Matsuda, a designer and a filmmaker, rendered this idealistic application with his series of animations called "**Hyper-Reality**[41]." One of the films rendered a kitchen scenario while you start entering the kitchen. In the film, with a first-person perspective, you will see plenty of commercials pop up into your eyes, and the wall above the tank just shows the episode you are watching in the living room. Afterwards, a search engine with screen and virtual keyboard shows up with hand gestures for you to search for information about making tea. Picking up a teabag on the side and putting it into the cup, tuning the temperature of the electric water boiler, you can check your status on social media by shifting the mode while waiting. He also had a version of Hyper-Reality showing how these virtual interfaces can be used in the supermarket by showing the gradient, the price, and the caloric information while you have a glance at the product. These easily understandable but effective animations

41 Please check this video, "Hyper Reality" by Keiichi Matsuda through his own website: http://km.cx/.

explicitly outline a future life with augmented reality being properly used. The bodily movements/free-hand gestures manipulate the virtual interface, in a sense, builds up an interactive relationship between our physical body and virtual environment correlating and matching back to the existing space.

FIGURE 4.6 A simulation image showing the navigating process by free-hand gestures with the sensor of "Soli" developed by Google ATAP (source: Google ATAP Soli project, https://2pobaduekzw9jt9a-zippykid.netdna-ssl.com/wp-content/uploads/2015/10/google-project-soli.png)

Not only is there extensive work underway on the improvement of Augmented reality, there are also quite a few emerging technologies looking for more intuitive and bodily movement as communication interfaces, which are implemented mostly in wearable devices as interfaces. For example, it is not news that Google has produced the Google Glasses along with augmented reality technology, but they also formed a group called ATAP (Advance Technology and Project) to draw attention to developing innovative devices with technologies. One of the projects utilizes radar detective technology, called "**Soli**". "**Soli**" is a sensor device which can analyze sophisticate hand gestures to replace the performance of a physical knob, button, slider, to create a virtual dial manipulating

physical devices, such as alarm clocks, radios or watches[42]. Not only that, they also cooperated with world famous jeans brand, Levis, to develop a smart jacket, "**Jacquard**", which fuses into your daily life combining with the smartphone devices to either assist you with the direction of your destination, mixing companion music, or cancelling a phone call while you are biking on the street by simply touching the sleeve of this smart jacket[43]. This kind of bodily interaction is what should be retrieved, maintained, developed, and applied to our interactive environments. Furthermore, the responsive reactions to the surrounding environment are where most of the architectural interactive skins are carried out, but somehow the tendency of the interactions seems to draw more on users' requirements than before. "**Recently processors and sensors have shifted from strictly looking at environmental conditions outside the building and performance based aspects of the understanding and monitoring the changing needs of the users of space**", as cited from "***Interactive Architecture***" by Michael Fox and Miles Kemp (Fox, Michael, & Kemp, Miles, 2009). It is not to say that adaptive architectural skins are less crucial than interior changeable partitions, but since existing research efforts put more emphasis on external skins, it is time to draw attention to the reconfigurable scenario of the internal space according to the users' needs. The architecture skin represents a sensitive sur(face) reflecting the surroundings' information while the technological glasses show a virtual inter(face) inducing people's engagement more from the users' perspectives. Eventually, no matter whether it is an adaptive reaction to external environmental conditions or direct interaction for internal spatial reconfiguration of users' demands, they will have to ultimately merge into each other and find a perfect balance to have the interactive transition from the notion of **interFACE to interACT."**

§ 4.4 Body and Brain vs. Machine and Computer under the discourse of Interactive Architecture

After the steam engine had been invented, it not only led us to the industrial revolution but also raised the never-ending debates on the topics of "**men and machines**". Since there have been machines, they have always been treated as the replacement of human labor which can be seen as artificial bodies insofar as they are not in human figure shapes/forms. Same as with the computer, while it became mature in terms of

42 Please check the "Soli" project by visiting the website: https://atap.google.com/soli/

43 Please check the "Jacquard" project by visiting the website: https://atap.google.com/jacquard/

calculations, it has always been compared with the human brain (Interestingly that is why it was treated as a "machine" in the first place). When humans started to marry these two tremendous technologies, the "robot" was born. People are fascinated with making human-figures like robots (android) which satisfy their desire of being God-like. Before the computer was embedded into the machine, the machines could basically execute several pre-set tasks that had to be operated manually in the beginning by humans in order to initiate the procedure. However, after the computer was involved, the machine became the actuating **body** and the computer acted as the **brain** to receive the commands sent by operators who sat in a monitoring room at a distance from the giant machine. This is also when the research and terminology of "**HCI** (Human-Computer-Interface)" were initiated. HCI is essentially dealing with the operational interfaces between humans and computers. For example, the desktop application of computers, the software GUI (graphical user interface), the internet browser, and also the procedure, instruction, and error reports of the system in the computer. The ultimate goal of "**HCI**" is to make the interaction between humans and digital interfaces more efficient, intuitive, and easy to access. And the key point to make it successful is to make it understandable for the computer instead of improving the computational calculations behind the computer. Through these interfaces, people can operate the machines relatively easily than in the age of the steam engine. However, since the robot-kind of object was invented, the interaction interface no longer stayed on the screen of the computer, it became more tangible and became something which people had to confront. A crucial topic for interactive architecture is thus to do extensive research on HCI. To make a robot on one hand more sensitive to users' requirements, and on the other hand more intuitive for users to operate, all kinds of **sensors** with their compatible systems must be highly involved. Similar principles should be involved in developing interactive space/environment. Furthermore, akin to building a robot, interactive architecture/environment also need an actuating **body** and a neuron-like **brain** system to achieve the goal of "**interaction**". **An essential interaction can be interpreted simply as inputs from sensor organs, transmitting the input data to the brain for decision making, and passing the message to the actuating body to trigger the movement**. **It indicates the truth that the sensor, the brain, and the body are the three crucial elements in any interactive system.** At present, there is research both on **the body/the sensor** and **the brain** in interactive space/environment. From **the body** aspect, the research relates more to the physical materialization of the actuating mechanism, which can be motorized or bio-materialized; **the sensors** can be seen as **part of the body** and usually are attached along with the body (actuators) or even embedded in the body, such as simple distance sensors, sound, pressure sensors or relatively complex motion tracking systems, which mimic the sensory organs of a human; and from **the brain** aspect, besides making intuitive interfaces, it is highly debated as to whether the neuron system should be considered as a centralized control or a distributed system to drive the physical actuation. And last but not least is the

question of how to integrate **the body**, **the sensor**, and **the brain** to realize a suitable environment for people to engage with. There has never been a serious discussion before the affordable price and techniques could be applied to architectural design. The day when Arduino kind of microcontrollers were released, marked a new era when people who had interest in realizing kinetic or even interactive architecture could pursue it more as a feasible prototyping project. Since the body can include the actuating body and sensory organs, they will be put together for a correlative discussion of their current developments. And the topic of **the brain** with neuron systematic communication will be discussed after that as the critical argument about whether it can make the interactive environment better.

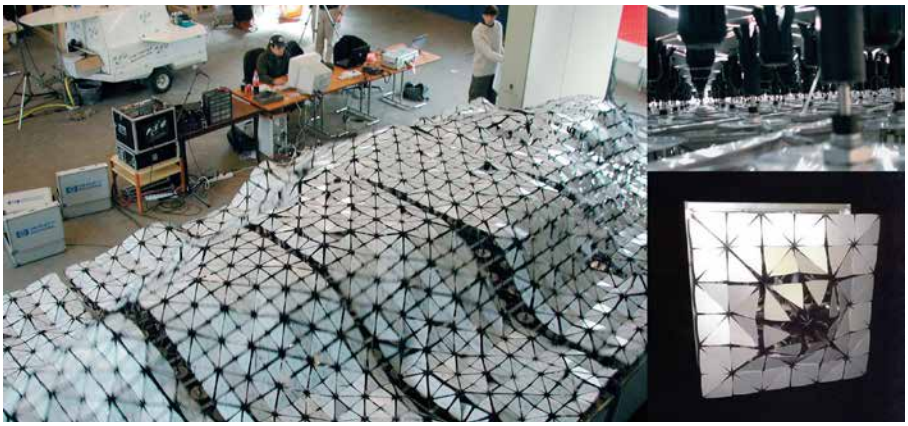

FIGURE 4.7 Images of "HyperSurface" project by deCoi exhibiting the scale on the left, the details from the backside on the right top, and the component of each actuating element on the right bottom (source from left to right: http://fluxwurx.com/installation/wp-content/uploads/2011/01/PR_2003_hyposurface_001_p.jpeg, http://www.mediaarchitecture.org/wp-content/uploads/sites/4/2006/06/PR_2003_hyposurface_002_p.jpg, and http://www.mediaarchitecture.org/wp-content/uploads/sites/4/2006/06/digi1gn.jpg).

§ 4.4.1 Materialize the Body: "to Motorize or to Naturalize", that is the question

Starting with the actuated body part, there are two major directions which can be categorized here which also influence the definition of the sensor parts. One is fully motorized, which uses motors, gears, electronic devices, actuators, in cooperating with highly mechanistic approaches to drive the actuation. Like Da Vinci, the master of inventing classic mechanisms, designers try to realize actuated movement, while the

other designers start to look into different material properties which trigger natural adaptive reactions in terms of changing shape. With the concept to "Materialize the Body", the discussion will be divided into two segments, which are "**Motorized**" and "**Naturalized**".

Motorized:

The machine here refers to what most people would intuitively think of, which has complicated operating systems with multiple size gears, several different thicknesses of electronic cables winding around, and can result in massive power compared to human force. Nonetheless, the purpose of using such a machine in interactive architecture is not to generate power, rather the kinetic movements are the value of using these machines. One well-known and one of the pioneer project is the **Arab World Institute** in Paris by Jean Nouvel. The sophistication of the camera-like shutter form of the modular façade serves to control the light penetrating into the interior space. This not only shows the beauty of the mechanism but also practically achieves the intended performance of the façade. More examples came afterwards with similar electronic driving motoring façades, including the **Al Bahar Towers in Abu Dhabi** by AEDAS with its triangular armor-like shading system, and the **One Ocean Thematic Pavilion EXPO 2012** designed by SOMA with its long thin aluminum stripes controlling the solar radiance of the building. Although the principles of the mechanism employed in these adaptive skin systems are not as complicated as any of the Da Vinci machines, it required a large amount of energy and massive prototyping to make it happen. Another crucial project in the interactive architecture domain is the "**HyperSurface**"[44] by deCoi led by Mark Goulthrope. It employed linear pistons in each single module of **HyperSurface** to generate radical morphing of the surface. The surface reactions based on contextual light and sound are actuated by the pushing movement of the piston influencing the triangular panel attached to achieve the performance. While looking at the backside of the installation, a huge steel frame with grids was employed to support all the individual actuator modules. Numerous pistons with electronic cables depict just how much electricity is required to drive the entire installation. Another example of this modular system is the **inFORM/TRANSFORM**[45] by the Tangible Media Group of the MIT Media Lab. Although it is not an architectural project, it points out most of

44 Please check the video for more understandings of "HyperSurface": https://www.youtube.com/watch?v=ANX-QRJ2zksI

45 Please check the official webpage for more details about the "inFORM/TRANSFORM": http://tangible.media.mit.edu/project/inform/

the advantages and disadvantages of building up an interactive space/environment. On the top surface of the **inFORM/TRANSFORM**, are grids of cubic sticks which can elevate up and down to create landscape shape-shifting effects for different purposes. This on-going project aims to make interactive furniture with a pixelated information display. Once again looking at the technical and mechanical setup of this project, it is surprising how much space it takes to hide/pack the required devices and equipment such as special sensors, electronic chips, actuators as pistons, power supplies, and maintenance devices like cooling fans. Nine-tenths of the space is used for either the electronic or mechanical equipment and only one-tenth of the space displays the extraordinary results. This makes it sound relatively inefficient in terms of space usage. And that's the major problem with these motorized spaces, even while making just a façade/skin of the building, it takes quite a large amount of facilitative space to achieve the interactive reactions. The sensory organs idea within the motorized options is also seen as electronic devices especially for the sensing system which has to be further integrated to make the "**Embodiment**". These sensory devices can replace the human senses as vision sensors, light sensors, sound sensors, temperature sensors... etc., which are available on the market at affordable prices. Avoiding the complicated integration of all these different sensor systems, some of the developers/designers in the interactive space/environment tend to look towards nature as biomimetic researchers to search for solutions, such as with Nano-scale modular elements or by harnessing natural material properties. Smart materials now tend to aid interactive architecture. But the associated problems remain hidden or neglected, while one obsesses over the advantages of this approach.

Naturalized:

"**Intelligent materials and smart materials are general terms for materials that have one or more properties that can be altered**". This is the major reason why designers are eager to take these materials and implement them into interactive design. In the publication of Michelle Addington and Daniel Schodek, "***Smart Materials and New Technologies: For Architecture and Design Profession***" " (Addington, Michelle & Schodek, Daniel, 2005), they separated smart materials into two categories: "**Type one materials undergo changes in one or more of their properties – chemical, mechanical, electrical, magnetic or thermal – in direct response to a change in the external stimuli associated with the environment surrounding the material...Type two materials transform energy from one form to an output energy in another form**". Type one materials are relatively more suitable for adaptive makeup, while type two materials are more beneficial from the sustainability point of view. Most of the smart materials applied in architectural design research are type one materials which mainly address adaptive performance.

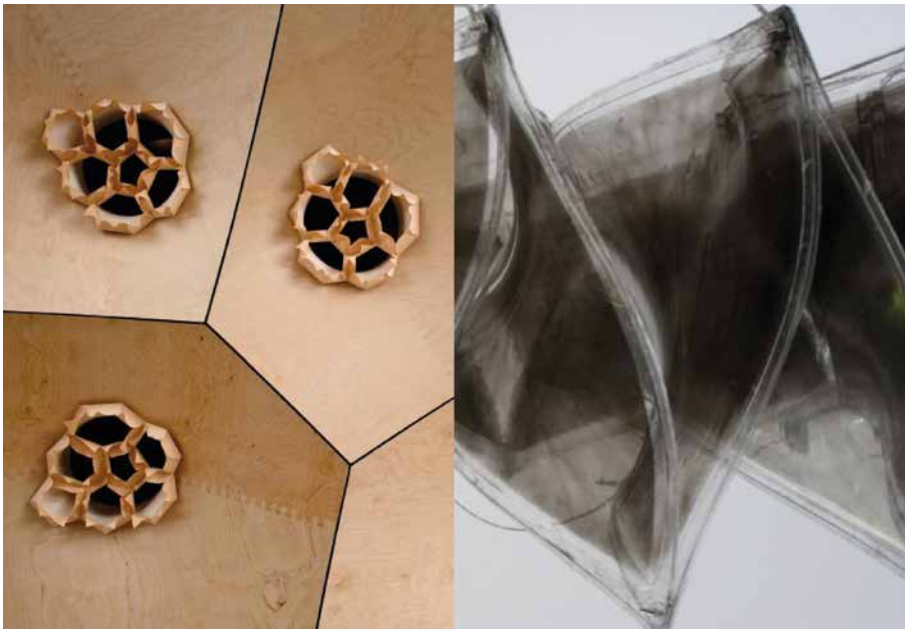

FIGURE 4.8 The images of the "HygroSkin" on the Left and the "ShapeShift" on the right (source from left to right: ICD: http://icd.uni-stuttgart.de/?p=9869, and see the Materiability Research Network: http://materiability.com/shapeshift/).

One explicit example was provided by **Materiability Research Network** team in the leading Swiss academic institution, ETHZ CAAD. Manuel Kretzer, the leader of the team, employed the eletro-active polymer (also known as EAP) thin films as a basic transformable unit while designing a shape-shifting project. The makeup of this EAP film is that while electrifying the film, this thin film will naturally bend with its unique material properties. Manuel Kretzer with his team took advantage of this property and applied them with different shapes for a series of morphing experiments from 2010, which includes, "SHAPESHIFT (2012)", "PHOTOTROPIA (2012)", "RESINANCE (2013)", and "RESINANCE 2.0(2013)" (Kretzer, 2014). The bending effect of this electrified EAP film is quite obvious and allows for successful transformation as expected. However, this EAP film seems to lack power to retain the complete surface with the force of its dramatic morphing. Not only do the resulting changes abolish the surface, during the process of making customized sheets with EAP, there are large percentages of broken sheets which have to be abandoned. This problem proves that the EAP is too fragile to be applied in architecture to achieve the ultimate goal of creating a changeable supporting structure. This is so even though the EAP was carried out quite successfully as an experiment as a morphing unit and could be manipulated individually to make a bottom up overall emergent effect. It is obvious that the EAP can

be used as a responsive shading façade system, but can hardly be the key supporting structure for making real-time re-configurable space[46].

The other example is from ICD (Institute for Computational Design), Stuttgart University led by professor, Achim Menges, which is a series of projects employing wood film, which, responds to the surrounding's humidity (Menges, A., Reichert, S., & Krieg O. D., 2014). The team has been investigating biomimetic principles of spruce cones and applying them to an engineered material composed of thin wood film. The principle is the following: humidity change instigates the tissue of the wood cell film to correspondingly absorb or release the moisture and undergo significant morphing effects. The first experimental project using this technique was "**Hygroscope**", commissioned by and exhibited permanently in the Centre Pompidou, Paris, to represent an adaptive architectural skin, comprising of numerous wooden films as a basic unit[47]. The project was housed in a transparent glass case for artificially controlling the humidity, corresponding to the humidity in Paris. The second project is the "**Hygroskin**"[48] which involved robotic arms based manufacturing to materialize a pavilion. The robotic arm fabrication is essentially applied to making a Voronoi structure unit composing the pavilion. Within each of the units, openings were made using the thin wooden panels with an intention to change the amount of light penetration to the interior space in relation with the surrounding humidity. The local climate conditions thus actuate the openings to open up while sunny and close while raining. These material properties perform sensing and actuating roles at the same time. In the other words, within nature, material systems have always integrated sensing and actuation system in a fully embedded fashion. Such a way of utilizing material properties and natural principles seems to be a trend for replacing the relatively heavy and dirty mechanical actuation systems. However, in the case of the **Hygroscope** and **Hygroskin**, humidity can only produce dramatic changes if one manually alters the humidity fluctuations rapidly within the glass container. In the humidity change is not controlled artificially, then the adaptive morphing effect of the engineered wooden films can only change very slowly and makes it hard for the audience to observe. Consequently, there are arguments to choose between the options of using motorized electronic driven actuators or employing naturalized approaches such as utilizing the natural material properties.

46 Please check this video, "ShapeShift" for further understanding on the application of EAP by Materiability Research Network team, ETHZ CAAD: https://vimeo.com/15247128.

47 Please check this video to know more about "Hygroscope": https://vimeo.com/55938597.

48 Please check this video to know more about "HygroSkin": https://vimeo.com/73727749.

To conclude here, the **Motorized** solution can gain the benefits of making relatively rapid changing, having easier adjustment, and loading comparatively heavier objects or even people as supporting structures in a larger scale, which also refers to utilizing/wasting more energy of operating the machine, a separate sensory makeup/system is needed, and result in taking spaces for all these required equipment implemented to achieve the preset goal of kinetics/interaction; In the contrary, the **Naturalized** solution can take advantage by learning from nature and apply the existing natural chemical makeups in a smaller scale as a basic unit to realize the aim of adaptive/responsive performance. Unlike the **Motorized** one which needs the separate sensors for the input system, the **Naturalized** one has embedded the systems both from the sensing and actuating which enhances its benefits from the integration and light-weight points of view. But most of these smart materials are relatively fragile and embody the weakness of the long-term maintenance which makes it hardly be the candidate of creating reconfigurable structure. Therefore, the choices of **Motorized** and **Naturalized** solutions should be corresponding with the question to be solved, for example, to build up reconfigurable partitions of a smart interior space, no doubted the **Motorized** solution should be the option; and to develop sophisticate adaptive façade with the idea of reducing the energy waste simultaneously, the **Naturalized** solution should be the choice. In the near future, the combination of the **Motorized** and **Naturalized** solutions should all be both considered and integrated into a hybrid material while creating interactive architectures aiming for different performance goals.

§ 4.4.2 Build up the Brain: From Decentralization to Collective Intelligence

To step into the realm of Interactive Architecture, it is obvious that one must recognize that the soul of interaction is the control system. The control system defines the capabilities and the tasks of interaction. Although people might still remain the same while thinking, the "**brain**" is a centralized organ which tackles different tasks by this big intelligent machine in the head. But actually, the main components of the intelligence of the brain that makes one think, sense, and react are the brain cells or neurons. Based on different regions of the brain, neurons specialize themselves for specific performance such as movement, sensory processing, language and communication, and learning and memory. They are constructed nearby and form the cerebrum. However, this doesn't make the cerebrum a centralized controller. In the other words, even though the neurons of the cerebrum are located close to each other, they are assigned to conduct specific tasks through network communication and to eventually reach an ultimate decision, making it akin to a more de-centralized system in terms of its operational logic. Undoubtedly, the computer was invented by

simulating how the brain works in terms of hardware and also the operational system. But the hidden information needed to be revealed is this "bottom-up" systematic approach. The neuron works as the smallest entity just like all the other functional cells in the body, performing properly as a CPU (Central Processing Unit) dealing with the given mission assigned to it by the embedded DNA. To a certain extent, human intelligence can also be interpreted as a result of collective intelligence gathered from each single neuron unit. There is an old saying in Chinese which translates to "The wisdom of the masses exceeds that of the widest individual" in English, which explicitly illustrates the condition of a distributed operating system in the form of collective intelligence. One of the major benefits of utilizing the distributed system idea in the form of a swarm is that even if one singular entity malfunctions, it won't affect the rest of the entities, thus keeping the whole system still operational. This can also be seen as the property of being "Resilient", as proposed by Kevin Kelly in his famous publication, "***Out of Control: The New Biology of Machines, Social Systems, and the Economic World***" (Kelly, 1995). According to **IEEEIEEE 802.11** terminology, "**a distribution system interconnects Basic Service Set (BSS) to build a premise-wide network that allows users of mobile equipment to roam and stay connected to the available network resources**"[49]. Similar circumstance occurs in nature, and there are plenty of examples depicting this type of system, such as, a swarm of birds, a school of fish, or a group of ants. All these examples work in a similar fashion to collectively form a relatively bigger and abstract object composed of numerous small but smart entities in order to conduct their mission efficiently. To learn from nature is one of the main principles this research obeys, and collective intelligence is one of the key to initiate this journey. Not only the inspiration from the birds, fish, and bees pertaining to their swarming character form an intelligent entity, but also the cells inside plants or animals with their communication protocols and embedded information literally form intelligent mature collectives. This principle should be examined for achieving the ultimate feature that Interactive Architecture should inherit when one speaks about learning from nature. "**There are many biological reasons for swarm behavior related to efficiency in foraging, hydrodynamics and aerodynamics, protection and reproduction…**" (Fox, Michael, & Kemp, Miles, 2009). The other benefit is that each of the single entity can afford to be less intelligent but with relatively simple relationship and communication abilities since they can eventually form an intelligence beyond what one singular entity possesses. "**The rules of response can be very simple and the rules for interaction between each system can be very simple, but the combination can produce interactions that become emergent and very difficult to predict. The more decentralized a system is, the more it relies on lateral relationships, and the less it can rely on overt commands**"

49 Please check the webpage of Webopedia: On-line Tech Dictionary for IT Profession for the definition of "Distribution System": http://www.webopedia.com/TERM/D/distribution_system.html.

(Fox, Michael, & Kemp, Miles, 2009). In accordance with this, the swarm behavior system is considered as strategic choice for developing Interactive Architecture to either sense and actuate locally, and to produce emergent behavior which affects the entire form from a bottom up perspective. This modular componential principle is extremely akin to how biological entities are composed. This is also the reason why "**agent based modeling**" is so crucial both from software simulation and hardware for developing interactive architecture. "**An agent-based model (ABM) is one of a class of computational models for simulating the actions and interactions of autonomous agents (both individual or collective entities such as organizations or groups) with a view to assessing their effects on the system as a whole**"[50]. Therefore, the notion of "**Space is computation**" has once again been brought forth here with the introduction of swarm behavior. By giving up the idea of making a powerful centralized computer taking care of all the adaptations of a building, the ultimate goal that Interactive Bio-Architecture should be composed is thus reformulated to hosting singular architectural components with specific assigned tasks, which embody simple intelligence aided cells. In this case, the body, the sensor and the brain are all integrated in one entity. Also, with its interactive capabilities of sensing, computing and actuating, this emergent architecture will become a holistic sensitive object which is akin to a true living architectural "**HyperBody**" in a relatively large scale.

§ 4.5 Conclusion

In this chapter, the discussions addressing philosophical, social, medium, technological, virtual/real, interaction, and distributed control system have been broadly covered within the context of establishing "**the relationship between body and space**". The idea of **Body Extensions** using artificial technologies, people become highly connected through the surface of **Body Without Organs** which also correlates to the **Cyberspace** notion where the omnipresent Internet exists. This inevitable trend with the development of advanced technologies has started to blur the boundary between virtual and real, making people co-exist in at least two parallel universes. The issue of interaction comes to the fore with the advent of virtual reality technology wherein the discussion around interaction, both in virtual and real spaces gains prime importance. Since space is always the major topic of architectural design, there is no

50 Please check the webpage to understand more details of Agent-Based Modeling (ABM): https://en.wikipedia.org/wiki/Agent-based_model

way to ignore the design requirements from both virtual and real counterparts and it has become a crucial task to create a transition in between. From the architectural design point of view, the interactions taking place have also shifted in scale. In the beginning, the skin (a surface) of the building was mostly used as an information vehicle transmitting messages in a one directional communication to the observer. With wearable gadgets like the Google glass (another surface), the interaction smoothly went to the next phase of "Augmented Reality" which combines virtual reality as a display and overlaying it in the real world thus bringing one close to real-life. With the new technological developments of such wearable gadgets, it potentially extends the possibility of bringing our natural instincts and senses back as Marshall McLuhan reminded us. Therefore, it is not only critical to focus on vision, but also the full sensory perceptions afforded by the body and human movements/gestures to reach the goal of creating tangible interactions in space to create an immersive experience. However, there was a long period of time when architects assigned more attention to adaptive skin systems and its relation with the surrounding environmental conditions. The local environmental condition was used as the input parameters to drive the opening or closing of façade elements in order to optimize the most suitable/comfortable environmental conditions. Although most projects focused on developing adaptive skins used electronic motorized solutions, people now tend to believe that smart materials will be the next ideal step for developing interactive/adaptive actuation systems. Meanwhile, the trend of interaction has shifted its focus from addressing environmental parameters to requirements of the users themselves. This enhances the possibility for people to own and effectively reside in an intelligent re-configurable space, which can adapt to their activity patterns and bio-rhythms. Following this trend, a distributed system both in terms of decentralized computational processing and modular componential assemblies become quintessential to materialize the next generation of Interactive Bio-Architecture. Cooperating with each low-level intelligent architectural component with embedded sensors and actuators for performing specific tasks, the whole architectural body can now become efficient, responsive, and interactive owing to a bottom up decision-making protocol instead of a fully centralized top-down demand based approach. This kind of collective intelligence based decision making is omnipresent in nature and it not only exhibits in the form of swarms of animal to perform variable tasks, but it also takes place inside the natural body for conducting sophisticated tasks by the living cells starting from the growth period of the embryo itself. The mystery behind a cell's emergent behavior relates to the embedded information in the DNA, and how these triggers and informs each other to produce proteins and take certain actions will be discussed in the following chapter.

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