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Topologies of the ICT-built space: an ecological taxonomy of space for social machines

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Abstract: Social machines are socio-technical systems made by the interaction of humans and computers; among them, there are platforms that span the world and shape economic, political, social relations. Social machines build environments that are topologically situated but heavily charged with informative and communicative value (infosphere, semiosphere) that transcend physical topologies. Along the geographies *of* the digital, we find geographies generated *by* the digital, environments where action and power at a distance is possible ("milieu"). What are the social consequences and ethical implications of this new communicative and informative environment? What *ecology* do we need to respect in designing them? Physically, social machines are spread over geographies that are part of a global economy. Semiotically, they host places that are simply "other" (heterotopies), or ideally good or bad spaces (utopias/dystopias). Following an environmental approach, a fourfold classification of spaces is here suggested: *a*-topic, *hetero*-topic, *iso*-topic and *soma*-topic: starting from an topology unrelated with any physical space to more proximal ones, ending with close-to-body relational spaces. Following this proximal and environmental approach, ethical issues may arise from concentrated powers altering the communicative context but also from typical ecologic issues such as reduction of variety and pollution.

Keywords: social machines, digital ecosystems, computer, society, platform economy, computer ethics, geography, space, place

Introduction: Space, Place, Environment and alternative topologies

Living beings live in a space with which they interact: on the one hand they are bound by the opportunities their environment offers, the limits it imposes, the threats it harbours; on the other hand living beings alter, and may eventually end up shaping their own environment as an evolving space[1]. For those living in it, space has properties, which depend on the sensory abilities of the living being which are not only physical, but also informative: the ability of sensing signals, decoding them, building a model of the world, the ability to predict events in the environment, the ability to shape the environment to their advantage.

According to Henry Lefebvre, social practice forges the space in which people live. These spaces are produced from nature as localized raw material[2], and from social practices reflecting relations of production and property[3]. Space is dominated, transformed and mediated by technology; as such, it reflects historical and political balances of power[4]. Social spaces *"interpenetrate one another and/or superimpose themselves upon one another"*[5]. Social human life builds its own environment: space is socially constructed by the interactions of people with nature and within social relations. "*We do not live, act, and work in space so much as by living, acting, and working we produce space"*[6].

Information in space. Semiosphere, Infosphere and spatial codes

When physical space is charged with informational and communicational value it assumes a dual aspect: on the one hand it is the physical "place" in the world where information is located and communication happens, but on the other hand it assumes a semiotic, abstract character, perceived as immaterial, due the abstract nature of information and also because of the dynamic nature of communication.

What is the relation between information and space? Yuri Lotman describes the "*semiosphere"* as an abstract semiotic space within which communicative processes and the creation of new information are possible[7]. Its topology is traced by internal languages and codes allowing translation at the boundaries

[1] Canguilhem 2006: 184; Canguilhem 2008.
[2] Lefebvre 1991: 84, 123.
[3] Lefebvre 1991: 83.
[4] Lefebvre 1991: 164.
[5] Lefebvre 1991: 86.
[6] Smith 2008: 116.
[7] Lotman 2005.

and assuring information circulation and interchange. Inside the semiosphere, different spaces are outlined by the validity of homogeneous codes: one code, one space. On the borders, an interface is required for translating from one code to another. We may consider for instance the semiosphere of a given *language* in relation with the areas in the world where it is spoken. But also we may extend the original Lotman's concept and consider other kinds of *codes* beyond linguistic ones: legal codes of national laws, international treaties or even social norms. In some way, each semiosphere circumscribes a domain where some kind of code is applicable or enforced. On one hand on the same physical space many codes may be simultaneously applicable: for instance, many languages may be spoken in a given area. On the other hand some codes are exclusive: one national legal code may be in force in a given territory at once. Social customs may also follow different patterns and trace different more nuanced geographies in the semiosphere.

As Lessig has shown computer code structures a prescriptive architecture as does the architecture of space, and regulates as laws and social norms do[8]. We can see the different semiospheres and their codes as layers that overlap over geographical spaces, determining their construction as social spaces. Computer programs running global social networks are used worldwide. While language localization provides means for integration with linguistic codes, it may be more difficult to adapt software to fit underlying cultural codes or different legal systems.

In describing what happens to space being deeply innervated with remote communication Luciano Floridi used the term "infosphere", representing the multiple folds of a topological space when it is traversed by information networks: space is not split between a topological space and a disjointed "cyberspace", but the two become the same, bearing both topological and informational properties. Space is populated by entities and agents and characterized by their mutual relations. Floridi goes further and considers that a frictionless information exchange has profound consequences, changing the very nature of connected spaces, places and agents. He describes this process so disruptive to call it "re-ontologization"[9].

We may conclude that places being provided with communication capabilities and invested with information flows become spaces with both a physical/static and an abstract/dynamic character that makes them complex and hard to depict. A physical place becomes also the the domain of validity of specific abstract informational codes or even specific computer programs,

[8] Lessig 1998b; Lessig 1998a; Lessig 1999.
[9] Floridi 2007.

and while being firmly anchored and located in space, at the same time it embeds information flow, and thus becomes highly dynamic.

Alternative topologies: Foucault heterotopies

Michel Foucault expresses some raw but very original thoughts on places harboring spaces. In our contemporary conception, space is a relation between places or sites (in French: *emplacements*), replacing Galileian stretch of space (*etendue*) and the hierarchy of (mostly sacred) locations from the middle-age. While utopia describes a space that does not correspond to an existing place, "heterotopia" is a location (*emplacement*) that somehow reflects some other location as its reflection, representation, or even inversion or opposition. Heterotopias are "utopies being realized". Examples of heterotopies are those spaces socially built to confine crises (cemeteries, hospitals) or to curtail deviating behaviors (asylums, prisons) or even designed to juxtapose multiple places in one single location, as in theatres. Foucault goes further: between utopias and heterotopias we may find other "-topies". For instance the mirror is an unreal (utopic) space that works as an heterotopy, as it links an unreal space with a real one[10]. We may find thay ICT connected spaces show some traits of Foucaultian heterotopies.

Internet as a space: utopy or dystopy?

Early depictions of the Internet were mostly utopian. Perry Barlow's Cyberspace being described as a "second plane", a sort of false bottom of reality where a potential infinity of sites (recalling Foucaultian *emplacements*) made of pure information and being independent from governments can be navigated in absolute freedom by a brotherhood of peers, and be their "home of mind"[11]. This utopian, perhaps escapist, vision has increasingly left ground to a dystopian one. This term, "dystopia", has been coined by John Stuart Mill to describe the opposite of an utopia. An utopia being "something too good to be practicable", a dystopia is "too bad to be practicable"[12] . Dystopian ICTs are blamed for loss of privacy, social control, government surveillance, loss of work, insecurity, and economic instability. In dystopian futures imagined by Cyberpunk literature, the hero is a "*stationary wanderer"* whose practice is to go instantly everywhere he wants without moving. *"Even better, you're it, you are the territory, […] Here you don't just plug in and 'go anywhere,'*

[10] Foucault 1984.
[11] Barlow 1996.
[12] John Stuart Mill 1988: 247.

move without moving. Rather, you become anything, shift shapes, shift bodies, entire sensoriums, at will" [13].

By this transformation, not only the cyberspace is the product of a technological society, but also those who practice the wandering through this built environment are, at least in part, a product of it.

The most recent dystopian outcome of this industrial production of space is, of course, our becoming aware that not only we are producers and consumers of social spaces, but we are also its raw material, transformed and consumed by social networks, mobile apps and smart cities[14]. The technological production process traverses physical space, crosses social space and comes closer and closer to the body, with sensors measuring it and devices intercepting its sensorium. The ultimate space built being *the body itself.*

ICTs in an ecological view: ethical issues

The study of living systems environments has always had to cope with action at a distance between distinct physical individuals, and the environment[15]. We should consider a systemic ecological environment in which social phenomena are both causes and consequences of individual phenomena[16]. The "milieu" is a "pure system of relations without a medium"[17]. Given their abilities to compress time and space, ICTs deeply alter the informative and communicative properties of space, truly redefining where events happen[18]. More than any other social space, a social environment that embeds ICTs is defined not only by physical and geographical properties, but also by its communication and information capabilities. Having a telephone available or not, having an wi-fi connection or not, or even a postal service available does not change the topology of space, but changes the topology of technology-enabled social interactions, making it part of a communicative environment or not, thus deeply changing the social capabilities of those placed in it. If a search engine ranking algorithm, given the same keywords, prioritizes commercial products pages and places them before news or scientific articles, this will change the informative environment of those using it. If major social networks allow only to distinguish between "being friends" and "not being friends", this excludes the many more indefinite forms of connection, association, intimacy, closeness and familiarity, and this may have an effect

[13] Bogard 2000.
[14] Kitchin 2014; Zuboff 2019.
[15] Canguilhem 2006: 166.
[16] Haines 1985.
[17] Canguilhem 2006: 172.
[18] Cohen 2006.

on the social environment. And so on… Postal service, telephone, wi-fi, search engines and social networks are ICTs whose architecture is not neutral, and the ability to define architectures gives power.

According to Rossi-Landi, the ability to control codes, modes of coding, communication channels, modes of circulation and interpretation of messages defines the ruling class[19]. From a communication studies and semiotic point of view, who builds the communication device may be able to define most of the communicative codes, up to a dominant/hegemonic position where the content of the discourse becomes part of the common sense, becomes natural, inevitable and taken for granted[20].

Eric Wolf says that he ability to shape the environment not only gives power, but gives "structural power", or what *"shapes the social field of action in such a way as to render some kinds of behavior possible, while making others less possible or impossible"*[21].

The symbolic, semiotic action of structural power parallels its architectural action, naturalizing artifacts and sinking them as natural elements of the environment: "Such structural power has a double nature. On one hand, it can and must produce measurable effects in the real world. On the other hand, it must engage in symbolic work to construct a world in which power and its effects come to be seen in 'the nature of things'"[22]

Asymmetry of power brings many issues. In particular ethical issues may rise when the relation between the human individual and its environment is somehow unbalanced: an individual or a community may have or not the possibility to change their own environment, or the environment of their community, or may also change the environment of other individuals or communities. One individual or community pursuing his own advantage may alter an environment impacting on others social and communicative life: many ecological issues follow this pattern, climate change included. On the contrary, too much stiffness in built environments change may also be unfair. An environment (physical, social, communicative) may be built in a way that stifles any possibility for individuals or communities to change it in a way that suits them: think of accessibility to physical spaces for disabled persons or the lack of access to digital resources we call the digital divide, or not having access to medical care or, – for linguistic minorities – being forced to talk to their government in some official language. In all these cases the environment (that is, physical, social, communicative, informative

[19] Rossi-Landi 1968: 249.
[20] Hall 1992: 136.
[21] Wolf 2001: 384.
[22] Wolf 2001: 375.

or even economic) may be too rigid and inflexible to some, while being too plastic for others. In this view, ecological mutual interests must converge: the term "disruptive" does not necessarily bear a positive connotation. The architects of the environment bear an ecological responsibility, having to anticipate the effects of the architecture on those using it. The bigger the environment and the impact, the bigger the responsibility.

With the recent algorithmic turn, environments hosting devices powered by artificial intelligence algorithms are so complex that they have various degrees of autonomy, or are even capable of autonomous decisions (algos do CVs vetting, process mortgage applications, suggest social connections) or actions (for instance self driving cars move in space, financial algorithms moving money). This way, the machinery acquires some influence in the co-creation of the social environment along with humans. Social, communicative and informative space is shaped together by humans and machines, further deepening the ethical issues about the ecological responsibility. Architects and developers who build the devices that co-create social environments bear a second order ecological responsibility: every decision of the machine builder will be amplified by the autonomous decisions of the machine itself.

Social machines

Every new technology eventually, incidentally or deliberately impacts on its enviroment. Communication at a distance makes action at a distance possible, and thus extends the environment itself, enabling the interaction of communities otherwise separated.

The "social machine" concept[23] was introduced as a complex assemblage of technologies, human beings, rules, policies, organizational structures intended to enable humans when interacting in social systems in a Web-connected environment[24]. The first wording of the "social machines" concept by its authors resounds of the utopic myth that machines will eventually free us from work: "processes in which the people do the creative work and the machine does the administration" [25]. Time has shown that machines are now also used in (rather dystopian) socio-technical assemblages where humans are doing tasks that are not (yet) automated, while the machine does the coordination. Examples are Amazon Mechanical Turk and many other digital workforce or labour marketplaces. Recent social machines definitions are more neutral: "Web-based socio-technical systems in which the human and

[23] Berners-Lee and Fischetti 2008.
[24] Hendler et al. 2008.
[25] Berners-Lee and Fischetti 2008: 172.

technological elements play the role of participant machinery with respect to the mechanistic realization of system-level processes"[26]

Social impact issues, as architectural and scale issues, have taught the necessity to involve communities in the design and policing of socio-technical systems shaping social environments:

> Just as human communities interlink in society they must be interlinked on the Web, and there is no single set of social policies or mechanisms that will work across all domains. Thus, new forms of social machines are unlikely to be developed in a single deliberate effort in a single application or site – rather, technology must be developed that allows user communities to construct, share and adapt social machines so that successful models can evolve through trial, use and refinement[27]

This and other contributions point to the ecological value of social machines acting in social, relational, communicative and political environments. For instance, some scholarly research has focused specifically to the emerging relation between governments and citizens[28], but further work may be done, possibly tapping from the *digital ecology* literature[29], to map and study the impact on the social ecosystem of the complex web of platforms and architectures where digital and human agents interact.

Topological taxonomies of social machines

Scholarly attempts to classify socio-technical assemblages focus on functional frameworks describing the "polyarchical relationship between infrastructure, social machines, and large-scale social contributions", along the main areas of contributions, participants, and motivation[30]. Further work outlines different features composing the *morphospace along which all social machines vary* as "space of social machine possibilities with respect to a set of common features"[31]. While being very comprehensive and detailed, these works miss a spacial dimension that considers on one hand the localization of the elements of the socio-technical system: technical infrastructures, software artefacts, architecture designers, software developers, owner companies, supporting communities and final users and on the other hand the symbolic, semiotic space where social machines deploy their activity.

[26] Smart and Shadbolt 2015.
[27] Hendler and Berners-Lee 2010.
[28] Tiropanis, Rowland-Campbell, and Hall 2014.
[29] for a review, see García-Marco 2011.
[30] Shadbolt et al. 2013.
[31] Smart, Simperl, and Shadbolt 2014.

We need to investigate both the geographies *of* the digital (where social machines are in the world) and the geographies *by* the digital (what kind of space they produce)[32].

Where in the world are social machines placed?

Where in space do social machines sit? What is their emplacement? It is difficult placing them in a single physical or topological space, since they occupy many. Here we may only try to briefly sketch the elements composing them and the different physical places involved, where different infospheres cross and overlap along different economic, legal, and cultural geographies.

Infrastructures (server farms, cabling, network exchanges) are distributed around the globe and also concentrated in hubs. This has an impact on regional economy: adequate infrastructural facilities, specialized industry and taxation may foster ICT economic clusters, that are usually strongly localized in the richest regions[33]. The software that makes social machines is written somewhere: skilled programmers and a challenging intellectual ecosystem may foster creation of startups and software firms. And, given the configuration the global software development market, software may be written in a different place from where the social machine architecture has been designed, and, given the variegated topology of global fiscality, taxes may be paid (or not) in some other country. Users and participants from the whole globe may be attracted to global software machines that speak their language, that are considered legal by their government (or selectively censored) and for their cultural needs. Otherwise they may be more attracted or redirected to national versions of machines with similar functions. Advertising companies and brokers that are part of the (mostly obscure) business ecosystem of many social machines may follow further distinct topologies. Social machines often feed on data: where does this data is being generated? From users in cities? Rural communities or hospitals? From cars, mobile phones, IoT, medical devices or smart city metering devices? Moreover, data and information may flow from and to places: the informative unbalance across national borders may be so severe that some governments restrict personal data flows and impose data localization laws[34].

All these possible combinations make the spatial localization of software machines difficult but at the same time reveals their enormous geographical relevance: spatial economy, employment and global spatial division of

[32] Ash, Kitchin, and Leszczynski 2018.
[33] Barrios et al. 2008.
[34] Moody 2016.

labour, cultural and political geography are involved. The importance of their ethical design is consequent.

Kinds of informative heterotopies

The previous section on alternative topologies tried to describe the spatial properties of non-topological spaces: these may be helpful in assigning spatial properties to social machines.

Following the alternative topologies described above, four possible alternative spacial dimensions are suggested in which social machines impact on the communicative, informative and relational environment. Given the attention to the relational habitat, this taxonomy may be considered "ecological", but also "semiotical" given its abstract, communicative and informative extension.

1/A-Topies (un-spaces). Websites, gaming platforms, software repositories, media depots, databases, most social networking platforms; all these are websites whose *navigation* is an illusory movement in a virtual space automatically produced by computer programs[35]. On one end of the communication there is a "somewhere" that is not supposed to be geographically place-bound for anyone involved in the communication: it's a *nowhere (an un-space or atopical there) whose localization is generally irrelevant for the user or* is even concealed. I don't really care where Wikipedia or Ebay are placed in the world, but I can feel them as a territory, a place I can move into, *where* I can go where to find things or informations. We may call this place an *a-topia, or un-place.* A proper metaphor may be the pool, both as a venue and as a common resource being located somewhere.

2/Hetero-topies (other-spaces). Email, voice-over-ip calls, video conferences, chats, economic and financial transactions, webcams*: these* are the "faster-further" versions of traditional communication methods happening in physical places. Both ends of the communication happen in a geographical place: a "here" for someone at one end, a "there" at the other end: two localized places linked by the communication network. Since the space in-between is cancelled by the technological means, it is not relevant for those at communication endpoints. A metaphor for this space is *the wire.* Being *wired* is a property of both communicating places.

3/Iso-topies (same-spaces). Augmented reality, internet of things, cloud computing/storage, sensors, some platform economy services, many smart city projects implementations, geo-location services as in the Ushahidi or Google Maps platform. In these machines, an endpoint physical location is

[35] Thrift and French 2002.

topologically relevant: so relevant that the machine deploys a layer over the topological space and acts as an extension of the user sensorium. The technological and topological complexity of the communication/computation is concealed giving the impression to users that informative/communicative space pervades all the place. Information is "everywhere" all over the place but also specific information is tied to specific locations *having the same place* and thus being *iso*-topic. A metaphor describing this situation is *the field*, as intended in physics: a property of the space that can be measured, provided you have the proper device. As gravitational field and electromagnetic field can be measured, the information field can be measured (or sensed) too; In this view, the presence of *pokemons* in the augmented reality game Pokemon Go is a property of the space that can be measured through the app, not an information being "injected" in "real" space. The "Pokemon field" is an isotopy accessible through the appropriate tools, extending oneself sensorium. In Google Maps, geo-referenced pictures of a place are a property of the place itself, are isotopic to the place, even if we know they are accumulating in an informative layer overlapping physical space. The real physical location of information is concealed by the technical layer, but its social perception is space-bound. We can imagine those information fields layering one on top of the other, representing different times, points of view, being linked one to another, accessible to the senses only through appropriate devices and programs. Data may go in both directions, and also flow from the physical place to the isotopic space: sensors from Internet of Things devices or Smart City projects stay in a topological space, and continuously feed another layer of the overlapping informative space.

4/ Soma-topies (bodily spaces): smart watches, mobile computing sensors, mobile geolocation, connected health-tracking medical sensors, body computing, body implants, wearable tech, "immersive" or augmented/virtual reality devices. A fourth kind of semiotic localization emerges when the communication endpoint is situated on the social machine user body or even inside it. It continuously measures the body and may be connected directly to the individual sensorium in a way that perception is seamlessly integrated. Google Glass may represent an example of such devices, intercepting the visual and sound flow of information and projecting it in a layer shared in a social ecosystem. The privacy issues with Google Glass may well represent the social problems emerging when social ecosystems are punctured. The extreme version of this [de]localization is the transhumanist utopia of "substrate independent minds" or "whole mind emulation"[36] transcending

[36] Koene 2014.

the body uploaded and freely moving in an information infrastructure as pure information (even in multiple identities).

This taxonomy draws an axis where the spatial dimension of the social machine action becomes more and more closer to the subject; from a purely *informative* value with no relevant subjective spatial position; to a *communicative* value, with located communication endpoints; to a *topological* value, where data and information flow is location-bound; ending with a *biometric* value, where the location is on the subject, in the subject, or even possibly the subject itself.

	1 - Atopic	**2- Heterotopic**	**3- Isotopic**	**4- Somatopic**
Space	un-space	point-to-point	ubiquitous	bodily
Attribute of the space	Apparently absent, has no geospatial attribute	Other, alien, different	augments sensorial perception, immersive	internal or fused with body
Locations	Nowhere	Away	Here	Me
Values	informative	communicative	links information to the space I'm in	biometric
Types	Websites, blogs, gaming platforms, software/media repositories, SNs	emails, voice calls, video conferences, chats, economic and financial transactions, webcams, chats	augmented reality, internet of things, immersive, sensors, smart city	Bodily sensors, Google glass, implants, being pure information
Examples	wikipedia, Google Search, Facebook, Twitter, Youtube	Gmail, FB Messenger, snapchat,	Google Maps, Georeferenced imaging, Uber	Facial recognition, fitbit

Towards a spatial ecology of relations

The ethical issues around the spaces of social machines develop two axes: a geographical axis and a semiologic axis. The first is physical, geographically located, bound to topologically situated infospheres following language, regional economy, currencies, national interests, law systems, social codes, community values. It regards where social machines components are

situated: infrastructures, people, knowledge, labour, payments. The second is tied to the fourfold proximal spatial dimensions identified above and regards what cultural environment social machines are designed to respond to, what are the algorithms, codes, interfaceso, possible encoding variables of the content the machine handles.

Geographies of inequality

We may only sketch here the ethical issues emerging on the geographic axis. Despite possibly being a major factor of social achievements, social machines are also part (and key player) of the inequality issues of an economically globalized world. Geographical polarization may end up in few elite cities acting as research, innovation, financial and creativity hubs, and low-value global landscapes where microworking and digital labour workforce is distributed along with personal data as a commodity. Cities and countries may be forced to invest in ICT infrastructures connecting them to a global market where they may compete only for marginal places and easily replaceable functions. Second, an enormous concentration of the global communication medium infrastructure in few hands represents an enormous power, enhanced by the ability to manipulate and exploit communication contents. Externalities exist when users derive utility from a service based on the number of other users adopting it. The relational nature of social machines makes network externalities very effective, and concentrations are a quite probable outcome in unregulated markets and vertical non-interoperable architectures, such as those of all popular Web platforms.

Global geographic concentrations of economic actors, infrastructures, knowledge, data, may make it very hard for the periphery to catch up, changing the Internet/Web decentralization utopia to a centralized oligopolistic dystopia.

The relational ecology

Along the semiotic axis, relational environments face various threats exposing ethical issues. Among these: context puncturing, reduction of variety and pollution.

1/Context puncturing. Any environment or semiosphere has a boundary that preserves its internal dynamics and performs input/output functions. There is no exception for relational environments. Privacy, for instance, has been redefined by Helen Nissenbaum as "contextual integrity"[37] with regard

[37] Nissenbaum 2004.

to norms that are peculiar to a given context and regulate the gathering, flow and dissemination of information within and beyond that specific environment. The Google Glass issue with privacy was that it punctured such integrity: it gathered environmental data in the somatopic space, projecting the here-now sensorium of the Glass wearer in an undefined social dimension, challenging privacy expectations of people sharing the same physical environment. European Union and the US have different data protection laws reflecting different cultures: social machines such as Facebook are hardly adapting to the European environment and face legal challenges. Code is not law.

2/Reduction of variety. Any environment has a variety, some sort of "biodiversity", that is typical to that environment but may represent a reservoir of differences for other environments. Digital technologies, especially when used by industry, need standardized products and streamlined processes: that means a reduced and controlled variety. When applied to low-formalized human-to-human interaction, this streamlining introduces a reduction of variety. To be processed by a social machine, human relations have to be encodable: for instance, a huge variety of shades of possible human relations becomes "friendship"; personal and professional skills should fit in predefined frames; products should fit in predefined categories; even legal systems should be coherent and compatible. In global communication platforms such as Facebook, social rules of appropriateness must fit a "black/white" pattern, no matter of the cultural background of local communities. See for instance the debate around nudity: iconic Vietnam war photos[38] and renaissance statues[39] being banned as too explicit or pornographic. We may expect that current "fake news" debate will force any news article into the "true/false" dichotomy according to rules, criteria and algorithms centrally decided by global social machines engineers rather than by national and local communities. Whole languages, cultures, social norms and legal systems, forced in the moulds of standardized interfaces – often forged in topologically and culturally concentrated environments – may be challenged. If this happens without necessary care, it eventually may bring to reduction of variety and even to the destruction of valuable social, cultural, economic and legal ecosystems. The alternative of not being encodable leads to the risk of being marginalized in the infosphere and the global marketplace.

3/Pollution. The delicate and shaded communication environment of personal human relations and analog communication, by the effect of the

[38] Alice Ross and Julia Carrie Wong 2016.
[39] Helmore 2017.

intrusion of industrial and commercial values may suffer of informative and communicative pollution, that is the presence of contaminating by-products of the industrial process. As an example of pollution in the inter-communicative space we may see unsolicited commercial emails ("spam"), the use of the content of personal communications to deliver targeted advertising and unwanted effects of personal profiling. Smart-city sensors used as a surveillance network[40] may represent a pollution of the geo-referenced iso-topic space. Pollution in the somato-topic space may be either the disclosure or abuse of personal biometric data or even the unauthorized use of photos uploaded to social networks for facial recognition. A hainous example of both puncturing and pollution of a social network environment is when a face recognition search engine was used to identify sex workers[41]. The analogy between natural environment pollution and the practice of dumping costs on the social environment is also emerging in the debate on algorithms. In this case, pollution means "negligent use of computational capacities that externalizes costs onto innocent others"[42]. This may mean: harms to reputation, discrimination, forcing a normalization or manipulation of behaviour, lack of transparency/accountability. "Algorithmic acts that is adequate for the needs of private companies (or government agencies) but not adequate from the standpoint of society as a whole"[43] are a nuisance, or polluting. The overall effect of pollution of the informative and communicative space may bring the depletion of social capital.

Conclusions

The analysis of the spatial dimensions of social machines may be difficult because their action space has both geographical/physical features and informative/communicative (semiotic) properties, building complex spatial environments. A fourfold taxonomy of the action space of social machines has been provided, along with examples of its possible use in situating ethical issues. These environments cross territories with overlapping semiospheres: different social norms and customs, different legal codes, and people who speak different languages and share different values. Socio-technically built environments may span various contexts and force a reduction in the variety of the ecosystem, or puncture contexts with different incompatible values, or even pollute them. Social machines may change the relational capabilities

[40] Galdon-Clavell 2013.
[41] Lisa Vaas 2016.
[42] Balkin 2016.
[43] Balkin 2016.

embedded in these ecosystems exerting a structural power in shaping space and relations in space. Designers who build machines altering an environment should develop an ecological awareness, oriented in two main directions: 1) considering the risks of disrupting valuable economic, communicative and informative balance of environments. 2) Avoiding to build environments too rigid from the communicative, informative or economic point of view, so that its "residents" are not be able to alter them. The current ecosystem of few globally extended social machines, concentrated in few countries (or even in few regions), pose ethical issues in this sense, since they are shaped along rather uniform architectural, linguistic, cultural and legal models.

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